CHAPTER 1 INTRODUCTION

1.1 General

The Study on "the Lining of Distributaries and Minors in Punjab" has been conducted from April 1996 to July 1997 according to the "Scope of Work" agreed between the Irrigation and Power Department, Government of the Punjab (PID) and the Japan International Cooperation Agency (JICA) in September 1995.

JICA entrusted the Study to a joint venture of engineering consultant firms: Nippon Koei Co. Ltd. and Nippon Giken Inc. A study team comprising nine engineers was organized.

1.2 Background of the Study

The Indus River Irrigation System has been developed since the mid 19th Century and become the largest contiguous irrigation system in the world. However, in the course of its nearly 150 years history a variety of problems have emerged. One is the severe shortage of water resources that resulted from the explosive population pressure, tremendous increase in cropping intensity, and hence increased demand of irrigation water. Inequitable water distribution at distributary level lent an impetus to the shortage. Two is the water logging and salinity that resulted from the continuous irrigation in the arid and semi-arid areas without drainage for many years. Three is the institutional failure of operation and maintenance system that resulted from the financial imbalance of government, and deficient farmers' trust in management.

The current project is aimed to solve these problems through the canal lining as hardware and the reinvented O&M system as software. The latter is based on the basic concept of the institutional reform to be implemented under the National Drainage Program (NDP) with financial assistance from the World Bank, Asian Development Bank and Overseas Economic Cooperation Fund of Japan (OECF).

Critical issues of the Study would be (i) assessment of seepage rate of canal and economic viability of canal lining which have been a subject of controversy among engineers from the outset of the canal system and (ii) consultation of farmers opinion on the institutional reform which is very necessary because success of the institutional reform solely depends on farmers will and ability.

1.3 Study Area and Objectives of the Study

The Study area comprises three canal systems in the Punjab province: the Lower Chenab Canal (LCC), Lower Jhelum Canal (LJC) and Central Bari Doab Canal (CBDC). There are 717

Distributaries and Minors in the Study area with a total length of 6,615 km and a total gross command area of 24,450 km^2 (GCA).

At present, it is the responsibility of PID to operate and maintain the irrigation system from the barrages to distributaries and minors. The Government of Punjab decided to bring about the institutional reforms in PID, which would be transformed into autonomous bodies, namely Provincial Irrigation and Drainage Authority (PIDA) under statutory arrangements.

The objectives of the Study under such circumstsnces are:

1) To select approximately 500 km of Distributaries and Minors as priority areas, to formulate a canal lining project, and to conduct a feasibility study of the project; and
2) To carry out technology transfer to the Pakistani counterpart personnel through on-the-job training in the course of the Study.

1.4 Process of the Study

The Study was implemented in two phases. The Phase I Study was conducted from April 1996 through August 1996; field works in Pakistan from April to June and office works in Japan from July to August. Main objective of the Phase I Study was the selection of priority areas, for which criteria were (i) saline ground water zones, (ii) channels with high seepage rate, (iii) farmers intention, and (iv) other on-going projects. Necessary field surveys were carried out including the seepage survey (60 reaches), water quality test (700 samples), soil survey (350 samples), soil mechanics test (10 samples), and farm survey (1,000 households). The survey results were compiled in the Interim Report.

The Phase II Study was conducted from October 1996 through March 1997; field works in Pakistan from October to the beginning of January and office works in Japan till March. The main objective was to formulate the lining project and to conduct feasibility study. The priority areas was finally decided to be 12 Distributary systems with a total lining length of 540 km and a total area of 241,111 ha (CCA). The outcomes were incorporated in this Report.

The Phase III Study was conducted from May through July 1997. The JICA Study Team made an explanation of the Draft Final Report to the officials of PID and concerned agencies and had question-and-answer sessions with them. The Minutes of Meeting were signed between PID and JICA representatives on May 15, 1997. Finalization of the Report was conducted in Japan incorporating the comments and suggestions made by the officials of PID.

1.5 Cooperation with World Bank

JICA and World Bank cooperated with regards this Study and NDP as for the survey area and planning of pilot project. The Study Team held a meeting with a representative of World Bank in April 1996 in Lahore to discuss the institutional reform. In September 1996 JICA sent the Interim Report to World Bank in Washington for comments. Taking into due consideration the comments given the Study Team conducted the Study. Due to the delay of NDP-I, however, any adjustment between this plan and NDP was not made. Certain adjustments would be necessary after commencement of NDP-I.

1.6 Sub-Contract Works

The following surveys were executed on a sub-contract basis. Specifications are attached to Annexes.

A. Phase I Study

(1) Seepage Survey (60 canal reaches by inflow-outflow method and ponding method) .....Irrigation Research Institute

(2) Water Quality Test (700 ground water and surface water samples for salinity analysis) .....Irrigation Research Institute

(3) Soil Test (350 soil samples for salinity analysis).....Irrigation Research Institute

(4) Soil Mechanics Test (10 soil samples for soil mechanics test) .....Irrigation Research Institute

(5) Farm Household Survey (interview with 1,000 farm households) .....Enterprise & Development Consulting (PVT) Ltd.

B. Phase II Study

(1) Canal Route Survey (542 km of profile and inventory survey) ..... Khyber Consulting Engineers

(2) Water Quality Test (30 samples of drinking water for quality analysis) .....Hydro-Envo Consultants

1.7 Reports

The Draft Final Report consists of five volumes as follows:

(1)	Main Report	Volume I
(2)	Annex - I	Volume II
(3)	Annex -II (Farmers Organization)	Volume III
(4)	Drawings	Volume IV
(5)	Main Report (Japanese version)	Volume V

Reports were prepared in the course of the Study as follows:

(1)	Inception Report	March 1996
(2)	Progress Report I	June 1996
(3)	Interim Report	September 1996
(4)	Progress Report II	December 1996
(5)	Draft Final Report	March 1997
(6)	Final Report.....	July 1997

CHAPTER 2 BACKGROUND

2.1 National Economy and Agricultural Sector

Pakistan's economy had grown rapidly during 1980-92 indicating an average annual growth rate of GDP at 6.1%. However, Pakistan's per-capita GNP is still low; it was US$ 420 in 1992. Therefore, primary objectives of the five year development plans in the past have been to increase per capita income and alleviate poverty.

Agriculture is the most important economic sector in Pakistan. The agriculture sector had achieved an annual growth rate of 4.5% during 1980-92. It accounted for one fourth of GDP, about half of employment, and substantial share in export earnings. Agriculture supplies most of the country's food and raw materials for major domestic industries.

Pakistan covers about 79.6 million ha. The cultivated area is 21 million ha, of which 16.2 million ha (77%) are irrigated. Of the total cultivated area 10.4 million ha are single cropped, 5.7 million ha are double cropped and 4.9 million ha are fallow. Pakistan's climate is arid to semi-arid, which makes non irrigated agriculture difficult. Around 90 % of agricultural output comes from irrigated agriculture.

Pakistan's population, which was 82 million in 1980, increased to 128 million in January 1995. The population growth rate was more than 3% per annum during the 1980s. The United Nation predicts that Pakistan's population will be 148 and 243 million in the years of 2000 and 2025, respectively, which is an alarming projection in view of the country's food production potential. Pakistan is a food importer even now. Imports of agricultural products such as wheat, sugar, tea and oilseeds amount to 12-14% of all imports, and agricultural inputs, mainly fertilizer, another 3-5% of imports. The Water Sector Investment Plan (1991) predicts that in the year 2000 food grain will be short by 40 % and other crops will also be greatly in short supply if the current rate of yield increase continues.

2.2 Indus River Irrigation System

(1) General

The Indus Basin Irrigation System is the largest contiguous irrigation network in the world. In 1960, the Indus Waters Treaty settled the division of the waters of the Indus Basin. Pakistan was bestowed the right to exclusively use the waters of the main stream Indus and two tributaries in the west: the Jhelum and Chenab. In 1960s and 1970s, Pakistan remodelled its irrigation system through construction of reservoirs, barrages and link canals.

Presently, there are three major reservoirs (Tarbela, Mangla and Chasima), 19 barrages or headworks, 12 link canals, 43 canal systems and 107,000 watercourses. The total gross command area (GCA) is 15.8 million ha (Punjab : 9.45 million ha) and the total culturable command area (CCA) is 14.0 million ha (Punjab : 8.22 million ha) The total length of the canals is about 63,000 km (Punjab : 35,300 km) and that of watercourses and farm ditches is 1.6 million km. The total authorized discharge is 7,300 m3/s (Punjab : 3,400 m3/s).

Under the Indus Basin Irrigation System, river water is diverted by barrages into the main canals and subsequently into the branch canals, distributaries and minors. The supply to the farm is further diverted from distributaries and minors to watercourses through outlets called moghas. Moghas are designed to allow a proportional diversion self adjusting to variations in the distributaries and minors. Within the watercourse command area ranging 80 to 280 ha, farmers receive water proportional to their land holding. The entire discharge of watercourse is given to one farmer for s specific period on a seven day rotation. The rotation schedule, called "warabandi", is established by the PIDs if the farmers cannot reach mutual agreement.

The Indus basin covers 566,000 km2 or 70% of the country's area. The average annual discharge at rim stations is about 181 billion m3 (Indus River : 161 billion m^3 and tributaries 20 billion m3). The diversions to canals are 131 billion m3, outflow to sea is 40 billion m3, and net system losses are 10 billion m3.

But, river flows are highly seasonal. Roughly 85 % of annual flows are in the Kharif season (summer), and only 15 % in the Rabi season (winter). Although Pakistan has large reservoirs such as Tarbela, Mangla and Chasima reservoirs having 18 billion m3 of total live storage, they are not enough to regulate seasonal waters. Due to inadequate water availability in winter and at the beginning and end of summer, cropping intensity is low.

The Water Apportionment Accord was signed in March 1991 between the Federation and four Provinces to distribute the post-Tarbela waters to provinces and to ensure increased availability of irrigation water for sustainable agricultural production. As per this accord, Punjab agreed to a cession of 0.87 MAF (1.07 billion m3) to North Western Frontier Province (NWFP). This volume is equivalent to 4.4% of the average canal head withdrawal of 19.74 MAF (24.28 billion m3) in the Rabi season. the cession of water right to NWFP may result in lower agricultural production and less farmers' income. In this regards, Government of the Punjab is planning to enhance urgently compensation for the cession of water through lining of branch canals, distributaries and minors with a total length of 9,600 km.

Water Accord 1991 (unit : MAF)

Province	Kharif	Rabi	Total	Share (%)
Punjab	37.07	18.87	55.94	37
Sindh	33.94	14.82	48.76	37
NWFP (a)	3.48	2.30	5.78	14
Balochistan	2.85	1.02	3.87	12
Total	77.34	37.01	114.87	100

(2) Problems of the Indus River Irrigation System

Pakistan has significant natural water resources, but they are inadequate for crop production on the available land. Availability of irrigation water at farm gate from canals and tubewells has gradually increased from 1.95 acre-ft/acre (594 mm) in 1979-80 to 2.27 acre-ft/acre (692 mm) in 1990-91. Yet this is less than the requirement of 2.7 acre-ft/acre (823 mm) suggested by Dr. Shah Mohammad, University of Agriculture, Faisalabad.

Since the Indus Irrigation System is made of earthen canals constructed on porous alluvial soils, considerable seepage losses are observed. In addition, due to age, overuse and poor maintenance, canal delivery is inefficient. Average delivery efficiency is 35 to 40 % from the canal head to the root zone, with most losses in watercourses. The loss not only reduces available water for crops, but also contributes to waterlogging and salinity. In the face of increasing shortages of water in the future, improvement in the irrigation delivery efficiency is necessary. At the same time, to avoid problems of waterlogging and salinity and excessive costs of providing drainage, improvements in the irrigation efficiency is essential.

Inequitable distribution of irrigation water is another problem. It is occurring that water does not reach users at the tail end of the system, or at least not at the rate intended in the design. Poor O&M, lack of monitoring facilities on the operation performance, illegal pumping from canals, and intervention of political powers on the water management add to the inequity in distribution.

Further, the design capacity of irrigation canals, which is only 0.2 l/s/ha, is a constraint during periods of high demand for crop water. The low design capacity is because of the low cropping intensity of 70% assumed at the initial stage of system design in the last century. Since then, as the population has increased and farm size has reduced, the cropping intensity has increased and presently reached to 120%. Thus, in many canal systems, there is a mismatch of water supplies to crop water requirements at the farm level.

(3) Groundwater, Waterlogging and Salinity

The Indus Basin has flat topography, poor natural drainage, porous soils, semi-arid climate with high evaporation. Irrigation without adequate drainage under these conditions inevitably

leads to rising water tables and salinity. Since the 1960s, a series of salinity control and reclamation projects (SCARP) were implemented. Despite these efforts, about 30 % of the gross commanded area (GCA) is waterlogged and about 13 % is highly waterlogged. Even though irrigation water is relatively free of salts, repeated irrigation and the rise in the water table will dissolve salts in the soil and bring them towards the surface. It is estimated that about 8 % of GCA is severely salt-affected and another 6 % is moderately affected.

In some areas with fresh groundwater, surface supplies can be supplemented by tubewells. Groundwater use has been a major factor in raising agricultural production over the past 20 years. About 54 billion m3 was pumped from groundwater in 1990-91. Tubewells not only supply additional water, but also provide flexibility to match surface water supplies with crop water requirements. Due to explosive development of groundwater by the private sector (6 % of annual growth), there is danger of excessive lowering of water tables and intrusion of saline water into fresh water aquifers. In many CCAs, where canal water is not sufficient because of inequitable distribution, farmers depend on tubewells and tend to overexploit groundwater. Excessive pumpage, in the absence of adequate leaching and ineffective conjunctive use of surface and groundwater, caused salinity in the root zone.

(4) O&M System

It is the responsibility of Provincial Irrigation Departments (PID) to operate and maintain the irrigation system from the barrages to distributaries and minors. In recent years, water and drainage charges are intended to cover only O&M. Charges are not linked to O&M needs; they are collected by the Provincial Revenue Department and become part of provincial revenue. The gap between O&M expenditure and recoveries through water charges has been increasing - reaching 30 % in FY92 in Punjab and Sindh. The gap would rise to more than 60 %, if expenditure of government tubewells were included. The overall gap of 44 % increases to 57 % if recoveries are compared with O&M requirements instead of expenditure. The required O&M spending in Punjab and Sindh is about US$ 11.0 per ha including public tubewells. (excluding tubewells requirements are halved) For comparison, O&M requirements in the Yanqui irrigation district of Mexico are US$ 60.00 per ha.

Regarding the O&M of the irrigation and drainage system, there are many problems such as the low water charges, insufficient O&M budget, high expenditure for PID' O&M personnel, farmers' complaints for insufficient O&M services, and inadequate method of O&M recovery, These problems have provided grounds for necessity of more efficient and autonomous O&M system and institutional reforms.

2.3 National Policies for Agriculture and Water Sectors

2.3.1 Eighth Five Year Plan

The emphasis of the Eighth Plan is on using the agriculture sector as the main instrument of growth and development. The primary goal of the agriculture sector is the achievement of a growth rate higher than the population growth, in order to ensure food security, self sufficiency and large exportable surpluses. With the agreement on water accord, emphasis will now be laid on (i) Integrated management of agriculture, irrigation and drainage; (ii) Efficient land management; and (iii) Efficient water management.

The major goal of policy and planning in the water sector continues to be that of uplifting the agro-based economy of the country by maximizing crop production. This goal will be accomplished through progressively increasing surface water supplies, replacing public tubewells with private ones, improving existing management practices using the latest technologies available, and protecting land and infrastructure from waterlogging, salinity, and floods. Efforts will also be made to operate and maintain irrigation and drainage sub-systems at a high efficiency level.

Regarding the distributaries and minors, the following strategies are proposed for implementation:

(i) water conveyance efficiency of canals and drains should be improved by lining and remodelling;
(ii) existing irrigation and drainage systems should be rehabilitated;
(iii) fertile lands should be protected from waterlogging and salinity by giving priority to disastrous areas having saline groundwater underneath. The exploitation of groundwater resources in fresh groundwater zones should be left to the private sector;
(iv) borderline waterlogged areas should be treated with preventive measures such as lining of minors and distributaries, water regulation and management, OFWM and improved cropping pattern;

2.3.2 Alternative Strategies of the Water Sector

(1) Accelerated Water Management Programme

The Government of Pakistan decided the Accelerated Water Management Programme in August 1995. The programme was three year plan for the water sector and a total amount of Rs.25 billion was approved as an additionality to normal water sector allocation. It was noted however, that a substantial portion of this programme will be in the form of foreign assistance. The Programme consists of seven items: (i) Lining of watercourses; (ii) Lining of canals and

distributaries; (iii) Rehabilitation of canals; (iv) Surface drainage; (v) River management and flood control; (vi) Hill torrents; and (vii) Institutional reforms.

As for the lining of canals and distributaries, the need for bigger channels such as main canals, branches, distributaries and minors or installation of interceptor drains along them was approved in principle, however, it was decided that the provinces would restrict lining channels and/or provision of interceptor drains to only those reaches of canals where: i) soils is porous, and/or ii) the channel is in high fill resulting in heavy seepage.

Regarding the institutional reforms, the followings were approved:

i) The Provincial Irrigation Departments (PIDs) shall be transformed into autonomous bodies, namely Provincial Irrigation and Drainage Authorities (PIDAs) under statutory arrangements, having independent revenue collection and spending authority. The process would be completed by the Provinces in a manner that the PIDAs become functional by July 1, 1996, the latest.

ii) Below the PIDAs, financially self-accounting Area Water Boards (AWBs) on the pattern of AEBs of WAPDA shall be created, preferably around canal commands.

iii) Below the AWB level, farmers shall be encouraged to form Water Users Formations at the distributary and minor level on a pilot concept basis. These formations would play an important role in the operation and maintenance of distributaries and minors using participatory approach. Based upon the results of such pilot projects, a workable model would be evolved for adoption on a countrywide basis.

iv) The newly created PIDAs shall not increase staff strength till such time as they have attained financial self-sufficiency.

v) It was also decided that since the existing PIDs will be converted into financially and operationally autonomous bodies, it would not be appropriate to fix any annual percentage increase in "abiana" because it would upto the concerned Provincial Authorities to achieve full recovery of O&M costs.

(2) PID's Policy of Water Resources Development

The PID, Government of the Punjab enumerated the following six items as the causes of short water supply at the tails:

i) Low supply in the rivers/source;

ii) Inability of the channels to convey the required discharge;

iii) Silt deposits in the channels;

iv) Higher expectations of the farmers;

v) Unauthorized withdrawals; and

vi) Deterioration in law and order situation.

The PID also enumerated the following eight items as the remedial measures for the water shortage:

i) Measures to provide assured supply through construction of dams;
ii) Strengthening of banks and repair of damaged/defective outlets;
iii) Lining of channels;
iv) Silt clearance of channels;
v) Special watching of channels;
vi) Enforcement/enhancement of strict penal action for unauthorized irrigation;
vii) Improvement of law and order situation.

2.3.3 National Policy on Institutional Reforms

From the meetings with the farmers in the project area, officials of the Federal and Provincial Governments and in pursuance of the documented studies carried out by Government itself and with the assistance of international agencies such as World Bank, Asian Development Bank, and OECF, it is realized that the performance of agricultural sector has been dismal and poor. It is recognized that among the various constraints one of the most serious constraint is the old colonial institutional system which does not allow the beneficiaries to participate in the development, operation & maintenance process of economic resources. This lack of participation by the beneficiaries is more evident in water sector which is having the highest influence on agriculture in the arid and semi arid region of Pakistan. The water resource is increasingly becoming scarce in terms of per capita availability due to rising population. The increased pressure on land and water for maximum productivity by individual farmers has resulted into unauthorized use of water particularly by the influential farmers in the head reaches of the distributaries. The problem was recogaized as early as in 1975 when the canal and drainage act of 1873 was to go through a major amendment in an attempt to remedy its increasing obsolescence. The back ground to this amendment can be seen in the following comment by Nasir (1981;3):

> *"The Canal and Drainage Act of 1873 was drafted more than a century ago when the irrigation in the Punjab was in its infancy. With the extensive development of irrigation, many new problems have arisen for which adequate and clear cut provisions do not exist in the Act. The growth in population and fragmentation of the land holdings have given birth to serious problems in the equitable distribution of canal supplies especially of internal watercourses within the standard canal irrigation unit of a square. The influential people have been and are resorting to unauthorized irrigation by tampering with the outlets or by cutting the canal banks or by using canal water out of their turns and in excess of*

their legitimate shares. The proposed amendments in the Canal Act are, therefore, necessary." (page 30-31)

The national commission on agriculture (1988) also comments "Not only does the availability of canal water vary seasonally, the distribution process itself suffer from certain chronic inequities, the worst being tailenders i.e.. farmers at the extreme end of the distributary system" The commission further comments "of all the inputs in agriculture the greatest gains can be expected from more efficient use of water, which also maximizes gains from other in-puts such as fertilizer. Increasing agriculture production will, therefore, depend crucially on the rational use of land, land improvement, increasing the supply of water by reducing the water losses, more efficient water use and better agronomic practices." It is therefore realized that it is highly essential to improve the efficiency of this resource and one way would be through the full participation of the farmers - the beneficiaries.

The policy of the Government to make the beneficiaries of economic resource participate in the management of these resources is reflected in the 8th five year plan which in its chapter on "Good governance" states to:

"Improve efficiency, responsiveness and participation in the management of economic system, through deregulation, accountability and empowerment of rural communities, NGOs and lower echelons of the Government."

Again in the chapter on "Approach to the plan", it states that the frame work will be geared to:

"encouraging participation of all people in the development process and a more equitable sharing of benefits."

The plan in its objectives and strategies on environment states that the National Conservation Strategy (NCS) implementation agenda during the 8th plan will focus on:

"Strengthening of Regulatory, Technical and participatory institutions. To create a balanced implementation frame work, the types of institutions need to be encouraged are (i) public sector research, regulatory and planning institutions, (ii) Local and community participation institutions and (iii) private sector institutions."

In the priority areas of the NCS emphasized by the 8th plan, the 1st three priorities are (i) maintaining soil in croplands, increasing irrigation efficiency and protection water sheds.

On the participatory organizations, the 8th plan states that community organization does not mean a small group of influential local representatives. It means broad based, decentralized

homogeneous local organizations at the village and neighbor - hood level with decision making being done by all those whose common economic interest is best served by working together. The plan recognizes that the development agencies tend to be organized on a sectional or functional basis instead of following an integrated multifunctional approach. To make optional use of opportunities it is important that villagers have management capacity to integrate the assistance available with their specific needs.

Many efforts at promoting group cooperation and activity have been captured by special interests that seek to optimize their own benefits. To avoid repetition of past mistakes, special procedures and disciplines are required to ensure participation of all possible beneficiaries and effective supervision of the development process. There is, however, an urgent need to promote village level capacity for innovation.

In formulating strategy for implementation in the water sector the 8th five year plan emphasizes on transferring partial responsibility for O & M to farmers associations so that O & M financial burden on the public sector is eased. It recommends to implement a pilot program to evaluate the concept of transferring irrigation department into autonomous bodies with the ultimate aim of involving the private sector in irrigation management.

The Government has also given a clear mandate to the international financial institutions helping the National Drainage Program to implement institutional reform which would make the participation of the beneficiaries essential to achieve the twin objective of making the system efficient and transfer the burden of O & M expenditure to the beneficiaries. In discussion with Government Agencies at Federal and Provincial level the institutional reforms were clearly mentioned and recognized. The will of the Government was also indicated to implement institutional reforms on pilot bases.

Policy Implementation during the 8 the plan

In pursuance of the above basic policy the federal and the four provincial governments have agreed on a draft statute to be promulgated bringing about the institutional reforms in the provincial irrigation department. The statute broadly stipulates that these departments shall be converted into independent authorities (provincial Irrigation & drainage authorities-PIDA) controlled by a board of Directors which will have the farmers' representatives also as directors besides the official directors including Irrigation & Power department, Agriculture department and planning and development department. The PIDA's will have all the powers of O & M and development of irrigation and drainage systems under their respective jurisdictions and the fixation of water charges to make them financially independent. Under the PIDA's will be established area Water Boards for each canal command which will be equally independent. Farmers organizations will be formed at distributary level on pilot basis to give full participation to the beneficiaries and to O & M the distributaries by themselves. These organizations will be

established under the corporate law authority having independent legal status and will be given the relevant powers and responsibilities under legal protection.

2.3.4 National Drainage Programme

In the early 60's a massive effort was made to control waterlogging and salinity by implementing SCARP Projects particularly in Punjab using the vertical drainage system recommended by "Master Plan - Initial Phase" by Harza Engineering International. Another Revised Action Programme was prepared (RAP 1979 to 1990) which supplemented the former studies but did not pay more attention to the disposal of drainage surplus. Yet another study 'Water Sector Investment Planning Study 1990-2000 was carried out which looked into drainage and disposal problems.

Taking stock of this situation the Government of Pakistan in August 1991 undertook an environmental assessment study of irrigation related drainage of which NDP was a conceptual part.

The drainage sector environmental assessment study of 1993 concludes that

(i) Projects which mobilize salt from deep groundwater storage needs to be avoided.
(ii) Additional surface water should not be supplied to areas which will need massive saline drainage.
(iii) None of the current methods of disposal within the basin seem environmentally acceptable and therefore National Surface Drainage System to carry the saline affluent to sea may be initiated.

World Bank examined the issue and concluded that there are no two opinion that the present state of affairs is fast heading towards the total collapse of the irrigation and drainage system in Pakistan. They further state that the poor performance of the drainage projects is due to deficiencies in policies and institutional matters and low priority given to O&M of drainage facilities in allocation and management of resources.

The cumulative effect is that the irrigation system in general and the drainage in particular have serious problems of (a) run drown projects, (b) shortage of funds for O&M and (c) lack of clear policy on sustainable investment.

NDP - I

The NDP-I envisages that the problems faced by drainage sector cannot be addressed in isolation by increased financial input. It therefore recommends multi-facet approach including

institutional and policy reforms, initiating changes in the legal and regulatory framework to allow farmers and private sector participation in improving O&M, improving management of public expenditure to increase allocations for O & M.

The main components of NDP-I are :

(a) Policy Component: It was intended to provide a framework under which the donors, Government of Pakistan, Government of Provinces would agree on performance targets and arrangements to monitor: (i) size, composition, and sequencing of annual development expenditure on irrigation and drainage; (ii) criteria for selection of drainage scheme; (iii) annual recurrent O&M expenditure on irrigation and drainage; and (iv) cost recovery targets for O&M on irrigation and drainage. The policy component would also formulate policies to encourage private sector investment and farmers participation in construction and O&M of drainage.

(b) Institutional component: It was intended to provide technical assistance to : (i) strengthen capabilities of WAPDA and provincial authorities to plan and implement projects, manage water resources; (ii) supervise NDP-I; (iii) form Farmer Organization (FOs) and to train them to carry out on-farm drainage; (iv) design and implement regulatory reform for irrigation and drainage and (v) Monitor the environmental effects of irrigation and drainage i.e. environmental assessment and monitoring.

c) Research and studies component: It had to be designed for carrying out: (i) studies to prepare further projects and NDP-II; (ii) a Feasibility Study for the proposed National Surface Drainage System; (iii) studies to develop structures, and formulate the necessary changes in the legal and regulatory framework to permit formation , of FOs, PUs and PWAs; and (iv) drainage research.

d) Investment component: It was to provide financial assistance for early completion of locally funded ongoing drainage projects, rehabilitation of existing drainage facilities, improving operation and maintenance of drainage infrastructure and implementation of selected high priority new projects. The investment component of NDP-I would represent a time slice of GOP investment programme in the 8th Five Year Plan. However, it was not intended to be synonymous with the entire 8th Plan."

It further highlights each and every component in detail including the policy issues, institutional issues, technical issues, sustainability of drainage investments, O & M procedure and budgeting, recovery of service charges, beneficiary participation and investment component. It clearly brings out that future investment on drainage without a comprehensive approach will not be sustainable.

(2) The Proposal for Institutional Reforms under NDP-I

The proposal for institutional reforms as given in the NDP-I is mainly concerned with the Water and Power Development Authority (WAPDA) and the Provincial Irrigation Departments (PID). The reforms in provincial Irrigation Departments and the formation of farmers' association for O&M are discussed in the draft ordinance. Broadly the ordinance would establish Provincial Irrigation and Drainage Authorities (PIDAs) in each of the four provinces and Area Water Boards (AWBs) in the canal command areas (Fig. 3.4.7-1).

The PIDAs will be autonomous bodies controlled by a Board of Directors, the Chairman of which will be the Additional Chief Secretary Planning and Development of the three Provinces. In case of Punjab it will be the Chairman P & D Board. The Secretary Finance, Secretary Irrigation, Secretary Agriculture and some experts from outside will be the members of the Board. The authority and its members will meet at least once in three months or earlier as the case may be and will be on a non-permanent basis. The authority will appoint a Managing Director and a Board of Management who will be responsible for day to day working of the authority. However, the corporate body will be fully empowered to hold property, to do planning and development of water sector projects within the provinces, to operate and maintain the irrigation, drainage & flood control systems. The autonomous Provincial Irrigation and Drainage Authority will prescribe and collect fees and other charges from the farmers, obtain loans from national and international financial institutions and formulate financial policies, ensuring that finances of the authority are managed in a consistent, conservative and diligent manner and service its debts and obligations. The authority will have its own staff down to the operational level for developing and operating the system. During the transition period the authority is empowered to prepare and implement its own policies with a view to ensure that the staffing level within the authority and other entities conform with the corresponding level indicated in the plan prepared by the authority itself. It will enforce a freeze on hiring new employees, replacement of retiring employees, reassigning of surplus employees and introduce policies of financial and other benefits for voluntarily retirement. The authority will be fully operational within a period not exceeding seven years.

With regard to the existing employees of the Provincial Irrigation and Power Departments it is stated that the employees of such departments will become automatically employees of the authority. The authority would then prune and reduce the staff in the manner prescribed above. The authority will be financed through (i) water charges, sale proceeds, development cess and drainage cess etc. (ii) grant made by the Government; (iii) loan obtained from the Government; (iv) grant made by local bodies; (v) sale proceeds of bonds etc. (vi) loan obtained from the

financial institutions with the general sanction of the Government; (vii) foreign assistance or loans from foreign agencies with the approval of the Government.

(3) Fixation of Water Charges by the Authority

The Authority is fully empowered to revise water charges under a well established procedure. The Authority will be working under Provincial Government.

(4) Area Water Boards (AWBs)

The Government will establish AWBs under the control of the Authority for canal command areas within a period of 90 days. Constitution of the AWBs will include a Managing Director, two elected representatives of farmer's organizations, a representative of the authority, Director Agriculture, two technocrats with proven background in water resources management and finances, one member representing the Government.

Under the above board there will be established a Board of Management under the Managing Director with two or three members.

(5) Functions of AWBs

1) To received water supplies from authority and deliver the same to the farmers' organizations at distributary/minor level.
2) To receive drainage affluent from the farmers' organizations and convey the same through relevant drains.
3) To establish the water rates to be charged from the farmers both for supply of irrigation water and disposal of drainage surplus. The AWB will be delegated the powers of the authority both for managing, operating and developing water resources and recovery of charges from the farmers.

(6) Farmers' Organizations

The ordinance specifies that within one year of the formation of AWBs they will implement pilot programme policies and take steps thereunder to ensure that farmer's organizations are formed at minor/distributary level in a phased and orderly manner. The farmers' organization so formed should be made financially self sustaining and self sufficient for the effective performance of their functions within a maximum period of four years. The authority shall within six months of its coming into being publish bye-laws and regulations relevant to the formation of farmers' organization in the provinces.

(7) Functions & Powers of the Farmers' Organizations

1) To manage, operate and improve the irrigation and drainage infrastructure located within the area under their jurisdiction.
2) To obtain water from AWBs concerned at the head of the distributary/minor and supply the same to water users.
3) To receive the drainage affluent from water users and convey the same through field/collector drain to designated nodal points of the drainage system.
4) To collect the agreed water charges and other dues from its water users and pay the agreed consideration for the supply of irrigation water and conveyance of drainage affluent to the AWBs concerned.
5) To engage, hire and employ any consultants, advisors and employees for the performance of their functions and powers on their own prescribed terms and conditions.
6) Any other powers which may be prescribed under regulations prepared by the Authority.

The farmer's organizations will be corporate bodies but they have not been empowered to transfer or dispose of any assets given or transferred to them. The statutes also provide for appointment of Provincial Water Commissioner who will resolve disputes between the authority, the AWBs, the Farmers' organizations and the water users under a given procedure.

Comments on NDP and Draft Agreement between GOP & Donors

As a result of the NDP-I discussed above, the donor agencies including the World Bank, Asian Development Bank and the OECF desired the Government of Pakistan to undertake institution related reforms in the Water and Power Development Authority and the Provincial Irrigation Departments of the four provinces. The donors insisted that the approval of the loans for NDP-I will be subject to the initiation of the institutional reforms by the Government of Pakistan. Frequent contacts were made between the donor agencies and the Government of Pakistan and it was tentatively decided that Government of Pakistan through a statute will introduce the institutional reforms on 1st July 1996.

A draft ordinance was prepared by the GOP and sent to the donors in March 1996 for their comments, if any. The donor agencies considered that the draft statute did not reflect the understanding reached between the donor agencies and the GOP. A delegation of the Pakistan Government duly represented by the four provinces visited the World Bank at Washington and held series of discussions in April/May 1996 on draft statute for institutional reforms. Since the Pakistan delegation did not have any mandate to make changes in the earlier draft statute, it was decided that a workable draft statute be prepared through informal discussions between the

GOP, Provinces and NDP Donors. However, the donors informed the Pakistan delegation that there is substantial degree of urgency associated with enactment of this statute by July 1, 1996.

During negotiations in June 1996 it has to be decided that Government of Pakistan will issue the statute on the above date and then the bank management would present the loan request to the Board. On return of the Pakistan delegation to Pakistan a task force has been established by the Government of Pakistan to go into informally proposed statute and expedite the finalization. The PIDA Ordinance has now been issued on May 29, 1997 by the Punjab Government giving broader parameters for its establishment.

CHAPTER 3 PRESENT ENVIRONMENT OF THE STUDY AREA

3.1 Physical and Social Environment

3.1.1 Location and Topography

Pakistan is lying in the west of the Indian sub-continent with a territory of about 796,000 km^2. The province of Punjab occupies 199,000 km^2, which is equivalent to approx. 25% of the territory. The Indus basin comprises the river Indus, the eastern tributaries of Jhelum, Chenab, Ravi and Sutlej, and northern and western tributaries of Kabul, Swat, Haro and Soan. The Location Map shows the situation of the Study area.

The Study area is located between the north latitudes 30° 40' and 32° 40' and east longitudes 72° 00' and 74° 40'. It extends 240 km in north - south direction and 250 km in east - west direction. It lies in the province of Punjab in the Upper Indus plain. It is divided into doabs, or lands lying between the rivers with very flat topography with 1/3,000 to 1/3,600 and micro relief of only more or less one meter. Jhelum, Chenab and Ravi rivers have long courses in this region with extensive catchment areas.

Geographical area, gross command area (GCA) and culturable command area (CCA) of the Study area are 27,250 km^2, 24,450 km^2, and 21,160 km^2, respectively, and broken down as shown in the following table:

Irrigation System	Geographical Area (sq km)	Gross Command Area (sq km)	Culturable Command Area (sq km)
Lower Jhelum	7,190	6,630	6,140
Lower Chenab	16,160	14,970	12,360
CBDC	3,900	2,850	2,660
Total	27,250	24,450	21,160

3.1.2 Meteorology and Hydrology

Located in the north of the tropic of cancer, Pakistan possesses a great range of climate diversity, from some of the hottest in the world in Jacobadad and Sibi districts to the snowy cold parts of Balochistan and northern areas. Along the coastal belt, the climate is modified by sea breeze. Pakistan is on the margin of the monsoon climate. The rainfall is barely sufficient and thus it possesses a semi-arid climate in general.

As seen in Table 3.1.2-1, meteorology of the Study area is represented by the meteorological data recorded at three stations, Sargodha for the Lower Jhelum System, Faisalabad for the Lower Chenab System and Lahore for the CBDC System. It is understood that there is a little difference in the records among the three stations.

Annual mean temperature of the three stations varies from 23.6°C at Sargodha to 24.7 °C at Lahore. The hottest month is July and the coldest, January at any stations. Monthly mean temperature in June is 35°C and that in January is 13°C, whereas daily mean temperature widely ranges up to 14°C in winter and 15°C in summer.

There is a notable difference in rainfall pattern. For instance, records of the meteorological station at Faisalabad indicate that the average annual rainfall is as little as 318.0 mm. In contrast with this, average amount of rainfall in Lahore is more than two times, 642.0 mm. Heavy rain is expected in July and August, whilst negligible quantity, from October to June next year.

Eventually, such difference in rainfall is reflected in relative humidity. Annual mean relative humidity (at 5:00 pm) at Faisalabad station is as low as 42.0%, whilst those of Sargodha and Lahore are 56.1% and 44.4%. The highest relative humidity is recorded in August in the rainy season and the lowest, in May during the hot and dry spell.

There is no notable difference in wind velocity at the three stations. Average wind velocity ranges from 1.3 km/hr in November and December to 4.9 km/hr in July. Annual mean wind velocity is 3.2 km/hr, which is rather small. This is attributed to the fact that the monsoon climate is marginal in the this area.

Annual total sunshine hour is approximately 2,990. The longest daily sunshine hour is recorded at 9.7 - 9.8 in May whereas the shortest, at 6.3 - 6.5 in December.

Irrigation water for the Lower Jhelum System is diverted from the Jhelum river through the LJC Feeder offtake from the left bank of the Rasul Barrage with a full supply discharge of 3,700 cusecs and supplemented by the Upper Jhelum, which offtakes from the left bank of the Mangla Reservoir. The Lower Jhelum Canal combines the discharge from the said channels and conveys to the Lower Jhelum System, with a full supply discharge of 5,300 cusecs. This canal branches off to Shah Pur Branch, Northern Feeder and Southern Feeder with respective full supply discharges of 460 cusecs, 850 cusecs and 460 cusecs. The GCA. under these channels is 1.63 million acres (6,600km^2) and the CCA. is 1.50 million acres (6,050km^2) (see Table 3.2.1-2).

Annual discharge of the Jhelum river fluctuates from 11.70 MAF (14.45 B m^3) in 1985/86 to 30.65 MAF (37.85 B m^3) in 1992/93 with an average of 22.36 MAF (27.61 B m^3) at Rasul Barrage, whereas the annual offtake through the Lower Jhelum Canal ranges from 2.55 MAF (3.15 B m^3) to 3.26 MAF (4.03 B m^3) averaging 2.99 MAF (3.69 B m^3), which is equivalent to 13% of the river discharge.

Irrigation water for the Lower Chenab System is diverted from the Chenab river through Lower Chenab Canal. This canal offtakes from the left bank of Khanki Headworks with a full supply discharge of 11,530 cusecs. It branches off to Upper Jhang Branch, Upper Gugera Branch and Burala Branch with full supply discharge of 1,140 cusecs, 1,550 cusecs and 1,530 cusecs, respectively. The GCA. under these channels is 3.39 million acres (13,700km^2) and the CCA. is 2.98 million acres (12,090km^2).

Annual discharge of the Chenab river at Khanki Barrage fluctuates from 17.62 MAF (21.76 B m^3) in 1993/94 to 30.42 MAF (37.57 B m^3) in 1988/89 with an average of 22.73 MAF (28.07 B m^3), whereas the annual offtake through Lower Chenab Canal ranges between 6.77 MAF (8.36 B m^3) and 8.35 MAF (10.31 B m^3) averaging 7.51 MAF (9.29 B m^3), which is equivalent to 33% of the river discharge at Khanki Barrage.

In April 1948, India stopped the supplies in those channels of the Upper Bari Doab canal system which enter Pakistan. The channels were renamed as CBD Canal System and now linked with BRBD Link Canal with the capacity of 5,000 cusecs which originates from Marala Barrage. The CBD Canal, branching off from the BRBD has a full supply discharge of 2,600 cusecs. The GCA. under this canal is 0.80 million acres (3,240km^2) and the CCA. is 0.65 million acres (2,620km^2).

Annual discharge of the Chenab river at Marala Barrage varies from 22.97 MAF (28.37 B m^3) in 1993/94 to 32.69 MAF (40.37 B m^3) in 1988/89 with an average of 27.50 MAF (33.96 B m^3), whereas the annual diversion discharge of the CBD canal ranges from 1.27 MAF (1.57 B m^3) to 1.52 MAF (1.88 B m^3) averaging 1.45 MAF (1.79 B m^3), which is equivalent to 5% of the river discharge at Marala Barrage.

Average withdrawal of 10 years from 1985/86 to 1994/95 is estimated at 84% of the design discharge, which is equivalent to approx. 300 irrigation days per year.

3.1.3 Ground Water, Waterlogging and Salinity

3.1.3.1 Groundwater and Waterlogging

The ground water in the study area was initially formed out of seepage from rainfall, rivers or streams. In summer with the melting of the snow in the Himalayas and the regular floods, the natural streams and rivers overflowed their banks spreading water over large areas. By this process large quantities of high quality fresh water seeped into the underground aquifers. A natural balance of water and salt was maintained in this process. With the introduction of the canal irrigation system in the early 19th century and the construction of main, branch,

distributaries. and minors irrigating the agricultural fields all over the doabs, increased the seepage area. The ground water level in the study area has been gradually increasing from the time of the introduction of the canal irrigation system. By the 1960's waterlogging had become a severe problem. Fig. 3.1.3 -1 shows the ground water table contours prior to the irrigation system and the post irrigation ground water contours.

In the early 1960's, a massive effort to control waterlogging and salinity was undertaken and the planning and programming studies culminated in an 'Action Plan' covering ten years period. These studies were supplemented by later studies under the changing circumstances, and to draw up investment plans to cover various periods. To overcome the problems of the rising ground water table, salinisation and poor drainage, SCARPS programmes were implemented. In the study area 12 SCARPS programmes have been implemented or are ongoing. These are indicated in Fig. 3.1.3 -2

The introduction of the SCARPS tube wells by WAPDA brought this rising ground water table and the associated water logging problems under limited control at that time. The SMO of WAPDA records the depth of the water table in June and October of each year. The table below gives the water table condition in the study area under each command in June 1959 at the commencement of the SCARP and in June 1989 after 30 years of implementation and also the results of the JICA study team survey of June 1996. The extents of land in LJC, LCC and CBDC areas where the water table was less than 5', between 5' to 10' and greater than 10' are indicated. The extents are indicated as a percent of the total extents.

Extent of land with Watertable depths less than 5', between 5' - 10' and over 10' indicated as % of total during June (1959 - 1996)

	CBDC			LCC			LJC		
	<5'	5'-10'	>10'	<5'	5'-10'	>10'	<5'	5'-10'	>10'
June 1959*	6	16	78	6	30	64	9	66	25
June 1989*	2	7	91	2	16	82	4	35	61
June 1996**	0	11	89	1	17	82	5	43	52

* SMO/WAPDA
** JICA study survey

Fig. 3.1.3- 3 indicates the depth of ground water table in the study area in June 1996.

With the onset of the monsoon, the water table rises and by October it almost reaches the highest levels during the year. The similar water table data for October 1959, 1989 and 1995 are given below. It has been observed that during the years with heavy rainfall the extents that get affected by waterlogging, which are the lands with the water table less than 5' increases more than in a dry year.

Extent of land with Watertable depths less than 5', between 5' - 10' and over 10' indicated as % of total during October (1959 - 1989)

	CBDC			LCC			LJC		
	<5'	5'-10'	>10'	<5'	5'-10'	>10'	<5'	5'-10'	>10'
Oct 1959*	10	24	65	6	23	71	24	33	44
Oct 1989*	0	32	68	4	22	75	11	34	55
Oct 1995*	1	12	87	2	20	78	10	29	61

* SMO/WAPDA

The above data indicates that the worst affected area by waterlogging was the Lower Jhelum Canal Circle with nearly 24% of its extent with the water table within the hazardous zone of less than 5' in October 1959. The position has improved by October 1995 to a reduction of 10% of the land getting waterlogged. This yet remains at too high a level to be considered as having solved the problem of waterlogging. The other very badly affected area which was CBDC has presently got a much reduced problem. In October the problem is very minor though there are in a few areas localized problems which are mainly due to flooding and poor surface drainage. In general in the CBDC area it appears as if the water table is getting too lowered. Fig. 3.1.3- 4 indicates the ground water table depths during October 1995 in the study area.

From the above it is seen that the ground water table has improved in the danger zone of less than 5' in almost all the areas during the last 36 year period. Although the rising ground water table and the associated water logging problem has reduced from the very severe conditions of the early 1960's, it is yet a very major problem and require to be further improved with the changing circumstances. The eighth five year plan of the Government of Pakistan has one of its major objectives for the physical infrastructure, as the elimination of water logging in the 1.40 million hectares of the disaster areas. During this Plan period it is proposed to complete the Left Bank Outfall Drain and to commence work on the Right Bank Outfall Drain under the National Drainage Programme. It is thus seen that the improvement of the waterlogging problem is of the highest priority in Government Policy.

The decrease in the ground water table has been due mainly to the operation of the SCARP tube wells and has been later on assisted by the installation and operation of farmer's tube wells in the fresh water zones. There are presently about 400,000 farmers tube wells in Punjab. The tube wells in the study area is estimated at about 75,000. The large number of private tube wells by the farmers have contributed to increased agricultural production while indirectly lowering the ground water table by extracting water for irrigation from the fresh water zones. The private tube wells extraction of irrigation water is limited mainly to the fresh water zone.

However there is a limit for the installation of such tube wells which depend on the availability of fresh ground water in the underground aquifer.

3.1.3.2 Salinity

(1) Groundwater quality

The groundwater in the project area consist of both fresh as well as saline water. The Salinity Monitoring Organization (SMO) of WAPDA carries out water quality tests under the various SCARPS programmes of the tube well water on a regular basis. The various agencies involved in carrying out different aspects in the irrigation system adopt slightly varying criteria for the water quality standards. For the purpose of this Study, it is assumed that the area of concern, as to where the groundwater has Total Dissolved Solids (TDS) greater than 1000 ppm.

The present study carried out water quality tests of the study area by sampling at 700 locations based on a grid drawn on topo sheets at 6x6 kilometers. The extent of saline and non saline water areas were determined on the basis of fresh water areas being those areas where the ground water has less than 1000 ppm of TDS. On this basis LJC, LCC and CBDC had 60%, 59.8% and 48.5% of fresh water areas. The details of the fresh and saline water areas are given in the table below.

Canal Command	Area	Fresh water area TDS < 1000 ppm	Saline water area TDS > 1000 ppm
LJC	7189	60.2 %	39.8 %
LCC	16157	59.8 %	40.2 %
CBDC	3901	48.5 %	51.5 %
TOTAL	27247	58.3%	41.7 %

The extent where the saline groundwater has different qualities between 1000 - 1500 ppm, between 1500 - 3000 ppm and greater than 3000 ppm was found to be as follows. These are given as a percentage of the total extent in each of the canal commands of LJC, LCC and CBDC

Canal Command	Total saline area TDS> 1000 ppm	TDS 1000 - 1500 ppm	TDS 1500 - 3000 ppm	TDS > 3000 ppm
LJC	39.8 %	24.0 %	11.7 %	4.0 %
LCC	40.2 %	19.4 %	16.1 %	4.6 %
CBDC	51.5 %	22.3 %	24.0 %	5.2 %
TOTAL	41.7 %	21.0%	16.1%	4.6 %

Fig. 3.1.3 -3 indicates the salinity in the area during the study period of May - June 1996.

Water quality survey carried out by the study team classified samples taken according to USDA Handbook # 60, which uses Electrical Conductivity (EC) and Sodium Adsorption Ratio

(SAR)* as the two important parameters. This gave the percent area of LJC, LCC and CBDC having different water quality in the major categories as follows.

Class	% LJC	% LCC	% CBDC	Remarks
C1 - S1	5			Low salinity and low sodium level could be used for irrigating almost in all soils with little likelihood of developing salinity.
C2 - S1	19	16	14	Groundwater of this class contains medium concentration of salts and can be used for irrigation without the need of any special measures.
C3 - S1	31	36	19	Ground water contains high salt contents and cannot be used in soil with limited drainage. Even with adequate drainage system, special management for salinity control may be required and plants with good salts tolerance have to be adopted in these areas.
C3 - S2	22	19	18	The water samples belonging to this class contains medium level of Sodium. These waters when used for irrigation can create Sodium hazard and as such should be used with precaution.
C3 - S3		6	8	High salinity water and high sodium contents may produce harmful levels of exchangeable sodium in most soils. Will require good drainage and high leaching. Not to be used on soil with inadequate drainage.
C4 - S3		5		Very high salinity and may produce harmful levels of exchangeable sodium in most soils and would require special management, good drainage and high leaching
C4 - S4	13	12	30	Groundwater of this class contains very high salinity as well as very high sodium and is totally unfit for agricultural purposes.

The ground water quality in the Study area which was determined by sampling 700 locations on a grid of 6km x 6 km and averaged for each parameter in the three canal systems is given below.

* Sodium Absorption Ratio (SAR) is defined as
$SAR = [Na^{+}] / [Ca^{++} + Mg^{++}]^{1/2}$ (ion concentrations are expressed in millimoles per liter)

Parameter	LJC	LCC	CBDC
pH	7.7	7.9	8.0
EC (microsiemens/cm)	1854	1722	2390
Ca + Mg (meq/l)	6.2	5.5	5.0
Na (meq/l)	13.8	12.8	20.4
K (meq/l)	0.3	0.4	0.6
CO_3 (meq/l)	2.1	0.9	1.2
HCO_3 (meq/l)	5.9	6.2	6.8
Cl (meq/l)	11.4	9.7	12.2
SO_4 (meq/l)	2.9	2.7	6.8
NO_3 (meq/l)	0.3	0.3	0.2
RSC	2.2	2.3	4.2
SAR	7.0	7.6	13.0
TDS (ppm)	1187	1102	1530

The water quality survey results indicated the following behavior of HCO_3, Cl and SO_4 anions with electrical conductivity. Bicarbonate anions in the fresh water have been found to be higher even up to 85%, but shows sharp decline trend with increasing salinity up to EC value of 5,000 microsiemens/cm. Thereafter a reduction in HCO_3 becomes gradual and almost asymptotic to a value of 10%, with further increase in the ground water salt content. The pattern of anionic variations in all three canal systems is more or less similar. Chloride concentration in the groundwater is quite reverse to their HCO_3 anions. These are low, about 6%, in the fresh groundwater, show a rapid increase up to EC of 5,000 microsiemens/cm and then to a level of about 40% with further increase in the groundwater salts. Sulphate concentration is low in the areas of good quality waters. It increases to a peak against an EC of 1,500 microsiemens/cm and then drops rather rapidly to a constant level of about 4 to 6% in highly mineralized groundwater. The initial increase in the SO_4 concentration appears to be due to the application of gypsum by the farmers in the areas of poor quality groundwater.

In the Lower Jhelum Canal Circle, the ground water quality survey indicated the location of highly concentrated brackish water mostly in the central, north south axis of the project area. A few pockets of saline groundwater also exist along the left bank of Jhelum river on its western boundary. Groundwater having TDS less than 1000 ppm covers 60.2% of the area whereas the groundwater containing TDS in the range of 1000-1500 ppm constitutes 24% of the total area. The remaining 15.8% is occupied by highly mineralized water in scattered patches specially in the center of canal system along north east to south west direction.

Sodium Adsorption Ratio of the groundwater in LJC varies from 2 to 67. Sodium Adsorption Ratio of water less than 15 makes up 89 % of the area. As such majority of the samples have SAR well within the permissible range. Only 11 % of the area has high SAR and is confined to those areas which are occupied by highly mineralized groundwater.

The water quality survey also indicated that the groundwater of low salinity and low sodacity mostly covers south eastern portion of the LJC area along the right bank of Chenab river. The groundwater within the main central body and along the right bank of Lower Jhelum Canal is well mixed from low salinity to high salinity and low Sodium to high Sodium waters. The groundwater at the deeper depth in the upper half portion of the project area and along the western part is very saline. The deep percolation and recharge from the irrigation fields, supplied with canal irrigation water have improved the quality of shallow groundwater. The area where the deep percolation losses are high, groundwater has shown marked improvement and where the percolation is of low order, the salinity/sodacity of groundwater is comparatively much higher.

In the Lower Chenab Canal Circle the extent with groundwater having TDS less than 1000 ppm covers 59.8% of the area whereas the groundwater containing TDS in the range of 1000-1500 ppm constitutes 19.4.% while 20.7% has TDS level higher than 1500. Examination of the water quality test data reveals that highly mineralized groundwater with nearly 6400 ppm TDS exists along the central line from north east corner to south west tip of the project area. A wide strip of groundwater along the left bank of Chenab river and right bank of Ravi river contains comparatively less salts and is acceptable for irrigation with or without mixing. Highly concentrated saline groundwater occupies central zone of the project. Groundwater along the main canals, rivers and in southern tip extending up to the confluence of Chenab and Ravi rivers is quite fresh and fit for irrigation.

SAR indicates the same trend as that of groundwater quality. In fact, higher the concentration of the salts in the groundwater, higher is the sodium contents and hence the SAR.

In the Central Bari Doab the water quality survey indicated the existence of mineralized water near Pattoki town in the south western zone of the project area. This pocket appears to have been extended downward up to BS. Link Canal and towards upward in north eastern direction along the Central Bari Doab Canal. The groundwater close to the main canal has considerably improved as a result of seepage.

Another pocket of mineralized groundwater exists below Kasur towards southern direction. A comparison of SAR of the former pocket located within the southern tip of the project area with that of south eastern corner, reveals a wide difference. This is explained from the fact that inherent or natural mineralized groundwater always contains high sodium contents as compared to calcium & magnesium. As such the natural groundwater posses high SAR. The SAR of the mineralized groundwater occupying the south eastern portion of the project area is much lower as compared to the SAR of the mineralized groundwater in the south western tip of the project area. This reflects that mineralized groundwater of south eastern portion is of different origin.

The evident source of this pollution is the huge amount of contaminated water having disposed off from a large number of tanneries established in the Kasur area. The water quality in a large strip of land between river Ravi and CBDC, excluding southern portion is excellent to good and fit for agriculture.

The water quality survey revealed that about 48.5% of the total area is occupied by groundwater having TDS less than 1000 PPM ,whereas 22.3% has a groundwater quality varying from 1000 to 1500 PPM. The balanced 29.2% of gross area contains highly mineralized water, having TDS above 1500 PPM.

About 32.9% of the water samples collected from the area are of low sodium contents, of course the salinity varies up to 2250 microsiemens/cm. Groundwater of this class can be used for irrigation without any arrangement of special techniques usually employed for saline water utilization.

Around 38.3% of samples belong to highly saline and high sodium classes. Use of these waters may provide harmful levels of exchangeable sodium in most of the soils . As such special soil management, good drainage, high leaching and other measures are needed to maintain appropriate level of physical as well as chemical status of soils.

(2) Surface Water quality

The quality of the canal water was found to be of excellent quality for irrigation. The TDS of canal water varied between 90 ppm to 202 ppm. The sodium adsorption ratio (SAR) of all samples were less than 1. These being categorized as low salinity low sodacity (C1-S1) class water. River water also is of excellent quality for irrigation. However the suspended solids in the river water and canal water is very high varying between 1214 ppm to 3041 ppm in LCC and 373 to 1465 ppm in LJC. During the rainy seasons these values increase many fold. Though the surface water quality is chemically suitable for irrigation and human use, they are unfit for human consumption due to the very high bacteriological contamination.

Drainage effluent was also of poor quality with extremely high electrical conductivity and high SAR. These waters are of the high saline - high sodic class C4-S4.

3.1.4 Salinity and Waterlogging in the Farm Land

The soils in the Study area are composed of the alluvium carried by the Chenab, Jhelum, Ravi Bias and Sutlej rivers from the Himalayan ranges. The soils are young and pronounced development of soil profile structure is not yet visible. The process of sediment deposition and erosion is still continuing. The area is predominantly medium textured silt loam and loamy

soils which have excellent drainage characteristics and very productive for major and minor crops and orchards. The textural classification of the soils in the area ranges sandy clay loam and clay loams which also has good physical properties and are fertile. The pH of the soil in this area varies between 7.2 and 9.0.

The farm land of Irrigated soils in Pakistan suffer from problems of soil salinity, sodicity or both. These soils are agriculturally problem soils which require special remedial measures and management practices.

The soil survey carried out by the study obtained the following status of the soil in the project area as regarding its condition of Salinity and Sodacity. The Table below indicates the percentage area in each of the areas of Lower Jhelum, Lower Chenab and Central Bari Doab areas falling into these classes.

Soil classification of LJC, LCC and CBDC given as a percentage of total extent.

Soil Classification		LJC	LCC	CBDC
1. Non saline - Non sodic	(NS-NS)	27%	42%	62%
2. Non saline - Sodic soils	(NS-S)	5%	24%	19%
3. Saline - Non sodic	(S-NS)		8%	19%
4. Saline - Sodic	(S-S)	68%	26%	
TOTAL		100%	100%	100%

According to the results of soil survey showing status of soil salinity at the surface, carried out by the Directorate of Land Reclamation, PID out of 2,400 thousand ha surveyed in the Study area, approximately 13 % were found to show salinity and 0.3 % were found to be water logged. The yield data of crops grown in these saline area are not available. These extents are for each Engineer's division of the three canal command areas. Sargodha Division has 27% of its land affected by salinisation while Lower Gojra has 23%, Kirana and Khanki divisions have 17% of their lands and Burala 15%, Hafizabad 14%, Rasool 13%, and Faisalabad 10%. Lahore and Shahpur has the lowest rates of soil deterioration with 3% and 2% respectively. The overall picture within the study area show that in almost all the divisions barring Shahpur and Lahore the condition of its soil to be very poor and with a tendency to degrade. In order to improve such soils, leaching of excessive salinity with water or water and gypsum is the technique of general applicability.

3.1.5 Administrative Division and Population

(1) Administrative Division

In Punjab province, there are one Metropolitan Corporation in Lahore, 7 Municipal Corporation, 73 Municipal Committees, 137 Town Committees and 2,481 Union Councils as

of July 1994. The Study Areas comprise 9 districts in total. The Lower Jhelum Canal System extends over Sargodha and a part of Jhang district. The Lower Chenab Canal System comprises 6 districts, namely Faislabad, Toba Tek Singh and a part of Jhang, Sheikhupura, Hafizabad and Gujranwala. The Central Bari Doab Canal System (CBDC.) are located in Lahore district and a part of Kasur district.

(2) Population

Since Population Census survey has not been conducted after 1981 Census, the data on the present situation of population are not available. The population in 1996 is estimated based on the trend during 1972 to 1981. According to this estimation, the total population of the three study areas is about 21.1 million persons, which accounts for 28.7% of the total population in Punjab province. Of this amount, about 52% or 11.0 million people lives in urban area and 48% or 10.1 million live in rural area. The annual population growth rate in urban area is higher than that in rural area, which indicates migration from rural to urban area.The estimated population for 1996 for each area is summarized below.

('000'persons)

		Total	Urban	Rural
Lower Jhelum	Population	3,241	1,020	2,221
	Growth Rate*	2.35%	3.67%	1.93%
Lower Chenab	Population	10,380	4,444	5,935
	Growth Rate	1.70%	4.29%	0.78%
Central Bari Doab	Population	7,496	5,512	1,984
	Growth Rate	3.42%	3.52%	3.15%
Total	Population	21,117	10,917	10,140
	Growth Rate	2.31%	3.81%	1.33%

*: Growth rate is calculated for the period of 1972-1981.
Source: Bureau of Statistics of Punjab, 1995

The number of households in 1981 census was 2.1 million for three study areas and the average household size was 6.6 persons. Most populated area among three study areas was CBDC. area where the estimated population density including urban area was 1,922 person/km^2. On the other hand, those in LCC and LJC are 616 and 451 persons/km^2 respectively.

According to the farm survey conducted by JICA Study Team, literacy rate is 45% for overall in the project areas. Among illiterate people, more than half of them are from small and marginal farm family, which implies that farmers will have better opportunity for education as the farm size become larger. The literacy rate for female is about 25.5% which is much lower than the rate of 61.0% for male. This fact implies that female have less opportunity for education.

3.1.6 Land Holding and Tenure

The tenure classification of farm and farm area obtained through the Census of Agriculture 1990 is summarized as below.

Size of Farm	The Punjab		Districts*1 in The Project Area	
(acre)	Number of Farmers	Farm Area (acre)	Number of Farmers	Farm Area (acre)
under 1.0	202,703	96,588	29,012	14,886
1.0 to under 2.5	545,984	868,656	130,815	211,614
2.5 to under 5.0	593,996	2,043,855	165,840	576,537
5.0 to under 7.5	499,571	2,919,017	153,662	903,148
7.5 to under 12.5	507,345	4,868,247	163,064	1,575,633
12.5 to under 25.0	405,502	6,504,344	100,128	1,628,666
25.0 to under 50.0	147,158	4,558,882	34,471	1,065,509
50.0 to under 150.0	48,4243	3,400,890	11,400	794,724
150.0 and above	6,699	1,846,871	1,319	326,158

Size of Farm	The Punjab		Districts*1 in The Project Area	
(acre)	% of Farmers	Farm Area (%)	% of Farmers	Farm Area (%)
under 1.0	6.9	0.4	3.7	0.2
1.0 to under 2.5	18.5	3.2	16.6	3.0
2.5 to under 5.0	20.1	7.5	21.0	8.1
5.0 to under 7.5	16.9	10.8	19.5	12.7
7.5 to under 12.5	17.2	18.0	20.6	22.2
12.5 to under 25.0	13.7	24.0	12.7	22.9
25.0 to under 50.0	5.0	16.8	4.4	15.0
50.0 to under 150.0	1.6	12.5	1.4	11.2
150.0 and above	0.2	6.8	0.2	4.6

Source: Census of Agriculture 1990, Punjab Province Report
*1: Lahore, Kasur, Gujranwala, Sheikhupura, Faisalabad, T. T. Singh, Jhang, Sargoda

From the point of view of agricultural economy, land ownership was organized into four categories, namely marginal (up to 6.25 acres), small (6.25-12.5), medium (12.5-25.0) and large (above 25.0). Based on the data of the Census of Agriculture 1990, approximately 789,711 sample farmers live in and around the Study area and more than 81 % of them cultivate less than 12.5 acres, while their share of agricultural land is limited to 46.2 % of the total. It suggests that the majority of farmers are categorized into the marginal or small scale. The average holding size of agricultural land in and around the Study area is about 9.0 acres.

3.1.7 Health and Sanitation

The health and sanitation conditions in the project area are very poor. A sample survey carried out in the study area revealed that over 50% of the population were affected by frequent illnesses. This survey indicated that during the previous year, 83% of the families were affected by flu or fever while 51% by malaria 47% with dysentery and 15% by typhoid as the

main causes of illnesses. Although there are the basic infrastructure facilities provided, the treatment sought at government hospitals, dispensaries, basic health units and rural health centers was only 27% of those surveyed. The majority preferred private treatment or some other treatment at home, by Hakim or by Pir/Fakir. 78% of those surveyed indicated that the health facilities were inadequate with absence of treatment center/doctor, lack of medical supplies and expensive medicines as the major problems.

An analysis of the data obtained from the Punjab Health Department on the number of cases that were treated in the project area at Government health institutions for the major water related diseases are given below on a district basis for the year 1995.

District	Population	Diarrhoea	Dysentry	Malaria	Typhoid
Lahore	5,835,000	149,202	90,313	46,253	18,199
Kasur	2,302,000	10,428	8,569	118	
Faisalabad	4,307,000	113,941	64,100	16,634	14,286
TT Singh	1,191,000	27,508	16,660	761	1,348
Jhang	3,011,000	69,259	34,301	11,056	3,907
Sargodha	2,628,000	52,871	34,897	979	6,022
Total	19,274,000	450,908	264,208	80,891	43,672

Source: Health Department

The above number of cases has to be considered in relation to the population in each district. On this basis the incidence of each of the diseases (population per reported case) is given below.

District	Diarrhoea	Dysentery	Malaria	Typhoid
Lahore	39	64	126	320
Kasur	220	268	19508	
Faisalabad	38	68	258	301
TT Singh	43	71	1,565	883
Jhang	43	88	272	770
Sargoda	49	75	2,684	436
Average	42	72	238	441

This indicates a substantially high incidence of water related diseases in the project area. Overall the incidence of water related diseases are high when one considers the fact that the above data is reflected from the estimated 27% who visit the hospitals for treatment. The high incidence of these diseases could be indicative of poor quality drinking water, lack of sanitation facilities and poor preventive services in the project area. Of the households surveyed 72% in LJC, 37% in LCC and 38% in CBDC had toilets in them. Overall 23% had sewerage systems.

The incidence of certain water related diseases could be connected to the quality of drinking water consumed and sanitation standards. Results obtained from the drinking water quality tests that were carried out on 30 samples which were taken by the study team indicated that 24 (80 %) of them were bacteriological contaminated and not suitable for human consumption.

The details of the results are given in Table 5.5.1- 3. In addition the quality of most of the drinking water does not conform to the requirements of the chemical parameters with almost half the samples having a TDS level above the WHO's maximum permissible level. It is generally felt that the people have developed a certain amount of immunity to some of the diseases.

3.2 Agriculture

3.2.1 General

Farm household survey was carried out during the Phase I Study in order to grasp the present condition of agriculture in the Study area. Additional data were collected mainly from Agricultural Department of Punjab and related other organizations.

The Punjab province has a total area of 20.63 million ha of which about 12.1 million ha (59 %) is cultivated and about 10.7 million ha (88.5 % of cultivated area) is irrigated by canals and tubewells, whereas the remaining 11.5 % is rainfed land. The total irrigated area in the Punjab province is accounts for about 75% of the total irrigated area of Pakistan (17 million ha). The Gross Command Area (GCA) in the Study area is estimated at 2.4 million ha and Present Cultivable Command Area (CCA) is estimated at about 2.1 million ha or 87 % of GCA.

Agro Ecological Zones (AEZs) are defined using criteria such as soils, climate, land-use, altitude, water supply, dominant crops, social infrastructure and so on. The Punjab province is divided into four (4) AEZs, namely Rice zone, Central mixed zone, Cotton zone and Barani (Rainfed) zone. The greater part of the study area is located in the Central mixed zone.

There are two seasons for cropping, namely, Kharif in summer (April -September) and Rabi in winter (October - March). Wheat is the main subsistence crop and the major Rabi crop. Rabi fodder is planted widely , too. The major Kharif crops vary depending on the natural and social conditions. The main Kharif crops are the cash crops like cotton, rice, maize, sugarcane and fodder.

3.2.2 Land Use and Cropping Pattern

The table below provides the CCA and cultivated area in the Study area.

Canal System	CCA (ha)	cultivated area (ha)	Cropping Intensity (%)
LJC	662,958	752,107	122.4
LCC	1,497,408	1,630,709	131.9
CBDC	265,628	327,734	123.4
Total	2,116,154	2,710,550	128.1

The cultivable command area is estimated at about 2,116,000 ha. The total area cropped is 2,711,000 ha, of which 595,000 ha is double cropped in the Study area. The annual crop intensity is estimated at about 128 %; 68 % in Kharif and 62 % in Rabi, respectively. (See Table 3.2.2-1) Put another way, more than 30 % of CCA are left uncultivated through the both seasons. Insufficient water supply is the main reason for uncultivated areas. The cultivable wastelands are due mainly to waterlogging and severe salinity.

Agriculture in the area depends on irrigation. The total irrigated area in the districts which cover the Study area 6.4 million acre or 97 % of the total cultivated area. The canal irrigation system was built to accommodate a cropping intensity 66 %, about half of the current cropping intensity. The table shows that the 1.8 million acre or 28 % of total irrigable land depends on the only canal for irrigation water. It suggests that the tubewells play an important role in irrigation farming in the area. The mode of irrigation differs with regions. (See Table 3.2.2-2)

In the study area, wheat is for self-consumption and forms a prominent part of the cropping pattern in the Rabi season. Fodder is also a pre-dominant crop in Rabi.. The proportion of other crops like oil-seeds, and vegetables is exceedingly low. The proportion of sugarcane in both Rabi and Kharif is low in the Study area. In Kharif, paddy, cotton, and maize are grown in the similar proportion. However, fodder is the main Kharif crop. Other than major crops, rapeseed, grams, vegetables are grown to a small extent. It is apparent that the cropping intensity of fruit crops (citrus) of LJC is relatively higher than LCC and CBDC.

3.2.3 Farming Practice and Agricultural Production

(1) Farming Practices

Agriculture in the area depends on irrigation. Four-wheel tractors are now the dominant source of farming power for land preparation and seeding in the Study area. The diffusion of the improved seed remains at insufficient level. Almost all farmers apply fertilizer, but the dosage of fertilizers remains at insufficient level mainly due to the poor economy. Little or no use is made of herbicides. Weeds are important as fodder. Harvesting is carried out by manpower except wheat.

Constraints of major crops (wheat, rice, sugarcane and cotton) are as follows;

Wheat: Critical turn-around times with rice and cotton (wheat planting delayed)

Rice:	Low plant population of rice
Cotton:	spreading CLCV
Sugarcane:	lack of water management technique during the critical stage

(2) Crop Yield and Production

The average unit yield and annual production of major crops in and around the Study area are summarized below:

Crops Year	Area (1,000ha)	Production (1,000ton)	Yield (ton/ha)
Wheat (Irrigable)	1,681	3,589	2.13
Paddy (Basmati)	557	618	1.11
Cotton*1	205	566	2.76
Sugarcane (Irrigable)	338	13,693	40.53
Maize (Irrigable)	153	220	1.43

Source: Crop Reporting
the Study area: Lahore, Kasur, Gujranwala, Sheikhupura, Faisalabad, T. T. Singh, Jhang, Sargoda
*1: Unit bales

Wheat is the main staple food crop in Pakistan. Punjab produces about 73 % of national production. Rice is the second most important food cereal and export commodity. Punjab is the leading rice growing province with about 59 % of cropped area and 44 % of total production. In Punjab, peak of cotton production was obtained in 1991, with about 11.4 million bales. However, Cotton Leaf Curl Virus (CLCV) infestation increased from nil in 1989 to 0.62, 5.43 and 9.97% of the area grown in 1991, 1992 and 1993, respectively. As a result of the CLCV infestations in 1992, the areas sown to cotton were decreased in 1993 and 1994. Sugarcane is one of the most important cash crop of Pakistan. Punjab with about 521,000 ha under sugarcane shares approximately 60 % of national cane acreage and about 53 % of total production.

Unit yields of major crops have not reached satisfactory levels. The reasons are the shortage of irrigation water, insufficient fertilizer application, late sowing, saline soil and water, shortage of capital and credit etc. The farm survey showed the similar results; 94 per cent of farmers reported the shortage of irrigation water as the major cause for low productivity, followed by salinity.

3.2.4 Animal Husbandry

Farmers in and around the Study area, especially marginal and small farmers engage themselves in the livestock farming which is profitable. Landless farmers have greater

proportions of goats and sheep raised by free grazing, while owner farmers and tenant farmers have buffaloes and cattle.

Rabi fodder sources are berseem, lucerne, weeds from wheat and other crop fields, and sugarcane tops. In Kharif, maize, sorghum, and again weeds are the main sources. The main periods of fodder scarcity are May/June and December/January, before the Kharif and Rabi fodder crops mature sufficiently to cut.

The maintenance feed requirements of 44.4 million animal units are 51.6 million tonnes of Total Digestible Nutrients (TDN) and 4.2 million tonnes of Digestible Protein (DP). The total available TDN and DP from fodder and other resources stands at 38.0 million tonnes and 2.5 million tonnes respectively. The net shortfall even in maintenance requirements comes 26.4 % in TDN and 40.5 % in DP. It clearly indicates that the animal wealth in the Study area on the whole remains underfed which results in poor performance.

3.2.5 Agricultural Supporting Services

(1) Agricultural Research

The Punjab province has a considerable reputation for agricultural research. There are 50 research institutes and stations with 63 substations and 89 farms totalling about 5,000 ha of land under the four Secretaries involved in agricultural research. Ayub Agricultural Research Institute (AARI), Faisalabad has over 30 institutes and sections being managed by one Director General of Research. Now half the institutes are scattered over the other parts of the Province.

(2) Agricultural Extension

Agricultural Extension System operates independently in the Punjab province. This has a hierarchy from the Director General Agriculture (Extension and Agricultural Research) to Field Assistant. The province is divided into Regions, Districts, Tehsil Markiz and Union Councils. Each Union Council has one Field Assistant (FA) and two Beldars to do the job of extension under the guidance and supervision of Agricultural Officers (AO) who operate in each district under the supervision of district officers of Agricultural Department.

In the early 1980's the Training and Visit (T&V) system promoted by the World Bank, was introduced in few selected districts. The programme has yielded significant results through intensive motivation of the farmers with field demonstration on the benefits of improved technology. On the basis of the success achieved, this system was extended to all districts of the province from 1987-88.

There is the gap between the farmers' opinion and the extension activity. The respondents of Farm Survey indicate that the lack of agricultural extension services was also a cause of low productivity. The 67 % of the respondents understand that the second biggest constraint they faced in farm management was the lack of agricultural extension services. On the other side, the staff of Extra Assistant Director offices enumerates shortage of budget, lack of mobility of extension workers, and the high illiteracy rate of farmers as the problems faced by extension services

(3) Seed Supply

There is no doubt that the seed is the basic and vital input which plays an important role in the increase of agricultural production. The Punjab Seed Corporation (PSC) established in 1976 is an autonomous public corporation under the Department of Agriculture. Its primary objective at inception was to enhance the province's facilities for production, multiplication, procurement, processing, storage and marketing of certified seeds.

It is an established fact that with the use of quality/certified seed, the yield can be increased by about 20 %. This can be made possible if availability of quality seed required to be replaced every year is ensured by 20 % in case of rice, maize, 33 % in case of wheat and 100 % in case of cotton. The Punjab Seed Corporation has now started an aggressive policy to increase sale and has made arrangements to increase production by at least 50 % of the requirement of seed to be replaced annually.

(4) Rural Credit

The source of institutional credit are the Agricultural Development Bank of Pakistan (ADBP), Commercial Banks and Cooperative Societies. On the other hand, farmers rely on merchants, friends and relatives as the non-institutional sources.

According to the result of farm survey shows that friends and relatives are the most common source of credit. Among the respondents, 42% of farmers rely on friends and relatives. Next common source is the ADBP which shares 41%. Although institutional credit is theoretically available, small and medium size farmers still rely on non-institutional credit rather than institutional one. In the case of marginal farmers, 68% are relying on non-institutional credit. The procedure for obtaining institutional credit is complicated, involves a great deal of bureaucracy and takes long time to realize, while the demand of smaller farmers for credit is rather seasonal or urgent. In addition to the problems mentioned above, following three points are also considered as the constraints of the institutional credit.

(i) Acute shortage of funds for institutional credit ,

(ii) Cooperative credit is not effectively utilized because of monopolization, and

(iii) Recovery rate is low especially for influential farmers .

(5) Marketing Support

Major agencies which support market and price of agricultural outputs are the Food Department of provincial government and Pakistan Agricultural Storage and Service Corporation (PASSCO). The major purposes of these agencies are to purchase of produce at the governmental fixed rate, to store and to release to the market. Thorough this procedure, these agencies controls market indirectly. The amount of wheat dealt by these two agencies during 1989 to 1993 shares about 20 to 30 % of total production in Punjab Province.

As to input supply, Punjab Seed Corporation (PSC) produces and markets certified seeds of major crops, and Punjab Agricultural Development and Supplies Corporation (PAD & SC) deals with imported fertilizers. For the marketing of agro-chemicals, the role of the private sector become more significant and important recently.

(6) Cooperative

There were 46,550 cooperative societies in the Punjab province during 1992/93. Of 46,550 societies, about 90% are agricultural societies and 10 % are non-agricultural societies. The major societies are the agricultural credit type, which accounts for 73 % of total societies. In 9 districts of the study area, there are 16,421 cooperative societies. Considering the fact that number of villages is 6,626 in 9 districts, it can be said that there are more than 1 cooperative in one village. This may be attributed to the various type of social stratification among villagers such as religion, political party and caste system.

According to the farm survey conducted during the Phase-I study, about 99% of respondents do not belong to any cooperatives. The participation of villagers in cooperative activities are still low irrespective to the number of registered cooperatives. The reason for this can be confined into following 4 points.

1) Monopolization of cooperative by influential individuals
2) Lack of education opportunity for cooperative leaders and members.
3) Lack of saving function of cooperatives and, as a result, their dependency on out sources for their budget .
4) Social stratification among villagers caused by religion, politics, caste system, etc.

3.2.6 Farm Economy

According to the data collected by the farm survey, the typical farm budgets for the study areas on different farm size are prepared as follows.

(Rs)

	Marginal	Small	Medium	Large
LJC				
Farm Size (ha)	(1.56)	(3.49)	(6.36)	(16.45)
1. Income	51,900	73,200	119,900	325,100
Farm Income*	33,200	50,600	100,700	218,500
Off-Farm Income	18,700	22,700	19,200	106,600
2. Expenditure	54,600	79,200	88,600	201,600
3. Net Reserve	-2,700	-6,000	31,300	123,500
LCC				
Farm Size (ha)	(1.52)	(3.70)	(6.82)	(13.99)
1. Income	98,700	115,900	155,300	298,000
Farm Income*	30,700	80,500	130,000	255,800
Off-Farm Income	68,000	35,400	25,300	42,300
2. Expenditure	101,700	97,000	122,400	179,600
3. Net Reserve	-3,000	18,900	32,900	118,400
CBDC				
Farm Size (ha)	(1.48)	(3.47)	(6.36)	(16.01)
1. Income	56,000	98,200	204,200	290,300
Farm Income*	21,000	66,600	157,900	258,300
Off-Farm Income	35,000	31,700	46,300	32,000
2. Expenditure	43,700	60,400	78,900	157,500
3. Net Reserve	12,300	37,800	125,300	132,800

*: Farm income after deduction of production cost.

From the above table, the characteristics of farm budget for each farm type can be summarized below.

(i) The dependence on non-farm income becomes higher as farm size become smaller except the case of large farmers. For the marginal and small scale farmers, farm income itself cannot cover their living expenditure. Accordingly, non-farm activity become more important as the supplemental income source.

(ii) As the farm size become smaller, farm income become less. It is significant for marginal farmers and they do not have funds for the improvement of their living standard or farming system.

(iii) Contribution of non-farm income is relatively high in LJC and LCC areas. The reason for this fact is the industrial zone or large scale urban area which are locating in LCC and LJC area.

The typical crop budgets for major crops are estimated as follows based on the data collected by the farm survey and data from PERI and University of Agriculture, Faisalabad.

(Rs/ha)

Crop	Gross Income	Production Cost	Profit Margin
Sugarcane	25,300	11,800	13,400
Cotton	26,800	9,700	17,100
Rice (Basmati)	7,000	5,500	1,500
Vegetable	49,800	13,600	36,200
Maize	9,400	7,300	2,100
Fodder	10,800	8,000	2,800
Mung bean	6,600	2,100	4,600
Wheat	11,500	7,100	4,500
Fodder (Berseem)	17,500	10,400	7,100
Oil Seeds	16,400	3,600	12,800
Citrus	42,800	7,800	34,900

Vegetable is most profitable crop and its net return per ha is about Rs.36,200. Next to the vegetable, citrus, sugarcane and cotton show high profitability. Oil seeds and Mungbeans show low production costs since farmer do not care its production so much.

3.2.7 Marketing and Prices

(1) Present Marketing Flows and Marketing Channels

The major sale destination of farm outputs at village level are village retailers, village merchants (Beopari), and governmental procurement center. Cereals and pulses are produced mainly for home consumption and surplus will be sold to merchants or markets in the villages. In case of large scale farmers, they sell their products to procurement center besides the local markets. Sugarcane is transported directly to sugar mill factory after the harvest by farmers themselves or transporters hired by the factories. Farmers refine sugar called Gur by themselves and use for home consumption or sell at village markets. In case of citrus, which is common crop in LJC area, most of farmers make contract with merchants or private agency on the pre-harvest bases for selling their products. Citrus is mostly sold to the merchants or agencies by acre-bases under the contract. Seed cotton is sold to the ginning factory by either farmers themselves or through the hands of merchants.

According to the farm survey, about 39% of respondents sell their commodities within villages, 22% are selling at local market and 18% sell to merchants. The farmers who sell their products to governmental procurement center account less than 1% among respondents. As to rice and maize, about half of production are sold within villages and almost all of production of fodder, gram/pulses, oil seeds and vegetables are also sold in the villages. 86% of orchard and 33% of cotton are sold to merchants. In case of sugarcane, about 82% are brought directly to sugar millers.

Regarding to input supply, most farmers rely on open markets at local level. 97% of farmers rely on open markets for the purchase of fertilizer. For the purchase of fertilizer, farmers go to local market nearby and purchase. In many cases, however, farmers have to face higher price than fixed rate. Moreover, farmers claim that contents of fertilizers are less than indicated amount or mixed with gypsum in some cases. In the case of seeds, 45% of farmers are obtaining from their own products besides from open markets. Farmers do not utilize cooperatives as input supplier and only 1% of them utilize for purchasing fertilizer and seeds.

(2) Price

Average wholesale prices of major crops at three districts are summarized below for the period during January, 1995 to May, 1996. The price fluctuations for wheat and maize are relatively small throughout the period. According to the market survey, transaction costs of agricultural commodities are estimated about Rs.0.42/kg for cereals and pulses, Rs.0.48/kg for vegetables, Rs.0.85/kg for orchard and Rs.0.7/kg for seed cotton. The financial farm gate price for each commodity is estimated by deducting the transaction cost from average wholesale price.

(Rs/kg)

Crop	Price		
Wheat	4.3	-	5.2
Maize	5.0	-	6.9
Paddy (Basmati)	9.6	-	13.4
Paddy (IRRI-6)	6.1	-	8.4
Cotton	17.6	-	23.8
Gram	13.4	-	20.0
Mung	11.2	-	17.1
Onion	2.3	-	9.4

3.3 Irrigation and Drainage

3.3.1 General

Water source for the Study area is river waters of the Jhelum and Chenab rivers. Diversion of the waters into off-taking canals is made through headworks/barrage. The main canals divert water to the respective irrigation systems. Branch canals which branch off from the main canals function as conveyance channels up to distributaries and minors in the respective irrigation divisions. These channels distribute water to the watercourses.

It is commonly understood that the irrigation water is not sufficiently and equitably supplied to the entire farmlands through the unlined channels due to limited water resources, insufficient canal capacity, remodelling of outlets, irregular sections of the channels caused by deterioration, theft of water at the upper reaches, seepage losses, etc. To cope with these situations, ground water is supplemented by the tubewells, which is still far shorter than the requirement.

There are many problems as discussed above. Among them, seepage of the fresh surface water to the saline ground water is one of the most serious problems since it is not only the waste of water resources but also the cause of salt hazard and waterlogging due to rise of ground water. Results of the seepage test, the ground water survey in terms of quality and table, and soil survey are the indications for solving the problem.

On the other hand, surface drainage of the rain water and the excessive irrigation water has been practised since long ago. However, subsurface drainage of the saline ground water has recently been practised by SCARP. The nation-wide subsurface drainage is about to be implemented by NDP.

3.3.2 Distributaries and Minors

The main canals and the branches have some sort of control structures to limit the distribution of water into the distributaries. There is, however, no control on the distributary/minor generally. When a proper quantity of water enters the head of these channels, it is distributed to each outlet automatically according to its capacity.

The distributary/minor is aligned on the local watershed. The natural drainage line forms a limit of the distributary/minor. It is aligned that the length of a watercourse taking-off does not exceed two miles (3 km), and is kept at a reasonable distance from villages and towns.

It is important to note that the canal system was designed in the second half of the 19th century during the British regime, with the objective of extensive irrigation to bring more areas under irrigation in order to settle more people without considering the crop water requirements. The perennial canal system, therefore, is not designed for maximum production on irrigated land but only to eliminate the possibility of famines. In order to maintain a cropping intensity of 75% the canal are generally allocated one cusec of water for every 333-350 acres of culturable command area (approx. 0.2 lit/s/ha).

The unlined channels are designed as regime or non-silting and non-scouring channels, requiring careful control on silt entry, and a continuous flows close to design discharges special in summer months when river waters are fairly silt laden. They are designed to operate successfully and distribute water equitably while flowing close to full supply (i.e. designed) conditions.

It is noted, however, that since the canal system is continuously deteriorating, the system is not functioning as expected in view of water conservation and hydraulic performance. In terms of water conservation, it is observed that breaching and overtopping of water frequently occur due to low freeboard of earth embankment, that steeling of water is a common practice near the upper reach of the channels either by breaking and increasing the size of outlets, and that considerable seepage losses are inevitable because of unlined condition. In fact, water does not reach to the tail in some channels due to the above reasons. In terms of hydraulic performance, it is observed that water is not appropriately conveyed to the downstream due to scoring/silting, sliding of side slopes, weed hazard and irregular cross section of channels. Distribution of water is not proportionally made due to deteriorating/ breaking of structures, especially outlets to the minors and watercourses.

The length of the distributaries and minors is 1,981 km in LJC, 3,787 km in LCC and 847 km in CBDC, totalling 6,615 km in the Study area. The number and length of the distributaries and minors in the respective irrigation systems of LJC, LCC and CBDC are broken down in the following table:

Irrigation Systems	Distributaries		Minors		Total	
	Number	Length (km)	Number	Length (km)	Number	Length (km)
Lower Jhelum	87	1,320	129	661	216	1,981
Lower Chenab	178	2,681	221	1,106	399	3,787
Central Bari Doab	34	510	68	337	102	847
Total	299	4511	418	2,104	717	6,615

3.3.3 Seepage Test

Most of the channels in the Study area are unlined. Out of 6,611km in length, only 814km, or 12% has been lined for the distributaries and minors. A considerable seepage losses are expected from the viewpoint of soil mechanical condition and groundwater table. Seepage tests have been conducted in this regard.

Seepage measurement of distributaries and minors was sublet to the Irrigation Research Institute of PID. Seepage loss was measured by two methods, inflow-outflow method and ponding method.

For inflow-outflow tests, canal reaches were selected in certain length depending upon the structures situated in the test reach or any change in the canal geometry/condition likewise unlined or lined sections. Before starting the test, a temporary gauge was installed on head of the test reach to check the uniformity of flow. The flow was maintained uniform approximately one day before the test. Discharge measurements were carried out by using Price current meter, and Pygmy meter and cut-throat meter to measure the discharge in watercourses.

For ponding method, the test reaches were selected so as to have the minimum variation in the cross sectional area of the channel. Temporary water dikes were constructed to isolate channel reaches. The dike heights were kept at the bank level of the channels and dike widths conformed to existing channel cross sections. Gauges to observe water levels were installed at about 250 to 350 feet from the upstream dikes end. Observation wells were installed to indicate the water table fluctuations over time during the test.

The test results are shown in Table 3.3.3-1. The location of the distributaries and minors selected for the seepage test is shown in Fig. 3.3.3-1. It is understood that average seepage rates excluding lined channels and rock excavated channels are 6.77 cfs/msf in the LJC System, 5.56 cfs/msf in the LCC System and 8.48 cfs/msf in he CBDC Systems, respectively. As will be discussed subsequently, the seepage rates are incorporated in selecting priority channels for lining.

It is understood that although the measured seepage rates disperse largely depending on the respective channels and their status, distribution ranges (maximum and minimum) of values measured by the two methods, inflow-outflow and ponding are more or less the same regardless of the measuring method. Due to the dispersed nature of the measured values, however, it is anticipated that they are too large (or small) when they are deemed to represent the seepage rates which are peculiar to the respective channels. Therefore, it is considered that the measured values are not peculiar to each channel, but are assumed as samples of a population of the Study area. On this assumption, they are treated as frequency in a certain

range of the values, and Fig. 3.3.3-2 was borne out as a result. Followings are the findings from the figure.

(1) As far as the values measured by inflow-outflow method are concerned, frequency decreases from low to high seepage rates with a certain trend of disbursement.
(2) The values measured by ponding method seem to be evenly dispersed, though the number of samples is too small to judge.
(3) The average values obtained from the two methods and that of all the measurements are very close each other (6.35, 6.13 and 6.32 cfs/msf, respectively).
(4) The median of the frequency distribution is equal to approx. 5 cfs/msf.
(5) The average seepage rate of the concrete lined channels newly constructed is estimated at 1.47 cfs/msf.

As a result of the above findings, the criterion in terms of seepage rate was determined to be 5 cfs/msf or more for the selection of the channels to be taken up for lining. In estimating the seepage rates of the existing unlined channels and the proposed lined channels, the average of the unlined channels stated above and that of the newly lined channels were deemed to represent the Study area Therefore, the saving rate after lining is calculated to be the difference between the former seepage rate and the latter as indicated in Table 3.3.3-2.

3.3.4 Tubewells in FGW and SGW Areas

In the Study Area, in order to compensate deficit of surface water, groundwater irrigation through tubewells is extensively applied. Tubewells are broadly divided into two types; ones are SCARP tubewells owned by WAPDA with discharge about 85 lit /sec and the others are farmer owned private tubewells with discharge about 28 lit / sec. In the following table, estimated nos. of the tubewells and annual discharge are summarized.

Nos. and Annual Discharge of Tubewells

Irrigation System	SCARP Tubewell nos.	Private Tubewell nos.	Total nos.	Annual Discharge (million tons)
LJC	2,300	10,300	12,600	3,400
LCC	1,800	58,300	60,100	11,200
CBDC	400	11,800	12,200	2,300
Total	4,500	80,400	84,900	16,900

Tubewells are used to supplement the canal water supplies in some specific areas according to the data from Agriculture Department. The tendency to use tubewell water gives reflection regarding the distribution of saline and fresh groundwater almost completely. The agriculture in

the Tehsils located in the saline ground water zone like Sargodha, Faisalabad, etc, depends on the canal water almost completely. However, contrasting observations have been recorded with respect to the agriculture in Tehsils lying in fresh ground water zones like Bhalwal, Kamalia, etc., where tubewell supplementation appears quite common. As a result, as is mentioned in 3.3.7, groundwater table becomes lower and groundwater utilization is thought to become difficult in fresh groundwater area. On the other hand, in saline ground water zone, ground water table rises due to canal seepage which results in water logging and salinity hazard. In line with Agriculture Census in 1990, the percentage of irrigated areas classified by irrigation method/source are categorized as follows:

1) Conjunctive use, surface and tube well water:	52%
2) Surface water only:	28%
3) Tubewell water only:	20%

3.3.5 Inequitable Distribution of Water

Despite the fact that inequitable distribution of water in terms of head and tail reaches of distributary and minor canals are often complained about by local farmers, so far, it has not been scientifically studied based on field data. In order to clarify the situation, data of seepage tests performed for selected canals in LJC, LCC and CBDC were used. Ratios between measured and designed discharge were taken to show the extent of water sufficiency. Ratios between reduced distances of test sites from canal heads and the total distances of corresponding canals are also taken to indicate the location of test sites quantitatively. These data are plotted in scatter graphs as shown in Fig. 3.3.5-1. In each irrigation system, correlation factors between the former and the latter parameter were calculated and they show negative values and consequently, it is appropriate to conclude that inequity of water is prevailing in the Project Area as was pointed out by local farmers.

During the seepage test, in addition to discharge measurement at seepage test spots, diversion to watercourses were also measured. In Table 3.3.5-1, total measured and authorized discharge are compared and summarized. Except for 2 test sections out of 14, ratios of measured over authorized discharge are more than 100%, consequently, it can be concluded Distributary canals discharge become less than designed as it goes downstream.

3.3.6 Watercourse

Comprehensive data on watercourses was collected from On-farm Water Management Project Office, Agriculture Department. The data includes nos. of watercourses, authorized discharge, command areas, water quality and present lining condition. Based on the data, there exist 2,946, 6,636 and 1,905 watercourses in the respective three irrigation systems. Of these,

number of water users associations so far organized and accomplishment of lining made fully or partially are 717 (24%) in the LJC System, 1,305 (20%) in the LCC System and 404 (21%) in the CBDC System, respectively. It is to be noted that the status of water users association and accomplishment of lining are incorporated in selecting priority distributaries and minors as will be discussed in the subsequent chapter.

3.3.7 Water and Salt Balance

(1) Irrigation Water Requirement

Net Irrigation Water Requirement was estimated based on potential evapotranspiration calculated with modified Penman equation . Usually, this method gives more accurate results as compared with other calculation method, however, requires various meteorological data such as temperature, relative humidity, wind velocity, solar radiation, etc.. Necessary meteorological data from 1986 to 1995 for the calculation were collected from three stations, Sargodha for LJC, Faisalabad for LCC and Lahore for CBDC. The calculation results are summarized below.

Net Irrigation Water Requirement for Representative Crops, LJC (mm)

Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
LJC													
Wheat	3.4						15.0	40.3	57.8	87.7	79.1	27.8	311.1
Maize					31.2	142.2	146.5	10.8					330.7
Rice			37.2	180.8	227.3	245.8	218.4	17.1					926.5
Cotton	7.7	68.7	72.0	105.0	180.6	160.8	95.3						689.9
Sugarcane	118.1	216.6	238.8	129.3	132.9	112.0	107.6	37.0		16.8	21.2	54.9	1185.2

Net Irrigation Water Requirement for Representative Crops, LCC (mm)

Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
LCC													
Wheat	11.4						18.3	44.2	75.0	90.6	89.5	64.0	393.0
Maize				4.2	69.3	171.2	173.8	12.3					430.8
Rice			37.9	231.8	274.0	277.6	248.1	18.7					1088.1
Cotton	11.7	72.1	79.2	164.1	230.6	191.2	116.6						865.5
Sugarcane	145.5	236.0	255.4	190.4	179.6	138.5	130.2	42.1	4.0	15.6	28.6	92.0	1457.9

Net Irrigation Water Requirement for Representative Crops, CBDC (mm)

Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Total
CBDC													
Wheat	15.0						16.7	42.9	67.4	82.9	72.6	51.0	348.5
Maize						126.0	166.7	12.0					304.7
Rice			34.8	162.0	158.6	231.0	241.1	18.5					846.0
Cotton	13.5	69.9	67.5	83.9	105.6	144.5	110.4						595.3
Sugarcane	150.9	227.7	239.6	107.9	60.0	95.7	123.9	41.4	1.5	11.7	15.5	78.9	1154.7

(2) Status of Surface Water Irrigation

Comparison of net irrigation requirement to the actual water supply was made for the three canal systems from canal discharge, cropping calendar, crop area, meteorological data and irrigation efficiency. Distribution and field application efficiency were assumed to be 70% and 60% respectively. As is shown in the table below actual surface water application is far from sufficient as compared with estimated net irrigation water requirement. Consequently, it was clarified that farmers in the Study Area would be in serious shortage of irrigation water without supplemental supply from tubewells.

Net Irrigation Requirement and Actual Application: LJC (unit: million tons)

Canal System	(1)Annual Actual Surface Water Supply (10^6 ton)*	(2)Net Irrigation Water Requirement (10^6 ton)	Balance (1)-(2) (10^6 ton)
LJC	1,551	4,254	-2,703
LCC	3,880	10,030	-6,150
CBDC	750	1,606	-856

* ....Discharge at Canal Head x 0.7 x 0.6

(3) Status of Ground Water Irrigation

Balance between irrigation water supply including ground water and water requirement was also performed. Irrigation efficiency of 50% was applied for the calculation.

Irrigation Water Supply and Water Requirement

Canal System	(1)Annual Actual Surface Water Supply (10^6 ton)*	(2)Annual Actual Ground Water Supply (10^6 ton)**	(3)Net Irrigation Water Requirement (10^6 ton)	Balance (1)+(2)-(3) (10^6 ton)
LJC	1,551	1,723	4,253	-979
LCC	3,871	5,602	10,031	-558
CBDC	751	1,130	1,606	+275

* :Surface Water Supply x 0.42
**: Ground water pumpage x 0.5

In LJC and LCC, even with supplemental supply of ground water, water requirement is not satisfied. On the contrary, 17% surplus water was found in CBDC, since the area is blessed with relatively sufficient rain as compared with the other two areas and the biggest ground water application.

(4) Surface and Subsurface Drainage

Continuous seepage from unlined canals, flat topography and lack of natural surface and subsurface drainage resulted in water logging and salinity in irrigated areas. According to NDP report, area of future drainage requirement is estimated as 1,060,000 ha for surface drainage and 2,007,000 ha for sub-surface drainage in Punjab. Water tables can be lowered by preventing excessive seepage losses from canals, by careful and efficient application of water on the farms, and by providing artificial drainage on areas for which natural drainage is inadequate. Although, in some part of the Study Area, drainage facilities had been already completed, because of deferred maintenance, much of it is in ill-repair and not capable of handling runoff of heavy rains, drainage problems are reappearing and has to be improved to keep water table depth from rising. Under these circumstances, drainage system in the Study Area should be developed as soon as possible in accordance with the development concept of NDP.

(5) Ground Water Balance Study

Each canal system was divided into fresh and saline water area for ground water balance study, since conditions are quite different in fresh and saline water areas. Taking into consideration the difference of conditions like ground water irrigation, water table depth, salt concentration of ground water, etc., it is more reasonable to perform the study for fresh and saline water area separately for each of the three canal systems. Basic condition of ground water and salt balance study are shown as below:

Basic Condition of Ground Water and Salt Balance Study

Item	Fresh Water Zone	Saline Water Zone
Canal Water Concentration (ppm)	200	200
Ground water Concentration (ppm)	800	3,000
Soil saturation extract Concentration (ppm)	1,500	4,000
Depth of Soil (m)	1.8	1.8
Soil Moisture Storage Coefficient	0.2	0.2
Ground Water Storage Coefficient	0.25	0.25
Aquifer Depth (m)	120	90
Beginning Water Table Depth (m)	3.6	1.8

Source:Irrigation Planning with Environmental Considerations, World Bank Technical Publication No.166.

Results of ground water balance calculation are summarized for the three canal systems in the table below.

Ground Water Balance Study

	LJC/FW	LJC/SW	LCC/FW	LCC/SW	CBDC/FW	CBDC/SW
Ground Water Recharge (Unit million ton)	-987	405	-5,635	777	-1,185	314
Ground Water Level Change (m)	-0.2	0.1	-0.6	0.1	-0.6	0.2

It can be interpreted from the results that at fresh ground water zones, the ground water table has a tendency of going down mainly due to large abstraction of ground water for irrigation and at saline water zones it is going up mainly due to seepage from canals and field irrigation water supply seepage. These ground water balance results coincide the field observation in the Study Area.

(6) Salt Balance

Salt Balance Study to illustrate the movement of salt between ground water and soil was performed based on the data and information collected during the Phase-I Study in Pakistan. Results are summarized as follows:

Salt Balance between Soil and Ground water

	LJC/FW	LJC/SW	LCC/FW	LCC/SW	CBDC/FW	CBDC/SW
Geographical Area (km2)	4,330	2,860	9,670	6,490	1,890	2,010
Salt Addition to Soil (million tons)	1.1	0.5	5.3	1.7	0.9	0.2
(tons/ha)	(+2.5)	(+1.7)	(+5.5)	(+2.6)	(+4.8)	(+1.0)
Salt Addition to Ground water (million tons)	-0.8	-0.8	-4.4	-1.2	-0.9	-0.2

From the results, it is understood that through continuous irrigation, both in fresh and saline ground water zone, salt moves to and accumulates in the soil. In fresh water zones, pumpage of ground water is thought to be the main cause of allocation of salt from ground water to soil. For saline area, capillary movement of water in evaporation is the cause of salt accumulation in soil, which means that, if the present situation continues, salt accumulation in soil might be detrimental to irrigation agriculture in long term in the Study Area.

3.3.8 Drainage Systems

There are three types of drainage methods which individually or in combination might be appropriate in a particular situation. These are:-

- Surface drainage
- Horizontal sub-surface, and
- Vertical sub-surface drainage.

The surface drainage system of LJC covers the entire geographical area of approximately 7,190 km^2. Number and total length of the drains are 144 and 1,310 km, respectively. The surface drainage system of LCC also covers the entire geographical area of approximately 16,160 km^2. The number and total length of the drains are 63 and 1,350 km, respectively. In CBDC, the surface drainage system covers 1,510 km^2, a part of the geographical area of 3,900 km^2, with number and total length of the drains are 19 and 230 km, respectively. There is no horizontal sub-surface drainage in the Study area, however, vertical sub-surface drainage through tube wells has been practised in the Study area under Salinity Control and Reclamation Project (SCARP). In the LJC System, some 280 tubewells were drilled for drainage. Also in the LCC

System, 20% of approximately 1,800 tubewells and in the CBDC System, approximately 20% of 400 tubewells were drilled for drainage.

Drainage discharge in the Project Area should be estimated in accordance with the concept of NDP by IBRD. Broadly, drainage discharge is divided into storm drain discharge and seepage drain discharge. According to a Manual of Irrigation Practice published by the Government of Pakistan in 1961, for the former, 0.11~0.44 (lit/sec/ha) has been adopted and the latter is estimated approximately 0.2 (lit/sec/ha) from the results of groundwater balance study as annual average.

3.3.9 Lining of Distributaries and Minors - Progress and Problems

(1) Current Researches and Studies

Several types of canal linings have been under experiment by Irrigation Research Institute (IRI[1]) for their water tightness, long-term degradation, durability against damages by root penetration, rodent attack and temperature fluctuation. Test section within Thathi Uttar minor carries EPDM rubber sheet lining covered by brick. Findings derived from the research results are;

1) Exposed membrane are obviously observed damaged by cattle or farm machines and not practical. They are suggesting 9 inch surface protection by earth material since penetration depth by sheep foot observed are 6 inch,

2) Buried thin membrane showed good water-seal-effect at the beginning of their application but relative weakness against penetration by rodents and weed. Rubber showed much higher protection than polyethylene sheet,

3) In case of brick or ceramic tile lining, loosening by rodent are reported as most vital damage and each pieces are observed separated at their joint especially at toe of canal slope.

4) Brick with surface cover by mortar and synthesized rubber sheet showed good performance for long term with requesting periodical repair. Rubber sheets with and without fiber reinforcement are tested and fiber-reinforced-sheet showed higher resistance against damage by weed and rodent.

[1] Founded in 1924 under Irrigation and Power Department, Punjab. Field research center of the Institute operating the canal lining researches.

Fordowah Eastern Sadiqia South(FESS) Irrigation and Drainage project carries several research programs as project components besides canal lining component for distributaries and minors of about 178 km planning to apply geo-membrane/geo-textile for lining material. As a research component, several types of lining material, their combination and ways of construction are to be tested. Bottom only lining, a concept stated by USBR, using polyethylene sheet and compacted soil cover is concluded to be applied except where horizontal seepage loss are anticipated significant or near by towns, to which reaches concrete lining are proposed in the Feasibility Study Report for Punjab Water Conservation Project conducted by ADB in 1995. Three(3) subprojects are selected as sample area for the first implementation group and among of them Dijkot distributary branched out from Pakh Branch is located within the Lower Chenab Canal System, to which buried membrane lining is proposed.

(2) Site Condition

There are several canal lining programs so far as listed below conducted within the Project area (LCC, LJC and CBDC) and concrete lining of 3 inch thick, brick lining of 4.5 inch thick[2] and brick side protection of 4.5 inch thick are major lining methods. Canal bank improvement works have been also conducted. Double brick lining was applied for some portions of Brach, Main and Link Canals and damages by uplift pressure have been reported. Linings are applied to relatively small channels or downstream or where nearby town or where there are canal maintenance were vital for proper operation and maintenance as well as even distribution of water through to the tail reach. Selection criteria of lining types is soil salinity rather than seepage or ground water quality and concrete lining were chosen to saline area generally.

- Irrigation System Rehabilitation Project (ISRP) Phase I and II, financed by World Bank, USAID and Government of Netherlands.
- Annual Development Program (ADP), by Government of Punjab.
- Member of Provincial or Federal Assembly Grant (MPA Grant)
- Maintenance and Repair Program (M&R), by Government of Punjab.
- Command Water Management Program (CWMP), by USAID, etc.
- Khushab Salinity Control and Reclamation Project (SCARP), by World Bank.
- SCARP Transition Pilot Project (STPP.), by World Bank

Most of canal lining works were completed within 1-8 years under the program above. Canals lined either by concrete or brick and protected by brick at inside slope within the Study Area under the above program are summarized in Table 3.3.9-1. Cost data are relatively undependable due to data lacking and mixture of canal lining works with appurtenant earth

[2] Thickness of flat brick tile is 3 inch and 4.5 inch thick for brick on edge alignment. Brick on edge lining is a improved alternative lining type prevailed.

works. The canals to the extent of 12% or 814 km out of 6,611 km within the study area. Brick lining is predominant and covering 58% of total length, concrete lining covering 30 % and brick side protection covering 12%. Canal lining ratio for distributaries and minors in Lower Jhelum, Lower Chenab and CBD canal systems are 5, 15 and 20% respectively concluding that much less input of canal lining have been given to LJC than the other two systems. Brick lining is dominant in LCC and concrete lining in LJC while Slope-protection lining is scarcely seen in CBDC. Specifications of canal lining are similar among the projects above. 3 inches thickness is for concrete lining and 4.5 inches for brick lining on edge supported on 0.75 inch mortar plaster[3]. Side slope of 1: 1 is common but 1:0.5 is applied for smaller canal. Major constraints observed in the field are;

1) Quality control of concrete lining for the initial construction are not satisfactory and deep and hair cracks are observed. Joints damages are much observed for brick lining especially where weeding occur from inside of lining.
2) Siltation which have caused berm formation and weeding within the canal prism consequently are much observed in LCC downstream reach of channels commonly than LJC and CBDC.

Bank deterioration such that canal sections are collapsed and widen by cattle passage or that bank comes vulnerable and never safe for normal operation were much observed. The former condition stated above were observed at more than 150 points (approximately 3 km in length) within the selected canals and at 80 points out of 150, new bridges are proposed. The latter conditions are very common and water leakage through bank were observed at more than 100 points.

According to the data[4] by ISRIP and their analysis, diameters of soil particles of suspended load at 90% pass and 50% pass are 0.066 mm and 0.027 mm for LJC area and 0.185 mm and 0.112 mm in LCC area. Concentrations of suspended load above 0.062 mm are 7.7 PPM only in LJC and 245.0 PPM in LCC area. The data above show that water flowing in LJC area are of less silt suspension and most of the suspended load can be washed throughout to farm land by normal flow velocity (1-1.5 ft/sec). Condition in LCC on the other hand requests special treatment since most suspended load precipitates within distributaries and minors canal reaches and concentrations are high.

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[3] Mortar Mixing; 1:6 mixing is common for plaster under lining. 1:3 mixing is commonly used for brick and masonry work.
[4] Siltation Data taken by ISRIP for 1982-1984 for branches and distributaries in LCC and main canal in LJC.

(3) Present Condition of the Canal Related Structures

Results of inventory survey of canal related structures are summarized in the Table 3.3.9-2. There found outlet, drop, bridge, steps, aqueduct, watercourse crossing, pipe culvert and escape within the distributaries and minors in the study area. Types of outlet at present condition are tabulated by area in the following table. APM(Adjustable Proportional Module) is predominant and open flume type follows. Combined open flumes outlet (Tail Cluster) is common at the end of channels. Total numbers of outlet surveyed are 1,085, out of which only 35 nos. outlet are in good condition and keep initial function, 725 nos. of outlets are observed somewhat damaged and need repair and 324 nos. outlets seem to have lost functions and need replacement.

Type of Outlet	LJC Area	LCC Area	CBDC Area	Total
1) Pipe Outlet	15	39	18	72
2) APM Outlet	153	390	123	666
3) Open Flume	153	150	27	330
4) Other*1	7	7	3	17
Total	328	586	171	1,085

*1: Type unknown and some screchly type outlets

Inclined type is major category of drop but not small numbers of drops are quite damaged so that original type could not be identified. Total numbers of drop surveyed are 176, out of which 82 nos. of drop are observed requesting repair or replacement. Total numbers of bridge in the study area are 433, out of which 244 nos. of bridges are requesting repair and 150 nos. are obviously required to be replaced. Railway bridge in the study area are 12 nos. Brick bridge are common and concrete slab are used for the rest of bridges. There are 85 steps, out of which 27 nos. steps request repair and replacement is necessary for 22 nos.

(4) Material Availability and Price

Supply of aggregate, sand and brick are confirmed available within the Project area. Aggregate are produced nearby Sargodha and delivered to entire Punjab, sand can be taken from Chenab Liver and brick production are prevailed anywhere. Price of aggregate are most varied by location, cheapest at Sargodha and highest in Lahore. Price variation for the other materials are much small. Portland cement is produced in Sargodha area and partially imported but plenty volume of cement are available in market. Lining Material unavailable to be imported are most of geo-membranes such as rubber sheet, PVC/EVA sheet and geo-textiles since they are not available in domestic market or in too low quality to be applied.

(5) Construction Period, Method and Machinery for actual Construction

Regarding construction period, there are two types 1) construction through year round and 2) only in irrigation closure period. For most of distributaries and minors inspected, construction

period are 1 year to 1.5 years through. Repair work and lining work for the larger canal have been made in the irrigation closure period of about one month in December and January.

Most of the construction works have been conducted on contract basis and average package price for a contract is about 5 mil. Rs. covering a minor or distributary. In case of exceeding 10 mil Rs. for a canal, works are to be divided into some packages. Canal diversion method has been applied where perennial construction is possible as there is enough right of way. According to site engineers comments and results of site investigation, it seems that the canal discharging more than 100 cusec does not have enough area by side for diversion. Ordinary length of a diversion work is reported from 1,000 - 5,000 feet for construction period of 1 to 5 weeks.

Another alternative method is to construct new channel by the side of the original channel and to shift after completion as observed in case of CMWP as stated in the feasibility study on lining of irrigation channels in Punjab. In the alternative case, canal bank are to be constructed on the original channel line and all structures are to be re-constructed or modified widely. Third alternative method is to construct within the canal closure period in December to January. Lining machine or motor driven slip form have never used for canal lining work.

(6) Problems to be Solved by the Project

Adoption of narrow and hydraulically ideal canal section to maximise the velocity and to make the canals free from siltation are necessary for canal lining works. Proper selection of lining material and methodology is also important. Institutional formulation for farmer's organization is necessary so as to operate and maintain entire canal system and facilities.

3.4. Operation and Maintenance of Irrigation and Drainage Systems

3.4.1 Operation and Maintenance of Irrigation System

Operation and maintenance of irrigation system is done by the Punjab Irrigation and Power Department established during the last quarter of 19 century. It is a department of the Government of Punjab headed by a political Minister and a permanent Secretary with a complementary secretarial staff of senior engineers as additional secretaries, deputy secretaries and section officers (Fig 3.4.1-1). For the control of field operations the province of Punjab is divided into six zones each headed by a Chief Engineer. The zones are

1. Lahore Zone
2. Faisalabad Zone
3. Sargodha Zone
4. Multan Zone

5. Bahawalpur Zone
6. D.G. Khan Zone.

The area under the project pertain to the first three zones. To illustrate the field control, administrative charts of Sargodha and Faisalabad Zone are attached (Fig 3.4.1-2&3) along with the chart of Irrigation Department(Fig 3.4.1-1). It can be seen that each zone has five circles three of which are for operation and maintenance of irrigation system and two are for drainage only. The O&M circles have two to four irrigation divisions which are manned by the field officers for operation & maintenance of the canal system and assessment of the water charges.

OPERATION OF THE SYSTEM

The divisional irrigation engineers assess the water requirements of their respective areas and depending upon the canal capacities, place an indent on the head works division directly or indirectly at least 10 days in advance through a canal wire. The indent is usually placed according to the historical record or as per demand/designed capacities of channels. The head works division depending upon availability of water regulates the head work to release the water as per sum total of the demands placed by the divisions after making due adjustment for the losses in the main canal and branches subject to availability of water in the river and taking due regard for the rights of the lower riparians. In accordance with the Water Accord, 10 daily releases for each canal system have already been fixed and are controlled by Indus River System Authority (IRSA), a representative of whom is posted at each head works. In case of shortages in the river system the IRSA divides the shortages on prorate basis with perennial canals having the 1st charge on available water. In case the shortages cannot be met even by total withdrawal from non-perennial canals then these are divided on prorate basis after deducting the losses in the river.

Within the canal command the shortages are similarly distributed over the entire command area to attain the concept of equity. Such shortages are although not frequent but are usually encountered in the months of April, May and June when the reservoirs have already been drawn down to minimum pond levels and the rivers have not yet risen due to low temperatures in the snowy mountainous sources of the Indus river and non commencement of the monsoon season in the rainfed catchments of Jehlum and Chenab. On the other hand, the temperatures rise in the Indus plains resulting into high water demand by standing crops and preplanting water for the ensuing crops. It is in this critical period that shortage shearing is normally resorted to. The generation of hydro power of course gets the second priority after irrigation requirements in the operation of the two major reservoirs i.e. Tarbela and Mangla.

MAINTENANCE OF THE CANAL SYSTEM

The maintenance of the canal system from head works to out lets (including the out let) is done by the Irrigation Department. The Department employs Engineers and Sub Engineers on permanent basis and some skilled and unskilled staff for maintaining the canal head works including its gates and gearing and the protection bunds, vigilance over the distributary branch and main canal banks against breaches, vigilance over outlets against interference, repairs to the minor works in the regulators, and banks, removal of weed if any and maintenance of banks and the roads along the banks of the system. Certain major functions are performed through contractors specially appointed such as annual silt clearance. The finances are supposed to be provided by the provincial Finance Department according to an approved yardstick in the annual budget of the province. The Irrigation Department have historically complained that enough finances based on the yard stick have never been provided and therefore the facilities have deteriorated due to accumulated short fall in the resources. The complaint of the irrigation department appears to be having a weightage as from the figures of Lower Jehlum Canal Circle (Table 3.4.1-1, Fig 3.4.1-4) it appears that the provision of O & M budget has remained constant in nominal prices over the last 10 years (1984 to 1994) although the price escalation would be between 200 to 300%. While the pay and allowances of the supervisory staff rise every three years to some what keep pace with inflation, the freezing of the O & M budget resulted into unbalancing the expenditure in favour of establishment making less and less funds available for actual maintenance. According to NDP the 1995 budget shows that 75% of it is spent on establishment and only 25% is available for maintenance. The finance department on the other hand complain that due to non-enhancement of water charges commensurate with inflation they are in no position to increase the budget for operation and maintenance of the system. The net result on the ground is that the system is continuously deteriorating despite some major financial dosage under Irrigation System Rehabilitation Project I & II. The department is also plagued with inefficiency, corruption, political interference and incompetence at middle and lower level.

3.4.2 Assessment and Collection of Water Charge

The major income of the irrigation system is from water rates (Abiana) assessed and recovered from the farmers. The Irrigation Department has a large revenue staff (In case of LJC, 2/5 of the total in terms of budget expenditure and 1/3 of the total in terms of number of employees) engaged on the assessment of the water charges. This has been further confirmed by the data collected for selected distributaries where on the average 80% of the O & M cost is incurred on establishment of which 36% is on revenue staff and 44% is on Engineering and maintenance staff (Table 3.4.2-1). The water charges are fixed by the Government for each crop and the revenue staff measures the area under each crop every six months through and elaborate system of checks and counter checks to ensure that the area under crops is correctly measured and that

the remission for partial or total failure of crops is correctly reported. The record is then transferred to the District Collector who recovers it through the Revenue Department. The water rates recovered during the 10 years (1984-1994) in Lower Jehlum Canal Command has almost remained constant with a maximum assessment in 1986-87 (Rs.79,441,176/-) and minimum of Rs.69,664,629/- assessed in 1992-93. (Table 3.4.2-2) It is further stated in various reports that almost 100% of the small land owners pay their water charges regularly and it is the big land lord who is responsible for an approximate annual less recovery of 7% to 8% both due to under assessment and pure default. In case of crops failure the Irrigation Department has the powers to quarter, half or full remission in water charges but such remission is not very frequent. As per three years record of two Divisions of LCC, the average remission is less than 0.5 % after ignoring the pest attack on cotton of 1993-94 in Burala division. (Table 3.4.2-3) The same three years average rate of remission in the 12 selected distributaries is 0.4% only including the years of pest attack (Table 3.4.2-4).

3.4.3 O & M of Drainage System

The drainage in the project area is of two type. (a) Surface Drainage (b) Subsurface Drainage. The surface drainage is mostly through natural drains consisting of old river beds or tributaries of the rivers. Some limited surface drainage has recently been introduced partly as a result of tile drainage system in Faisalabad area. Most of the sub surface drainage is done by tubewells both in the public and private sector. The public tubewells were installed under SCARP programme. A substantial number of these tubewells have either deteriorated or have become saline and abandoned. Where ever the public tubewells are used for irrigation (SCARPS) a drainage cess has been applied and is recovered along with the water charges. The NDP-I is aiming at rehabilitating some of the drainage projects, but emphasis is being given to transition programmes where the farmers are being given incentives to replace the large deep tubewells with high salinity to small shallow wells with comparatively low salinity. The success of the transition will reduce a large burden of operation and maintenance cost of these tubewells on the Provincial Government. The large surface drains are being maintained by the provincial government and its successor, i.e., PIDA. will take over these drains for maintenance. The operational costs, in the long run, will be recovered from the beneficiaries including the farmers. The farm level drains upto 15 cusecs discharge will be transferred to farmers organizations.

3.4.4 Role of Other Departments

Although operation and maintenance of irrigation system is in the exclusive domain of Irrigation department of the Provincial government yet other departments such as Agriculture (Agriculture Extension, Agriculture Research, Agriculture Engineering, On-Farm Water Management, Soil conservation, Animal Husbandry), Rural Development, Revenue ,

Cooperative, Food, Forest etc. are closely associated and effected by Water Resource Management.

The closest among them is the On-Farm Water Management of Agriculture Department which have done a substantial work on the improvement of water courses after the out let. This programme was introduced in 1976 under the U.S. Aid and is still continued. They have so far improved close to 21,000 water courses out of 100,000 water courses in Pakistan and claim savings in water by 28%, increase in cropped area by 13%, increase in irrigation intensity by 14.8% , increase in yields by 17% etc. The criteria for water course improvement was that there should be a water user's association who were to pay, initially, about 25% of the cost of improvement through labour input. This participation has been gradually increased to 50% by now showing a great success so far as water course improvement is concerned. The water users associations were formed under 1981 ordinance. The water user's associations got dispersed usually after the improvement for the obvious reason that they had neither been given any responsibilities nor powers to operate the water course - a requirement most important for sustainability of the farmers' associations.

The other function of the On-Farm Water Management was precision land levelling which was popular as long as a substantial subsidy was available but is rarely practised by the farmers at their own being higher on cost as compared to the benefits particularly from food crops. They were also involved in the Command Water Management Project where improvement in the canal system was done by the Irrigation Department and the on-farm improvement was done by Agriculture Department. Although coordinators were appointed to coordinate their activities but the desired results could not be obtained. The coordination between the various departments is one of the most difficult problem because of water tight vertical hararchal system concentrating powers at the top of each department. The departments work in clearly defined narrow corridors and have little side vision or even respect for each other. Perhaps the farmers association formed at the distributary level with well defined powers and responsibilities but not limited by rules and regulations will play a powerful role to obtain other departments support and involvement in agricultural improvement.

3.4.5 Constraints for Irrigation System Management

In order to confirm the constraints for institutional reforms for irrigation system management, the team asked for interviews with the farmers in the Study area and the officials of the provincial government, in addition to collection of information and field investigations.

(A) Farmers Argument

During the team meetings with the farmers the constraints in irrigation system were high lighted in the following order of importance.

1. The water supply in the system is deficient to respond to the increased cropping intensity which in turn is essential to fulfil the food requirements of the increasing population. It was argued by the farmers that where as their parents and grand parents had more land to look after the requirements of the same family size, the farms got subdivided among their sons and grand sons to almost 1/10 th of the original size and therefore this small plot of land has to grow enough to fulfil the needs of a similar size of family. To do so more intensive irrigation is needed to grow two or three crops per year and consequently more water is required.
2. The irrigation management which was efficient and equitable has deteriorated in the last 30 to 40 years with the result that the canals are in disrepair and desilting of the system is usually deferred. The water distribution which was proportional to the land holding has become highly inequitable to the detriment of the tail farmers. The head farmers and the large farmers using their political and economic influence interfere with the system and draw three to four times more water than their authorized share at the cost of the tail farmers. They resort to use of pipe siphons in the distributary, breaking and lowering the crests of their water courses, making their animals stand in distributary just below their out lets to raise the water level in the distributary enabling their out lets to draw more water or some times even breaching the distributary. They complained that the irrigation canal officers and staff which used to be highly professional in the exercise of their legal powers, a quarter of a century back, have been rendered power-less by the interference of the political system and therefore, the legal frame work used for equitable distribution of water has been totally dismantled and is rarely applied. They stated that during the last ten years no farmer has ever been punished under the canal and drainage act despite more frequent commission of crime of misappropriation of water. It was desired that the law should not only be made applicable but should be seen to have become applicable.
3. A large number of farmers interviewed stated that they have to pool their resources in order to make informal payments required for obtaining some what regular supply at their water courses. Such informal payments are equal or same times more than the formal payments of water charges and are on the increase.

4. Because of the shortage of water, their lands have become saline due to lack of leaching and higher use of tube wells, pumping water with far more salinity than canal water. At the same time the tube well water is many times more expansive than the canal water.
5. Loss of water by seepage, from distributaries was pointed out to be the last item. In fact the lining of distributary and minors was preferred more for system efficiency and equitable operation than for saving the water lost by seepage.

(B) PID's Opinion on the Constraints

The department of irrigation on the other hand commented about the constraints that

(i) The canal system has gone into decay because of lack of O & M financing by the government year after year resulting into deferred maintenance. The fixation of yard stick for financing the O & M, has not kept pace with the inflation on one hand and on the other the availability of funds lag far behind even the present yard stick revised some times in eighties (Table 3.4.1-1, Fig 3.4.1-4). In fact the O & M financing for LJC has not changed since 1984. The Government in the Finance Department complain that since there has been no revision in the water charges since early eighties, it is not possible for them to provide the necessary funds for O & M (Table 3.4.1-1). They argue that return from agriculture to the farmers has increased more than twenty times since the sixties but water rates have only been doubled. In real terms the water rates have declined to one fifth or one sixth of the water rates paid in sixties.

(ii) The irrigation department also accept the fact that there is enormous political interference in the legal, functional and administrative responsibilities of the department resulting into over all deterioration of the system. They are however, confident that the stoppage of such interference by political system, the provision of adequate finance for O & M and corresponding increase in water charges could revive the department to its old glory.

Further studies indicated that irrigation department is highly over staffed particularly at the lower level. In some of its functions which appear to be no longer necessary it could make itself far more efficient by trimming itself into a proper and manageable level. As has been stated else where the expenditure on staff consume more than 75% of the funds (in LCC area more than 95%) available for O & M of the system (Table 3.4.5-1~3). Obviously this situation should no longer be tolerated. It can be seen that of the three thousand five hundred and one (3501) staff of LCC the engineering staff is only 115 or 3.3% of the total (Table 3.4.5-4). In LJC it is 3.2% (Table 3.4.5-5). Almost the entire field staff except for some office

functionaries and some regulation staff on main canal, is engaged on the secondary distribution system. One of the major element in the staff strength of distribution system is the revenue staff which could be rendered totally surplus by making one policy decision of changing water rates assessment to flat rate basis in place of current crop basis. This issue has been studied and raised at some level in the provincial Government of Punjab but has made no progress because of vested interest.

During discussion with farmers it was felt that the introduction of flat rate charges would pose no formidable problem. In fact almost in all the meetings it was stated by the farmers that this system would be most welcome as it would eliminate unnecessary interference of the Government functionaries with the farmers. On further study with particular reference to the two major project areas of Lower Chenab Canal and lower Jehlum Canal it was found, that the revenue staff was consuming an annual budget of Rs 45 million and Rs 28 million respectively on their salaries which was far more than maintenance and repairs requirements of the canals. From the data collected for the 12 selected distributaries it is further confirmed that almost 36% of the total O & M cost is incurred on the revenue staff which can be easily avoided if flat rate assessment is introduced.

3.4.6 Present Status of Farmers Organization for Irrigation Management

Farmer organizations do not exist in Punjab at the distributary level. Water User Associations, however, have been formed in various parts of the province under the On-Farm Water Management (OFWM) programme since the mid-1970s. The WUAs are best viewed as functional entities required by the OFWM Directorate to perform the specific functions associated with watercourse improvement. In this connection, they have been used largely to mobilize unskilled labour, collect farmer contributions for the civil works, and hire masons to undertake the lining and improvement. Once these tasks have been completed, the WUAs cease to function.

The formal management structure of the WUAs has been that of a closed shop: there is no requirement under the enabling legislation for WUAs 1981 to meet regularly to plan and review their activities and accounts. Virtually all powers of the members have been assigned in the legislation to a small committee. In the absence of open discussion and legal powers, the general body of the WUA is rendered impotent. Thus, participation is replaced by representation, and it is the representatives who interact with outside agencies and take decisions in the name of the farmers. In the actual process of implementation the supervisor / a government functionary of the OFWM has assigned to himself the pivotal responsibility of direction and decision making on behalf of the farmers and therefore the farmers representatives have been reduced to obey and carry out the instructions. Although the vision of the WUA,

when it was first articulated in the mid-1970s, was that of a permanent farmer institution for irrigated agriculture, in practice the farming community has not been engaged in achieving this vision.

3.4.7. Comments on NDP

As a result of the NDP-I discussed earlier, the donor agencies including the World Bank, Asian Development Bank and the OECF desired the Government of Pakistan to undertake institution related reforms in the Water and Power Development Authority and the Provincial Irrigation Departments of the four provinces. The donors insisted that the approval of the loans for NDP-I will be subject to the initiation of the institutional reforms by the Government of Pakistan. Frequent contacts were made between the donor agencies and the Government of Pakistan and it was tentatively decided that Government of Pakistan through a statute will introduce the institutional reforms on 1st July 1996. A draft ordinance was prepared by the GOP and sent to the donors in March 1996 for their comments, if any. The donor agencies considered that the draft statute did not reflect the understanding reached between the donor agencies and the GOP. A delegation of the Pakistan Government duly represented by the four provinces visited the World Bank at Washington and held series of discussions in April/May 1996 on draft statute for institutional reforms. Since the Pakistan delegation did not have any mandate to make changes in the earlier draft statute, it was decided that a workable draft statute be prepared through informal discussions between the GOP, Provinces and NDP Donors. However, the donors informed the Pakistan delegation that there is substantial degree of urgency associated with enactment of this statute by July 1, 1996. During negotiations in June 1996 it was decided that Government of Pakistan will issue the statute on the above date and then the bank management would present the loan request to the Board. On return of the Pakistan delegation to Pakistan a task force was established by the Government of Pakistan to go into informally proposed statute and expedite the finalization. The Task force has finalized the draft statute, through intensive negotiations and lengthy discussions between the provincial and Federal Governments in Dec. 1996. The draft statute agrees to the formations of PIDAs, area water boards and farmers organizations at distributary level on pilot basis. This draft statute has now been promulgated as an Ordinance on May 29, 1997 giving broader parameters of establishing PIDA in Punjab.

3.5 Farmers Meetings

3.5.1 General

The Interim report prepared as a result of Phase-I field study contained the basic concept of institutional reforms needed in the light of constraints presently experienced by the farmers of the three target canal commands of Lower Jehlum canal, Lower Chenab canal and Central Bari

Doab canal. This report was discussed with the Irrigation & Power Department of Government of Punjab, on October 14, 1996. The minutes of the meeting are appended as Attatchment C. During these meetings the issues of present constraints and proposed Institutional reforms were discussed at length. Except for certain phraseology used in the statements of the farmers while high lighting the constraints, the proposal was accepted to be adopted on a pilot basis.

In response to the observation of the irrigation department on the interim report that the size of sample was very small to rely upon with respect to the constraints high lighted by the farmers, the team organized additional meetings along the selected 12 Distributaries in the head reach, middle reach and tail reach where the distributary was very long, and in the head and tail reaches where the distributary was a short one. In this way 24 meetings were held in November, 1996 in addition to the seven meetings held in May-June, 1996 jointly involving about 1200 to 1300 farmers. These meetings were intended to elicit an articulate response from the farmers regarding their under standing of the current situation and their prospective for a more equitable and sustainable system of water management at the distributary and minor level. This participatory appraisal involved direct dialogue with farmers at the locations along the distributary given in the Table below;

Lower Chenab Canal

Day	Date	Time	Village	Distributary	Minor	Location
Saturday	09 Nov,	1200	361 JB	Gojra	Gojra	Head
	1996	1400	95 JB	Nasrana	Nasrana	Tail
		1600	369 JB	Gojra	Gojra	Tail
Sunday	10 Nov,	0930	437 GB	KillianWala	KillianWala	Head
	1996	1300	453 GB	KillianWala	KillianWala	Middle
		1530	KillianWala	KillianWala	KillianWala	Tail
Monday	11 Nov,	0900	241 GB	Mungi	Mungi	Head
	1996	1200	251 GB	Mungi	Mungi	Middle
		1600	536 GB	PirMahal	PirMahal	Head
Tuesday	12 Nov,	0930	269 GB	Mungi	Mungi	Tail
	1996	1200	660/1 GB	PirMahal	PirMahal	Middle
		1430	674/15 GB	PirMahal	PirMahal	Tail

Lower Jehlum Canal

Day	Date	Time	Village	Distributary	Minor	Location
Saturday	16 Nov,	1100	22 / SB	Kirana	Kirana	Head
	1996	1400	90 / SB	Kirana	Kirana	Middle
Sunday	17 Nov,	0900	16	Hujjan	Jaspal	Tail
	1996	1200	Kot Raja	Hujjan	Kot Momen	Middle
		1415	Hujjan	Hujjan	Hujjan	Head
Monday	18 Nov,	1200	84 / NB	Pindi	Pindi	Tail
	1996	1300	104 / SB	Kirana	Malkana	Tail

Central Bari Doab

Day	Date	Time	Village	Distributary	Minor	Location
Saturday	25 Nov, 1996	0900	Sirhali Khurd	Thamman	Thamman	Head
		1200	Thea Roosa	Thamman	Siharan	Tail
		1400	Kaly	Chinna	Kalu	Tail
Monday	26 Nov, 1996	0900	Matta	Chinna	Chinna	Head
		1200	Chinna	Chinna	Chinna	Tail

The JICA team was composed of two JICA specialist viz. Mr. T.Othani, the Team Leader, and Mr. A.R.Mahsud, the Institutional Expert, supported by Mr. A.R.Saleemi a local consultant specializing in Socio Economic development including Institutional reforms. Some of the meetings were also attended by local counter parts.

The application of this approach engendered a very strong and articulate response from the farmers during the appraisal. Farmers expressed acute dissatisfaction with the current Water management practices particularly at the distributary and minor levels. Free and creative discussion between farmers and JICA team members resulted in rapid emergence of key issues.

3.5.2 Present Conditions of Irrigation O&M at Head, Middle and Tail Reaches

Farmers in the head reaches of the distributaries did not make any severe complaint against the inequitable distribution of water but they did indicate that their was a general shortage of water for the present cropping intensities and therefore, some of their colleagues in this reach indulge in unauthorized use of canal water by putting siphon pipes in the distributaries and interfering with the outlets. The head reach farmers particularly in the areas where ground water was sweet, used private tube wells to supplement canal water and obtain much higher intensities of irrigation. This sweet ground water apparently resulted from distributary seepage at the head, as these tube wells were generally located in the near proximity of the canals. However, even these farmers complained about the intermittent canal closures that did not ensure a regular and plentiful water supply. The outright admissions by these head reach farmers, that they did indulge in unauthorized use of caval water, confirmed the oft repeated complaint of the tail water users that they (the head farmers) are drawing more water than their authorized share.
The consistent complaint from farmers at the middle reaches was that too much water was being appropriated by the upstream farmers. Lack of proximity to the canal meant that augumentary irrigation from tube well at the middle was drastically less than the head reaches because of brackish ground water.

Most tail-end farmers received severally restricted and irregular quantities of canal water and were forced to depend largely on brackish tube well water. (Fig.3.3.5-1)

The exceptions to this pattern were two tail reaches (at the Mungi and KillianWala distributaries), where all surface water sources had been permanently closed off for over a decade, forcing farmers to pump up sweet ground water from a steadily falling water table of a possible aquifer, endangering future access. At the Mungi and KillianWala distributary tail reaches, one village alone had 40 tube wells of 25 horsepower each, drawing water from a depth of 22 meters. The water table was reportedly falling at a rate of 45 cm per year. With this fall of water table, the differential head in the adjoining saline aquifer could trigger ground water movement resulting in salinization of the sweet water zone.

Government owned and operated tube wells have been installed for lowering overly high water tables. They are mostly out of order, except for one location (head reaches of distributary on the Lower Jehlum Canal) where two operative tube wells were observed pumping sweet water into the watercourses.

3.5.3 Water Transactions

(a) Informal Water Transaction: No incidents of canal water sales were reported. Informal ground water markets have established themselves at the head reaches where sweet ground water from tube wells is available. An hour pumping of tube well is transacted between Rs.50 to Rs.80 per hour. At this rate the water charges for an acre of Wheat crop from sowing to maturity dependent on the tube well water alone would be Rs.600 to Rs.1000. At the middle and tail reaches where tube wells yield brackish water, water markets transform to informal non-cash reciprocity transaction between allied farmers kin groups. In this zone, tube wells are usually rudimentary boreholes fitted with pumps to which tractor power is intermittently applied by individual tractor owned farmer as and when water is needed.

(b) Formal Water Transaction: The only formal water transaction is the *abiana* or seasonal water tax, which is ostensibly applied for the supply of surface water to farmers. Farmers were aware that this taxation has been rising regularly over the years, although the actual supply of water has become more irregular.

3.5.4 Farmers Perception of Management Problems

(i) General

The participatory nature of the appraisal ensured constant interfacing with farmers in order to achieve a deeper understanding of their perception regarding powers around water that impinged directly or indirectly upon the adequate and timely supply of irrigation water. These powers were identified by the farmers as primarily being the Irrigation Department and

influential local farmers / politicians. Farmers openly aired their grievances and put forward their ideas about what they believed to be an ideal situation.

(a) Irrigation Department: Farmers wrath was directed at the line departments in general and the Irrigation Department in particular, whom they held directly responsible for the current situation. The wide spectrum of grievances listed by them included;

- dry moghas with no water supply for years
- lower officials in connivance with the head reach farmers let them use more water than authorized
- no punishments or sanctions for water theft
- farmers fined collectively (*tavan*) for individual water criminality
- deliberate damage of irrigation works by miscreants to fine innocent farmers
- no registration of police cases without acquiescence of irrigation department
- corrupt water gauge operators
- faulty design of irrigation an drainage works
- unscheduled closures of minors and distributaries
- not adhering to water share schedule
- no desilting of canals
- destroyed banks and silted beds yielding below authorized discharge
- farmer initiatives in mending breaches charged as official works
- water taxes charged even if no canal water used by farmers for years
- bribes extracted regularly for illegally increased outlet dimensions
- no response to grievances by small farmers.

(b) Influential Farmers: Influential farmers and politicians were held directly responsible for intimidating and influencing irrigation department officials and perpetuating inequity in water management. Among other aspects, big and influential farmers and politicians in the areas studied were accused of the following;

- placing of obstacles (including buffaloes) down stream of outlets
- intimidation of Irrigation Department officials on official duty
- widening of outlets
- using unauthorized pipe siphons for increased water share
- bribing officials for sanction of increased water for non existent gardens and fish farms
- manipulating honest Irrigation Department officials posting and transfers by members of parliament

- non-perennial operation of distributaries illegally (closed one week in a month)
- creation of unauthorized additional outlets at cost of other farmers
- diversion of subsidized gypsum for sodic soils away from small farmers
- night theft of water by erecting temporary bunds down stream of outlets.

Thus a much larger sample of farmers from the project area not only confirmed the constraints given above but added the area specific constraints also.

(c) Water Rates Assessment: Most farmers thought that the current water charges were not high. They were also aware of the fact that the Government was actively considering imminent increase in these charges. there was considerable resentment among those farmers who had to pay water taxes even though they had not received any canal water for decades, where as influential farmers paid the same nominal rate while enjoying illegal access to water.

When further asked about the current low water rates, the farmers indignantly retorted that the cost of each mogha to remain at authorized discharged over the year was Rs.10,000 paid informally in addition to the formal water charges. They said that this was in effect the true water rate being paid by them without the concomitant services from the official departments.

The official with the highest visibility at the mogha level is the water tax assessor - the irrigation Patwari. This official is charged with the assessment of a minimum annual amount of revenue from a given surface irrigation network. His current role is perceived by farmers to be dysfunctional, as the system has remained static over several decades. For example, in former times, a tax relief was given by the Patwari for crop failure or for land destroyed by floods or salinity / water logging. This relief, known as *kharaba* is now unknown to the farmers participating in dialogues with the JICA team. Similarly water charges are levied by this official even on land that is fed exclusively by tube well water at the farmer's own expense under the pretext that it lies under command of a given irrigation channel.

(ii) Objectives:

Dialogues with farmers indicated that their desired objectives were clearly articulated, even if the mechanism for achieving these objectives was not. Farmers were unanimous about their felt needs, which saliently included;

- complete lining of the distributaries and minors with well-secured banks upon which motor able paths were constructed; the lining should be deigned to accept the authorized discharge and not the currently low discharges
- increase in water supply if possible to respond to the present intensity
- construction of flow gauges at control points to measure actual discharge at various points
- tamper proof outlets of heavy gauge steel lining
- management by competent incorruptible persons familiar with local farming systems
- any new outlets should be built only after a concomitant increase in irrigation water in the distributary / minor was ensured at the canal head gate
- adequate arrangements for buffaloes to prevent them from damaging minors/distributaries/water courses
- moghas to be designed according to the actual water requirements of the land; in particular the level at the tail reaches be correct
- illegal supply of water to influential farmers be stopped
- closure of distributaries / minors should not be beyond the annual canal closure period
- acceptance of farmer reports to police without Irrigation Department involvement
- provision of water according to the authorized discharges
- realization of heavy fines and other sanctions for water theft and water related crime.

3.5.5 Farmer Perception of Management Options:

After concluding the initial dialogue on grievances and desired situations outlined above, attempts were made to develop a farmer consensus about a workable solution to the constraints and moving towards a realistic attainment of desired goals. The farmers were, therefore, asked to comprehend and perceive various management options that could bring about such an attainment.

Farmers were not aware of detailed mechanisms for achieving such a plan, nor was any reflection on their part forth coming about possible solutions to their current unsatisfactory condition. In fact their responses consistently perceived the problem as being of an external nature and thus, alien to their every day lives. Water received from distributaries / minors was perceived as an external public utility service for which the farmers paid. However, after a great deal of time and patience the following three perspectives emerged which were discussed one by one to arrive upon the best solution.

(a) Improvement of the Existing System: Farmers initially believed that the solution lay in the physical improvement of surface water supply which included increased availability, lining, proper maintenance of canal banks and correct outlet installation and design. Regarding the irregularities committed by both the line departments and influential farmers they vehemently stressed that all political influence should be removed from the institutions and all postings and transfers should be made on merit only. Strict and honest persons should be made responsible for the water distribution and maintenance of canals and in case of any default heavy and exemplary punishment should be awarded. The pre democracy (1971) conditions of institutional independence should be restored.

Controversy among farmers arose on this point, as no one was sure about who would bring about such a change. Many farmers wanted a just dictatorial system instead of democracy, as elected representative of the people were perceived to be the root cause of corruption.

(b) Contracting Out the Distributary / Minor: The dominant popular ideology currently operative in the country is the *theka* , i.e, contracting out requirements of goods and services. The farmers participating in the discussion were no exception to the rule and chose the contracting option as a viable one. they believe at the outset that the Government should hold periodic auctions of minors / distributaries, in which private contractors would be entrusted with their management. These contractors would pay water tax to the Government from the amount appropriated by them from the farmers as water charges.

A lively discussion on this option soon revealed to the farmer that such a contractor could become an exploitative middle man looking only after the interests of influential farmers who could pay higher water charges under the table. The initial naivety of the approach was soon overcome by the pragmatic farmers, who began to realize that such an operation on the ground would certainly not solve their problems or bring them closer to their desired objectives, but would cause further inequity in water distribution.

(c) Farmer Management: After discovering flaws in the above two options, the discussion moved on to the novel approach of farmer-managed surface water supply. Farmers were confident that if the management of the distributary / minor was given to them, they would be able to manage the water adequately. They emphasized that the preconditions for such a farmer-managed approach would be at least;

- an agreed upon discharge with safeguards ensuring the correct amount of water emanating from canal to distributary / minor

- complete lining and strengthening of embankments throughout the length of the distributary / minor
- formation of village committees empowered to fine defaulters with police recognition of these committees
- election to these committees should be by the farmers only and be non political
- the time frame and validity of these committees should be for a maximum period of two years - preferably one year
- monopoly on such committees by influential and big farmers should be avoided and ensured by law.

3.5.6 Institutional Reforms and Farmers Organization - A Proposal Jointly Evolved with Farmers:

Discussions moved on to the final phase of modalities and mechanisms required for farmer managed distributaries and minors. The discussion encompassed a wide variety of related themes including the composition and constitution of committees both at the water course and at the distributary level; responsibilities, powers, privileges and remuneration to the office bearers of such committees; the linkage of such committees to the line departments and their standing as a legal body.

The farmer consensus resulted in the formation of a tentative plan for farmer management of water resources up to the distributary / minor level. This plan is outlined below. Framers created and agreed to this plan with the three main reservations that;

- comprehensive training and initial technical assistance was to be provided to them by neutral people ("such as you (JICA team)")
- the plan should enjoy complete legal cover under notification by law
- the farmers committee should have funds for operation and maintenance of the distributaries.

(i) The Farmer's Character:

There would be two-tiered committee structure, the apex committee being in charge of the distributary / minor and the base committees dealing with all watercourses emanating from a specified distributary / minor.

(a) Water Users Association: Each water course taking off from a distributary / minor will have a 3-member (one Chairman and two members) Water Users association (WUA) voted in by an electorate consisting of the share holders in the watercourse CCA. Each

share holder will have one vote, regardless of size of holding. The committee will be elected for a maximum period of 2 years.

The WUA will be registered with the Corporate Law Authority (CLA) and a bank account will be opened in the name of the WUA, carrying the name of watercourse. The account will be operated by cheques bearing all three signatures of the WUA members.

Such committees will be constituted for all the watercourses taking off from a distributary, regardless of their number.

(b) Farmer Organization: The Chairmen of the WUAs will become members and will constitute the electorate of the Farmer Organization (FO) and will have one vote each. Voting will be in two rounds: one round of voting will select the Chairman, second round will select member finance, member technical and four FO members in such a way that out of the total of seven members at least four are from the lower half of the distributary including the member of finance..

The FO will also be registered with the CLA and joint bank account will be opened in the name of the FO with the title identical to the name of the distributary. The operation of the account will be possible only with the signatures of all three office bearers members.

(c) Powers of FO: The powers of the Chairman of apex committee (FO) would be identical to the powers currently held by a Divisional Canal Officer (DCO) of the Irrigation Department and that of member technical will be analogous to Subdivisional Canal Officer (SDCO).

The validity of all elections under this process would not exceed two years, nor would previously elected candidates be allowed to run for any subsequent office. However, to keep some experienced members in the new FO, 50% of the WUA members could be retained for three years for the first time only. As to which of WUA should be for three year may be decided by a draw.

(d) Auditing Arrangements: Both the Watercourse Committees (WUAs) and the Farmer's Organizations (FOs) will be subject of audit by the Office of the Auditor General, Pakistan Revenue or any other competent authority of the Provincial or Federal Government.

(e) Meetings: The meeting of the seven member Executive of the FO will be mandatory once a month. The complete FO will meet at least every three months and will be paid a specific attendance honorarium. During the FO general body meeting, the FO Chairman

will present a statement of income and expenditure to the general body for information and de facto audit. This would also forestall any incidence of corruption at FO level. In order to reduce expenses and make attendance effective the outlets in a village or adjoining villages may be grouped together to chose one group leader for FO meetings.

(ii) Water Supply Contract:

The relevant line departments would be bound by contract containing checks and balance to ensure a mutually agreed upon regular discharge at distributary head. This contract would be negotiated every two years between the relevant line department and apex committee.

All subsequent maintenance, repair and other upkeep of the distributary / minor and watercourses would be the responsibility of the respective committees constituted for this purpose.

(iii) Water Charges:

Presently the water rates are charged on the basis of crops grown with in the command of a canal, irrespective of the fact whether it has been irrigated by canal water or from a private tube well. Instances in the tail areas of these distributaries were available where the water rates were charged on crops entirely irrigated by tube wells as no water was stated to have been received during the last 10 years. Further, the irrigation Department employs a large staff for assessment of water charges in each cropping season allocating a large Operation & Maintenance budget to this operation.

On the other hand, however, the water is supplied on Rota system in accordance with land holding of the farmers irrespective of what crops they grow. The system is, thus, anomalous and contradictory to the extent that water charges has no relationship with the water supplied but is related to the crop grown by the farmer. This was highly resented by the farmers and they wanted that water charges should be related to the supply of commodity . It was discussed in great detail by the farmers among themselves and with the team . The consensus was that since the quantity of water supplied was proportional to land holding only it will be rational to charge water rates on the same basis. Where as, it will make the assessment and collection much easier, it will also do away with the present system of charging water rates for crops grown by the farmers from their own tube wells. This system will also substantially reduce the cost on assessment and make it very easy for the farmers to assess and collect water charges themselves with out involving any seasonal or yearly assessment . Since the rates will be charged seasonally on the basis of land owner ship it will remain constant unless there is a change in water rates or a change in the owner ship of the farmers . This system was very much preferred by the farmers. This preference when translated to operational terms would

mean that the water charges assessed per season at the time of transfer of the distributary will be divided by the total CCA of the distributary to arrive upon flat rate for that season. The same process will be repeated for the ensuing season. In this way the water charges will be fixed per acre and recovered accordingly. It will have the advantage that the manipulation by the assessor will be eliminated and so will be the assessor himself.

(iv) Financial Arrangements:

The maintenance of distributaries and watercourse requires funding. In addition, the functionaries elected from the farmers will have to be paid a regular salary or perdiem.

Currently, the Irrigation Department is responsible for distributary maintenance with a large number of functionaries, whose salaries are also paid by the department. All these expenses are perceived by farmers to be realized from the water charges.

Under the new proposed financial arrangements, the water charges will be paid by the Farmers Organization (FO) to the relevant department after deduction of maintenance and repairs costs and salaries currently being paid to Irrigation Department staff working on the distributary. A mathematical relationship will be established between the expenses on distributary and that on the parent canal system for future use.

These savings will constitute a generated fund to be used by the farmers' elected functionaries at the distributary level. The expenditure will include maintenance costs and functionary salaries.

The Chairmen of the Watercourse Users Associations will pay themselves a salary equivalent to 2% of the water charges levied on his watercourse, while a further 3% would be paid into the account of the WUA. This amount (5%) is currently being paid as a commission to the Numberdar, whose services would not be required once such an organization is in place.

The remaining 95% of the amount collected as water charges would be paid to the FO who after deduction of its agreed share, would pay the amount to the Irrigation Department / PIDA This deduction would ensure the salaries of staff and upkeep of the distributary by the Farmer Organization.