Chief Engineer, D.G.Khan (1993): A post of Chief Engineer, D.G. Khan, was created in July 1993 by re-adjusting the canal circles in the Multan and Bahawalpur zones. This was considered necessary because of the increased work load of the Multan zone, which had to supervise irrigation activities in 11 districts and 4 civil divisions. In addition, a large number of irrigation and drainage development activities were being planned and implemented in the D.G.Khan Civil Division, which included the management of hill torrents, construction of surface drainage systems, Chashma Right Bank Irrigation Project and other development projects. With the creation of the D.G.Khan zone and re-adjustment of canal circles, the jurisdictions of irrigation zones were redefined to correspond to respective civil divisions better.

1.3.8 1984 Reorganization

In the wake of administrative changes in rapid succession and almost a complete blockade of expansion after the inception of the Indus Basin Project works, there was a general feeling of frustration and despondency prevailing in the department. This started reflecting on the morale, confidence and competence of the staff. As a result of the awareness of this state of affairs, a high level committee, comprising senior echelons of the department and two senior professors of the University of Engineering and Technology was constituted in July 1981 to propose organizational changes to improve the performance of the Irrigation Department.

The committee had, *inter-alia*, noted that there had been a considerable increase in the work load in the field, in respect of revenue and engineering matters. The irrigation intensity had reached an average figure of 110 percent when compared to the designed value of 70 percent. This had resulted in a very keen demand for canal water and a more than 50 percent rise in booking irrigated areas. There were more cases of tampering with outlets and trespassing along the canal banks had increased, especially with the increasing use of tractors / trolleys by the farming community. The cultivators were now more conscious of their rights and required expeditious disposal of their grievances. They had free access to senior officers. Modern means of communications had made them quite mobile. With growing emphasis on development and more powers for local bodies, there was a constant demand for co-ordination and meetings at various levels. However there had been no increase in the original strength of the field staff in the field division, and sub-divisions, since 1937.

In view of the above perspective, the committee made a number of recommendations to improve the working of the Punjab Irrigation Department. The main organizational changes recommended by the committee included 50 percent increase in the revenue staff up to *Ziladar*, 50 percent increase in the engineering staff and 25 percent increase in the canal divisions. This was proposed to be achieved in 2 stages. In the first stage, 25 percent increase in the revenue and engineering subordinate staff as well as 25 percent increase in the sub-divisions, was recommended. Subsequently in the 2nd stage, other changes recommended by the committee were proposed for implementation (Mazhar Ali et al, 1981).

Some of the recommendations were accepted in 1984, with the over-riding condition that no additional funds would be provided. Therefore, it basically meant departmental re-organization; creating some new positions with matching surrenders of some existing positions. A new post of

Additional Secretary and Chief Engineer (Power) were created. The Electrical Inspectors organization was strengthened. A Planning and Review Organization under a Chief Engineer (Planning) was set up. There were adjustments in the functions of Chief Engineers at Lahore and the post of Chief Engineer Central was renamed as Chief Engineer Development, with jurisdiction over the Central Design Office, Project Organization and the mechanical outfit of the Department. The Zonal Chief Engineers and the O&M field staff remained almost unchanged. Recommended expansion of field divisions and sub-divisions was not carried out as an economy measure. Setting up a Board of Chief Engineers at Lahore also did not meet with approval.

1.3.9 Canal O&M Staff

Ever since the creation of the department, there have been substantial and significant social and administrative changes; from empires to the colonial system and then to independence; from separate provincial administration to one-unit administration and back to a federal system; from shared water sources to an independent and integrated irrigation network; from feudal culture to a more democratic system and from large holdings, the extensive fallow lands to intensive agriculture with emerging problems of fragmentation due to immense pressures of a rapidly growing population (Bandaragoda and Firdousi, 1992). Despite these developments, the basic organizational structure of canal O&M and revenue units has remained unchanged, except for the creation of the posts of Chief Engineers and the establishment of new disciplinary wings, such as Drainage, SCARPs and Mechanical, etc.. The jurisdiction, functions and staff strength has not been updated despite tremendous increase in work load caused by the rapidly escalating demand for scarce canal water, rising disputes among the irrigators and sharp decline in the discipline of society.

Table 1.6 presents a summary of the approved positions of the canal O&M and revenue staff since 1980. That there have been few changes in the organizational structure and staff positions in these important disciplines is clearly demonstrated.

Table 1.6. Canal O&M and Revenue Staff Positions.

Staff Positions	No. of Posts			
	1995	1990	1985	1980
A. Engineering Staff				
C.E's	6	5	5	5
S.E's	18	18	18	18
XEN's	56	55	55	55
SDO's	171	171	173	173
Sub Engineers	765	758	768	760
B. Revenue Staff				
Collectors	6	5	5	5
Dy. Collectors	45	45	46	45
Zilladars	421	425	436	435
Patwaris	4495	4469	4485	4480

Source: Punjab Budget Books.

1.3.10 Historical Review of Stature and Agency Performance

The Irrigation Departments have played key roles in developing the world's largest contiguous irrigation network that converted desert wastes into lush green fields. These also have long traditions of performing key roles in the economic and social development of the country.

This grand irrigation system, while providing a livelihood to the millions, also proved to be a massive and lucrative source of revenue earnings for the government during colonial rule. Therefore, it was government's the utmost effort, at that time, to devise a befittingly efficient administrative set-up to manage, operate and develop the irrigation infrastructure. Highlighting the importance and performance of the Irrigation Department, Farooq (1996) has observed:

> *"....The Irrigation Department was accorded a unique and privileged position among all the departments of the province. It was realized that the constant, close and highly technical attention that this Department warranted, was beyond the span of control of one single person. So quite contrary to the normal concept of one secretary as the head of one Department, a unique arrangement of providing four secretaries-cum-chief engineers to head the Irrigation Department concurrently was adopted.....*
>
> *The imperatives of quick processing of financial matters and issuance of timely finances for the Irrigation Department were also fully realized. In pursuance of this requirement, another innovation of bringing the Finance Department to the door-steps of the Irrigation Department was adopted. A Deputy Secretary of Finance Department along with the allied staff was housed in the Irrigation Secretariat. This in-house arrangement resulted in very expeditious disposal of important and urgent cases.....*
>
> *Notwithstanding strict instructions prohibiting incurring of expenditure on works without a budget provision and approval of estimate, a Divisional Officer of the Irrigation Department on grounds of emergency or urgency could take up works for which no financial provisions exist".*

The history of the Irrigation Department's performance has been traced in an exclusive report regarding the reorganization of the Punjab Irrigation Department that was edited by Mazhar Ali (1981). The report brings the factors that have been influencing the working of the Department into sharp focus. Some selected reflections from the above report are reproduced below:

> *".....In the past, the Irrigation Department of the Punjab occupied a top position in the Government's power hierarchy and in national development. Young engineers entering the department had a sense of pride and senior engineers had a feeling of deep professionalism and achievement. They worked with dedication under harsh and difficult environments and made the deserts bloom. The outlook then was progressive and forward looking.....*

During the One Unit period, the department successfully planned, designed, executed and operated two major irrigation projects, viz; the Guddu Barrage Project and the Taunsa Barrage Project. The department had a strong Central Design Office to conceive, plan, design and oversee major projects and to undertake major changes and improvements in operating works. It had also a large construction team to execute major projects expeditiously and economically. It carried out all the complex and difficult studies which subsequently became the basis of the Indus Basin Replacement Plan. Tripartite negotiations on the Indo-Pakistan water dispute among India, Pakistan and the World Bank were successfully handled.....

In 1960, planning, design and construction activities connected with the development of water and power resources underwent a major change. All resources in materials and manpower were diverted to timely completion of the Replacement Works under the Indus Basin Plan. WAPDA was created in 1958 as an autonomous organization to execute the Indus Basin Plan, mostly with the help of foreign consultants and foreign contractors due to Pakistan's obligations under the foreign assistance for the Indus Basin plan. Policy decisions for the execution of the Indus Basin Plan were based on advice of foreign consultants with Pakistani engineers playing only a secondary role.....

Due to pressure of work of the Replacement Plan, a large number of experienced engineers of the Irrigation Department were assigned to WAPDA. No major canal irrigation project outside the Replacement Plan was undertaken during the period 1960-70 as the entire emphasis was on the timely execution of the plan works. The engineers in the Department found themselves at a disadvantage as compared to their colleagues in WAPDA, where they had much better career and professional opportunities. WAPDA was a young, expanding and powerful organization for the Power Sector and execution of all replacement works. Major new projects in the water sector were also assigned to this organization. The transfer of responsibilities for irrigation development to WAPDA adversely affected the professional competence of the Irrigation Department. The engineers in the department were forced into an environment of the inactivity with little chances of professional growth. An organization can blossom only in the face of challenges; inactivity can destroy even the best organizations.

Slowly, but steadily, the Punjab Irrigation Department, which was once the pride of engineers in the field of development and enjoyed a high status in the government hierarchy, went sliding down into near inactivity and stagnation. There were no major projects where the personnel could get important field experience and professional maturity. Departmental promotions became slow as new jobs were not forthcoming. The whole climate became rather stale as there were fewer chances for exposure to modern knowledge and experience. As such, the engineers greatly lost their initiative and confidence."

Commenting on the relevance of the present role structures of the Punjab Irrigation Department in the changed socio-political environments of the society, Bandaragoda and Firdousi (1992) have observed :

".....Organizational structures, distribution of responsibilities and even the size of organizations basically remain in the same form as left by the colonial administration. Minor sporadic changes have resulted only in some appendages, and consequent administrative anomalies...

For instance, the PID, which was created about a hundred years ago, despite its expansion with some new disciplinary wings such as Drainage, SCARP, Mechanical, etc., has not changed in its basic structure of the Open Canal Circles since its creation. Since then, the demand for water has increased manifold due to fragmentation of lands, changes in cropping patterns and expanded irrigable areas, all leading to increased problems concerning distribution of water and disputes among the irrigators.....

Among the institutional factors that affect Pakistan's irrigation performance are the problems of complex and outdated formal rules and procedures compounded by the over riding effect of several socially evolved information institutions, and the associated management deficiencies of a static administrative structure.....

It is recommended to review the present organizational structure of the Punjab Irrigation Department with a view to removing present administrative anomalies and making them more effective in supporting and monitoring irrigation management at divisional level where greater farmer participation can be achieved in decision making."

1.3.11 Foreign Assistance for Water Resources Development and Institutional Reforms

External assistance has played a dominant role in water resource development in Pakistan. Both, the World Bank and the US Agency for International Development (USAID), have provided facilities and finances for development and management of the irrigation infrastructure since the early 1950s. More recently, assistance for the water sector has been provided by the Asian Development Bank, JICA, ODA, and several other bilateral donors. The major foreign-aided projects in Pakistan have included the Indus Basin Replacement Works and Salinity Control and Reclamation Projects (SCARPs) during the 1960s and 1970s; Irrigation Systems Rehabilitation (ISR-I&II) Projects, On-Farm Water Management (OFWM-I, II & III) Projects, Left Bank Outfall Drain (LBOD), and Flood Damages Restoration Projects during the 1980s and 1990s. Some of these projects are still on-going. In addition, two major projects, one for dis-investment of public tubewells and the other to address the overall drainage needs (National Drainage Program), have been launched recently.

Foreign-aided projects have had specific objectives and also carried certain conditions as part of the loan covenants. While these project have contributed significantly towards water resource development and in improving irrigation management in the country, the implementation experience has also brought to focus certain weaknesses and concerns related to optimal utilization of the allocated resources. The major concerns include persistence of waterlogging and salinity as a long-term threat to agricultural development, general lack of financial sustainability, serious issues with regard to adequacy of planning and design of the projects, heavy dependence on technical assistance provided by expatriates, and exorbitantly expensive projects.

The main thrust of investments in the water sector during the 1980s and early 1990s focused on the rehabilitation of the irrigation network to cover the deferred maintenance, and to improve the efficiency of water use at the farm level. The agenda of loans conditionalities, generally, aimed at increasing the O&M funding for the proper upkeep of the irrigation network, raising water charges to bridge the gap between O&M expenditures and system revenues, and phased dis-investment of public tubewells in FGW areas. A review by the World Bank in 1993, however, pointed out the need for major institutional changes in the irrigation management. The major recommendations included treating irrigation water as private goods, re-defining water rights, introducing market incentives for improvements, and establishing public utilities around canal commands to manage irrigation functions with the help of farmer organizations (World Bank, 1994). The proposed reforms have since been extensively debated at the highest policy and public levels. Now the resolution is to pursue a much milder approach to irrigation management reforms that does not contemplate any changes in the existing water discipline, and proposes introducing participatory management concepts by transforming the existing Irrigation Department into an autonomous authority and establishing an Area Water Board in one canal command on a pilot basis.

CHAPTER 2

OBJECTIVES AND FUNCTIONS OF THE PUNJAB IRRIGATION AND POWER DEPARTMENT

2.1 Goals and Objectives of Irrigation Agency

2.1.1 General

Irrigation management deals with the planning, organization, motivation and control of activities to achieve the purpose of irrigation. The activities in irrigation system management can be divided into three main categories: those focused on water, structures and organization.

Goals and objectives are the starting point of the most modern planning and management methods. These provide endpoints, which make it possible to determine the level of the success of an effort. Setting and clear definition of goals and objectives, therefore, is central to the performance assessment of any institution or business enterprise.

The final goal of irrigation schemes should be to improve farmers' welfare through increased agricultural production. This can be achieved if the irrigation schemes are managed according to specific goals and objectives. These goals in ascending order of importance, include appropriate use of water, appropriate use of other agricultural inputs, remunerative selling of agricultural produce and improvement in social facilities (FAO 1982).

The first step in irrigation management is to identify the interest groups with their respective objectives in irrigation. The main interest groups are the farmers, the irrigation agency and the government. Their common aim is to increase agricultural production, but the objectives might sometimes conflict. For example, individual farmers want enough water for optimal crop yield, but in the case of water scarcity, the government or the agency wants the water to be divided among all farmers equitably. The key objective in managing an irrigation and drainage system is to provide levels of service as agreed with the government, irrigation agency and farmers at the minimum achievable cost.

2.1.2 Institutional Set-up for Irrigated Agriculture in Pakistan

A multitude of state agencies and departments share responsibilities for the management of irrigated agriculture in Pakistan. The broad division of responsibilities between irrigation and agriculture starts at the federal level, with two separate ministries, and runs through the sector's whole structure up to the farm level. Irrigation management in Pakistan, thus, follows a segregated organizational structure.

The Water and Power Development Authority (WAPDA), linked with the Federal Ministry of Water and Power, is an autonomous agency responsible for the development of water resources in the country. WAPDA manages the storage dams and operates these in consultation with the Indus River System Authority (IRSA) and Provincial Irrigation Departments (PIDs) according to

the water rights and seasonal allocations of the provinces. WAPDA has also been responsible for the construction of the Indus Basin Project Replacement Works, installation of tubewells in various SCARPs, and installation of drainage projects throughout the country. After the construction of barrages, link canals, tubewells and other drainage schemes by WAPDA, the responsibility for their operation and maintenance is transferred to the PIDs.

The major responsibility for irrigation system management rests with the PIDs, and some of its elements are with Provincial Agriculture Departments (PADs). PIDs undertake some construction works, but primarily attend to the O&M of irrigation facilities, extending from barrages and main canals to outlets, upkeep and maintenance of drainage and flood works, assessment of water charges, and resolution of conflicts among water users. On-Farm Water Management (OFWM) Directorates carry out watercourse lining and on-farm water management, while PADs are responsible for agricultural research, extension and productivity enhancement. On the other end, farm level decisions regarding application of water and non-water inputs are made by the individual farmers. A host of complex factors and the external environment impinge farmers' performance and decision-making processes.

2.1.3 Objectives of the Punjab Irrigation Department

Goals and objectives of irrigation management in Pakistan have not been explicitly set out in any single document. The objectives given below have been extracted from various documents and interviews with irrigation engineers. Objectives directly concerning the Punjab Irrigation Department have been listed. The broader objectives, like `increasing the agricultural production' or farm level objectives of `improving the application efficiency', although quite relevant in the context of overall irrigation management, have not been included because these objectives extend beyond the functional jurisdiction of the department. While irrigation water definitely helps to increase the agricultural production, it is only one of the inputs. Other non-water inputs, as well as farming and marketing policies, impact the productivity of the system. Similarly, the jurisdiction of the Irrigation Department extends up to the outlet level and beyond this, farmers are responsible for managing their watercourses and field applications. Therefore, downstream outlet activities have not been included, except for those specifically included in the purview of the irrigation department, e.g. assessment of water charges, etc..

A. Planning Stage Goals

- To overcome recurring famines.
- To develop vast tracts of barren land.
- To provide livelihood to local inhabitants.
- To improve the well-being of the rural population by stabilizing and increasing agricultural production.
- To generate revenue earnings for the state.

B. Design Stage Objectives

- Improved control and command for the acquisition and distribution of irrigation water.
- Optimal allocation and utilization of scarce water resources.
- Bringing maximum area under cultivation to benefit the maximum population with available irrigation water.
- Partial irrigation with restricted cropping intensities.
- Operation of the system with minimum human intervention.
- Equitable and proportional distribution of available irrigation supplies.

C. Operational Objectives

- Effective and efficient management of irrigation and drainage infrastructure.
- Equitable distribution of available canal supplies.
- Control of illegal water abstractions.
- Water resources development.
- Control of waterlogging and salinity.
- Flood protection of population centers, agricultural land and communication network, as well as the industrial and irrigation infrastructure.
- Revenue generation through efficient assessment of water rates.
- Resolution of conflicts related to the mutual water rights of the share-holders.
- Control of environmental degradation of land and water resources.

D. Objectives of the Water Scheduling

The irrigation system of the Punjab Province is mainly a run-of-river system with a limited storage capacity upstream in the system. Therefore, variability and shortage of surface water supplies are expected. The main objective of the canal operations is to achieve as much equity as possible, and to ensure supplies to tail-end farmers. The objectives of the water scheduling can be categorized as global and operational objectives.

These objectives, for various system levels, are described in Table 2.1 (Shafi and Zaigham, 1996).

Table 2.1. Global and Operational Objectives of Water Scheduling.

System Level	Global Objective	Operational Objectives	Decision-making Authority
Reservoirs and Inter-provincial Canals	• Providing maximum water for agriculture and power generation • Flood and drainage control • Sustainability of the network	• Matching the water demand of different systems • Implementing the Water Apportionment Accord among the provinces	Water & Power Development Authority (WAPDA) and Indus Rivers System Authority (IRSA)
Main Canals	• Deliver water to the secondary system according to the design discharge • Maintenance of the main canals • Satisfy the demand of the secondary system	• Distributing the water shortages or excesses equitably • Minimize the operational cost	Punjab Irrigation Department (PID)
Secondary Canals	• Deliver water to the tertiary canal system according to the design rights • Take care of the environmental impacts • Increase productivity	• Distributing the water shortages or excesses equitably • Minimize the operational cost	PID
Tertiary System	• Providing Water to all cultivators on an equitable basis	• Following the authorized scheduling	Frequently the farmers, occasionally the PID

2.1.4 Review of Department's Goals and Objectives

Vander Velde and Svendsen (1993) have reviewed the goals and objectives of irrigation in Pakistan by conducting review of official published reports and documents, and the interpretation given to the stated goals by irrigation system managers.

The study indicated that a listing of goals for an irrigation projects often presents a picture of bewildering diversity. That the majority of the irrigation staff interviewed defined the equitable distribution of the irrigation supplies to farmers as a system operation objective has been reported. In most cases, the design discharge, or gauge level, was recognized as a target. Increased agricultural production was also identified as a national goal in all the documents reviewed, except the Manual of Irrigation Practice (MIP) and Revenue Manual (RM). The MIP and RM make no mention of any explicit agricultural goals at the irrigation system level. This is understandable because the Irrigation Department's activities do not extend to crop production at the field level. Another irrigation goal mentioned at all organizational levels in all the documents was the need to control water-logging and salinity. Preventing the un-authorized use and theft of water was also mentioned as a system operational objective. The study concluded that articulating clear and specific goals/objectives has not received the attention it warrants. The need to clearly define the goals and objectives of irrigation management in Pakistan, therefore, was proposed. The study also identified inconsistencies in the goals and objectives that have been mentioned in major reports and the actual capacity on the ground, at the operational level, to achieve them.

Two most striking facts need re-emphasis. One is the lack of clear objectives and specific targets for irrigation management in Pakistan and the second is that as a consequence of agricultural development over time, the current water requirements are far in excess of the system capacity during peak demand periods, but the organizational goals have remained unchanged. This means that the existing infrastructure is just not capable to deliver water `on demand' basis or to meet crop water requirements. This gives rise to conflicts between the Irrigation Agency and Farmers and also reflects on the performance and image of the Irrigation Agency. Therefore, there is an urgent need for redefining the objectives of irrigation management through national debate. The objectives have to be compatible with local setting and also achievable given the system constraints. In this context, the observation of Murray-Rust and Snellen (1993) is quite relevant whereby they have postulated that when irrigation managers do not state their objectives clearly, they run the risk of having objectives imposed on them by others.

2.2 Functions of the Punjab Irrigation Department

2.2.1 Irrigation and Drainage: A Provincial Subject

Irrigation and Drainage is a provincial subject in accordance with the provisions of the Constitution of Pakistan (1973). Article 142 of the constitution provides guidelines concerning subject matter of the Federal and Provincial Laws. This article prescribes that the Provincial Assembly shall have the power to make laws with respect to any matter not enumerated in either, the Federal Legislative List or the Concurrent Legislative List. The Federal Legislative List and the Concurrent Legislative List have been notified under the Fourth Schedule [Article 70(4)] of the constitution. Irrigation and drainage have not been included in either of these two lists, and therefore, it becomes a provincial subject.

2.2.2 Official Functions

The functions of the Irrigation and Power Department, as enunciated in the Punjab Government Rules of Business, are given below:

A Irrigation and Drainage

a) Rivers and riverain Surveys.
b) Barrages: construction work and all matters connected therewith.
c) Construction and maintenance of canals.
d) Tubewells and other water utilization schemes.
e) Flood control and flood protection schemes.
f) Drainage schemes.
g) Land reclamation schemes.
h) Storage of water and construction of reservoirs.
i) Basic and applied research in irrigation, hydraulics, groundwater and land reclamation.
j) Administration of the Canal and Drainage Act, 1873.
k) Administration of the Soil Reclamation Act, 1952.
l) Administration of the Land Improvement Tax Act, 1975.
m) Assessment of water rates.
n) Distribution of canal waters.

B Power Sector (Not relevant for the Case Study)

C Service matters, except those entrusted to Services, General Administration and Information Department.

D Purchase of stores and capital goods for the department.

2.2.3 Core Functions

- Operation and upkeep of the irrigation system of the province;
- Planning, prioritization and implementation of maintenance works through approved O&M Work Plans, and under third party top supervision;
- Optimizing the use of water resources in the province by the equitable distribution of irrigation water supplies (about 54 MAF) through 52,000 canal outlets;
- Assessing water rates based on actual field inspections by the revenue staff of the department;
- Implementing the development program portfolio and foreign-aided projects;
- Providing for and executing a plan for the management of river floods in the province, and to construct and maintain flood protection programs/works;
- Promoting the participation of beneficiaries in the management of the Irrigation and Drainage Systems of the province, in line with requirements of the Punjab Irrigation and Drainage Authority (PIDA) Act, 1997;

- Administering the Electricity Act and Village Electrification matters; and
- Acting as the Personnel Department for over 52,000 employees of the Provincial Irrigation Department, including matters related to career development, posting and transfer, promotion and in-service training.

2.2.4 Brief Description of Irrigation-related Functions

Irrigation-related functions of PID Punjab are briefly described below:

i) River Surveys and Hydrology Data

Pakistan's rivers are characterized by mobile beds and meandering river courses due to highly variable discharges and sediment inflow. Changes in river courses are quite frequent, particularly after each flood season. Mapping river courses and its longitudinal sections is an essential activity for effective and efficient planning of the flood protection works. This activity is carried out by the department's Hydrology Directorate and by engineers posted at various barrages. In addition, the Hydrology Directorate makes discharge observations and keeps a comprehensive record of river and canal flows and sub-soil water levels in the province. The record of discharges and water levels forms the basis of planning and designing new schemes. Suspended and bed sediments, as well as some climatological data, are also observed and recorded by this directorate.

ii) Operation and Maintenance of Barrages

Barrages are the gated structures across rivers to affect better control and command for the off-taking canals. There are 14 barrages in the Punjab Province, where 21 main canals off-take and provide irrigation water to 20.78 million acres of culturable commanded area (CCA). Being the most crucial component of the irrigation system for controlled diversion of irrigation supplies, proper and efficient operation and maintenance of the barrages is essential to sustain irrigated agriculture in the province.

Since the construction of new barrages has been frozen for the last two decades, the main responsibility of the department relates to the proper upkeep and maintenance of existing barrages. The major functions under barrage O&M include effective regulation, control of water and sediment flow into the canals, safe passage of floods, proper maintenance of all the barrage components (guide banks, marginal bunds, spurs, etc.), river surveys, repair and maintenance of gates and the superstructure, periodic safety inspections, and carrying out necessary repair works, particularly during the annual canal closures.

iii) Operation and Maintenance of Canals

Effective and efficient operation and maintenance of canals is one of the most important functions of the department for providing assured and equitable canal supplies to the irrigation area. The total length of canals in the Punjab Province is 23,184 miles, with about 4,000 miles of main canals and branches and over 19,000 miles of distributaries, minors and sub-minors. The

operation activities include the efficient management of canals to supply canal water reliably and equitably; data collection, processing and analysis; control of water levels and discharges; monitoring discharges of the canals and outlets; and feedback. The maintenance activities include maintenance inspections, field surveys, preparation of estimates, budgeting, contracting, and execution of approved works. Silt clearance, berm cutting and repair to the canal structures is carried out during the annual canal closure. Comprehensive rules and procedures have been prescribed to implement the works through proper supervision, checks by higher officers, and financial controls.

The department has employed exclusive O&M staff for canal operation and routine inspections, preventive maintenance, minor repairs to the canal banks and structures, and checking outlets, etc.. Inspection officials/officers (Sub-engineers, SDOs and XENs) also carry out routine and special inspections of canals, checking canal operations versus the planned schedules and identifying maintenance needs.

iv) Distribution of Irrigation Water

The main objective of canal operations is to achieve as much equity as possible and to ensure supplies to the tail-end farmers. Within the limitations set by surface water availability, the farmers have the authority to decide most matters related to crop production and cropping intensity. Exploitation of ground water is also managed by the farmers and they are free to share and manage this water. The state management ends at the turn-out (out-let). A seven-day roster called "*warabandi*" is formulated for all the farmers along a water course. The share-holders are expected to operate and maintain the watercourse and implement the *warabandi* system. In the case of a dispute, the state management intervenes and fixes the start and duration of the turn for each cultivator according to his land-holding size.

At the provincial level, a special regulation program is prepared for each crop season (two seasons in each year) and for all canals. These programs are prepared on 10-daily bases and are conveyed to the headworks where the canals off-take. The main canal flows are monitored at the headworks and conveyed to the Regulation Directorate. The Indus River System Authority (IRSA) distributes the water according to the apportionment accord between the provinces. An account of the provincial-level canal flow for a five day period is maintained by the IRSA.

The quantity to be released to a canal is based on the allocation made by the Regulation Directorate, or the indent placed by the canal management, whichever is less. This quantity is then released by the engineer in charge of the headworks. The engineer in charge of the headworks monitors the canal flow and informs variations from the schedule to the Regulation Directorate.

A sub-division is the basic administrative unit of the network and a Sub-divisional Officer (SDO) is the "Regulation Officer" of the sub-division. Each SDO works out the requirement (indent) of the area under his supervision. The water requirement from the tail-end to the head-end is conveyed by the respective SDOs. The SDO is expected to include the effects of events, such as rainfall, canal breaches, etc.. When the supplies are less than the demands, a rotation program is

implemented. An eight-day rotation is usually adopted. The tailend of the distributary would run under this system for seven days (Shafi and Zaigham, 1996).

v) Tubewells

In orders to control the twin menace of water-logging and salinity, about 10,000 tubewells were installed in the public sector under various SCARPs. These tubewells are mostly of deep well turbine type. In some areas, tubewells with centrifugal pumps under a `Grow More Food' program have also been installed. The SCARP tubewells provide supplementary irrigation supplies in fresh groundwater areas in addition to controlling water-logging. The achievement of these objectives very evidently depend on the efficient and economic operation and maintenance of the tubewells. For this purpose, the department has employed exclusive staff comprising operators, mechanics and properly qualified mechanical engineers, who take care of daily operation, as well as special and emergency repairs of the tubewells. The operators are stationed at tubewells for proper operation of tubewells as per operating schedules and local needs. The department also has workshops for the expeditious repair of tubewells. A complete record of the running hours, actual discharge of tubewells and sub-soil water levels is also monitored to evaluate the impact of tubewell operation. As a result of rapidly escalating energy tariffs, O&M costs of the tubewells have increased tremendously . This has forced the government to initiate projects for the dis-investment of tubewells in FGW areas. The responsibility for the O&M of SCARP tubewells in the SGW area, however, would continue within the public sector.

vi) Flood Protection Works

The construction of flood protection works, viz. flood embankments, spurs, studs, etc., is essential to protect irrigation infrastructures and to safeguard agricultural lands, and *abadies* (towns) from the onslaught of floods. Departmental activities in this regard include both, short term measures (temporary protection against river erosive action along its banks), as well as long-term measures (training river flow). For optimal results, precise planning of protection works between the control points on the basis of model studies and then implementing the package in one working season, is recommended. Financial constraints and delays in approval formalities, however, do not allow this and the packages are only partially implemented. This restricts the usefulness of the flood works. The department is also responsible for the proper upkeep of the existing *bunds*, spurs and other flood protection works covering a length of 1600 miles. Flood watching and flood fighting during the flood emergencies is another important function of the department. In addition, the restoration of damages caused by floods is also the responsibility of the Irrigation Department.

vii) Drainage Schemes

As a consequence of the development and intensification of canal irrigation, the necessity to construct surface drainage schemes was felt. Accordingly, a large surface drainage network with an aggregate length of over 4,800 miles has been constructed to facilitate the drainage of rain and seepage water. Major drainage projects are implemented by WAPDA, which are handed over to the Irrigation Department for subsequent O&M. Smaller drains are planned and constructed by

the department. The main functions of the department, therefore, relate to proper functioning and maintenance of completed drainage schemes, as well as monitoring the planning and implementation of new drainage projects undertaken by WAPDA. Maintenance activities include weed and debris clearance; bed clearance; maintenance of banks inlets, bridges, outfalls and other structures; and monitoring the drain flows to evaluate its effectiveness and identify the need to remodel.

viii) Land Reclamation

Soil and water quality and its suitability for irrigated agriculture has an important bearing on the development and sustainability of irrigated agriculture. The department has developed research facilities over the last 45 years to determine water and soil standards and measures for the reclamation of salt-affected soils. Both, biological and chemical methods, have been developed and demonstrated.

The Land Reclamation Directorate is equipped with research laboratories and experimental field stations spread all over the province. Research studies pertaining to soil deterioration, soil survey and land classification, water quality, irrigation water management and water requirements of crops, cropping patterns with regard to the physio-chemical aspects of salinity control and other features of land improvement, are undertaken by this Directorate.

ix) Construction of Small Dams

The development of *barani* areas has been specifically mentioned in the strategies of the 6th, 7th and 8th five-year plans, with special reference to agriculture. As one of the measures for increasing agricultural production in rainfed (*barani*) areas of the Potohar Plateau in the Punjab Province, a program to construct small dams was initiated in the early 1960s.

A common feature of rainfed areas is that agriculture is not developed due to erratic and uncertain precipitation and loss of rain water due to rapid run-off. The high velocity rain water flow generated by steep slopes of the plateau also causes acute problems of erosion of fertile land/soil. In order to address the problem of soil erosion and to conserve rainwater for agricultural development, the construction of small dams offer promising prospects. In order to plan and implement the construction of small dams in the *barani* areas of the Punjab Province, a Small Dams Organization has been established in the Irrigation Department. This organization is responsible for identifying potential dam sites, collecting hydrological, hydraulic, geo-technical and other needed data, conducting feasibility studies, preparing detailed designs, constructing small dams and allied irrigation network. A total of 31 small dams have so far been constructed in the Punjab Province, which provide irrigation facilities to about 36,000 acres of land. Under the Small Dams Umbrella Project (1987-95), 12 small dams have been constructed, along with comprehensive measures for command area development, fisheries development and institutional strengthening.

x) Irrigation Research

While developing the world's largest integrated irrigation system, irrigation engineers and scientists had encountered a number of complex problems associated with the design and construction of large hydraulic structures on permeable foundations, stable alluvial canals, and training / control of large rivers. The Irrigation Research Institute, established in 1924, has now grown into a premier research organization, with facilities for large-scale hydraulic model testing. The research conducted by this institute has led to the development of safe and economic design of large hydraulic structures, dams, spillways, bridges, river training and flood protection works.

Many research projects, of basic and applied research pertaining to the Agricultural Research Council, PCRWR, and WAPDA, are also handled by the Research Institute.

xi) Administration of Canal and Drainage Act

The Canal and Drainage Act was promulgated in 1873 to regulate and control the development of irrigation and the distribution of canal water. The rapid population increase has resulted in mounting pressure on land, increasing competition for canal supplies. The Canal Act is administered by the officers of the Irrigation Department. The divisional and sub-divisional canal officers (XENs & SDOs) have been given magisterial powers and legal authority for the expeditious resolution of water disputes among shareholders, effective administration of the Act, control of encroachments and equitable distribution of irrigation supplies. The enquiries and proceedings under the Act are deemed as quasi-judicial, requiring adherence to the prescribed procedure and a proper understanding of the law.

The main functions of the department under the Canal and Drainage Act include application of water for public purposes, construction and maintenance of irrigation works, supply of water, water rates, recovery of charges, drainage, internal water distribution, and offenses and penalties. Most work connected with the administration of the Canal and Drainage Act relates to the settlement of mutual differences among the shareholders (Section 68), supply of water for new area or change of source of water supply (Section 20), water rates and liability for unauthorized irrigation (Section 33-35), and offenses under the Act (Section 70).

xii) Assessment of Water Charges

Every irrigation system needs money to finance the O&M costs. This is done by collecting water fees from the farmers for irrigation water supplied to them. In the Punjab Province, service charges are recovered from individual farmers in the form of Occupiers' Rates or *Abiana*. This charge is in respect of matured crops in accordance with the provisions of the Canal and Drainage Act-VIII of 1873 (Nasir, 1993).

For the purpose of assessing water rates, there is an exclusive revenue set-up in the department. The revenue wing arranges the initial/final records on which canal revenue is assessed and collected. The cropped area of each field is measured, along with the complete data of each

owner/cultivator, village, channel, outlet and field. This data is recorded in the Field Measurement Book (*Khasrah*) and is subjected to checks and rechecks by a tier of departmental senior officials/officers. Demand Slips (*Parchas*) are prepared for the owners/ cultivators, with details of the crops and the area finally measured and assessed. These are finally delivered to the "*Lambardar*" for distribution among the cultivators. The demand statements (*Khataunis*) are prepared from the *Parchas*. The demand statements are prepared by villages / *tehsils* / districts, and are supplied to the civil administration for the collection of water rates. The district administration collects revenue through village headmen (*Lambardars*), who are allowed to retain a certain percentage of the collected amount.

2.2.5 Review of Current Functions and Activities Versus O&M Universals

All irrigation systems in the world must be properly operated and maintained to sustain its effectiveness. There are common aspects, or `universals', of good operations and maintenance that are present in all good irrigation systems. Basically, these `universals' can be categorized by disciplines (operation, maintenance, equipment management and organizational management) and activities (planning, implementation, inspections, reports). A review of the Discipline-Activity universals for the existing irrigation systems in Pakistan was conducted by USAID Consultants (PRC/Checchi, 1986). The results have been compared with the `universals' in order to assess the relative stage of development / implementation of each discipline and function for Pakistan's irrigation system. The conclusions drawn from the study were that all the disciplines are present in Pakistan's irrigation system; but that detailed functions among the activities in each of these are sometimes non-existent, or very obsolete. The main findings of the consultants include :

- The discipline of operation has an extensive degree of obsolescence scattered through its activities. The activities requiring attention in operations are: criteria/standards; adequate water measurement devices and methods of measurement; benchmark network up-dating; adequate and up-dated maps, files, inventory of facilities and longitudinal sections; coordination of inter-departmental policies and activities regarding priority of irrigation operations.
- The discipline of maintenance is outdated in many instances. The activities requiring attention in maintenance are: modernization of criteria/standards; appropriate physical and financial yardsticks; adequate scheduling of maintenance; updated Schedule of Rates; slow-moving, fractionated, small-scale contracting; lack of equipment at Sub-divisional and Divisional levels; lack of coordination of inter-departmental policies and activities regarding priority of proper maintenance, and enforcement of laws and regulations.
- The discipline of equipment management is very weakly equipped, staffed, organized and programmed to support irrigation system management activities.
- The discipline of management/training for O&M is obsolete in many instances, and in a number of cases, appropriate processes have not been developed. Examples of items needing attention include: authority and discipline; personnel planning and management; work unit responsibilities; job / task work specifications; supervisory transport and communications; and control systems, including budgeting and inspection.

2.3 Performance Assessment and Indicators

2.3.1 Framework for Performance Assessment

The performance of a system may be defined as the acquisition of inputs, and the transformation of these inputs into intermediate and final outputs, as well as the effects of these activities on the system itself and its environment. The performance of a system is represented by its measured levels of achievement in terms of one, or several, parameters, which are chosen as indicators of the systems' goals (Abernethy, 1989). Important aspects in performance assessment are those of scale and audience. The irrigation management impacts the water delivery system up to the national level. The level of achievement can have different contexts and implications according to the perceptions and objectives of the reference level. Another point of interest is that of change in performance expectations over time. An effective management system, therefore, needs to adjust to the changes, both within the system itself, as well as in the external environment.

Small and Svendson (1992) have categorized the monitoring of performance assessment into three types, as given below:

- Operational Performance Monitoring
- Accountability Assessment
- Intervention Assessment

In addition, the fourth category could be identified as Environmental Impact Assessment.

The operational performance monitoring deals with day-to-day monitoring of operational performance. The scheme managers need a consistent and continuous inflow of data to enable them to decide on operational matters. The data include river discharges and reservoir levels, water levels and discharges at various regulation points in the off-taking canals, cropped area, climatological and hydrological data, and water demands. The accountability assessment can be applied to the internal processes of the irrigation organization, the relationship and procedures of the Public Accounts Committees, and the relationship between irrigation agencies and the farmers. For accountability assessment to be fair and objective, the active participation of the various interest groups at different levels needs to be institutionalized. The intervention assessment deals with monitoring of strategic interventions in the system, and is undertaken to determine the ways and means to improve some aspects of the scheme's performance. This may range from modest changes in water distribution procedures to major institutional reforms. The intervention analysis involves assessment of scheme performance at a given time, evaluation of the performance with a view to identifying constraints in effective management, and taking appropriate corrective action.

Irrigation management experts point out that evidence of an effective performance assessment framework, which would help management to evaluate and improve overall performance is still lacking (Murray-Rust and Snellen, 1993). Setting a framework for irrigation system performance is a first step towards analyzing the functions of the irrigation system. This framework needs to be evolved in the context of various components of the system: the irrigation service, the agriculture service and the farmer (FAO, 1991).

Perry (1996) has proposed the minimum set of indicators for performance assessment of irrigation schemes. These indicators are listed below in Table 2.2.

Table 2.2. Perry's Minimum Set of Performance Indicators.

Indicator	Definition / Description
Output / unit land ($/ha)	Standardized gross value of output/ area irrigated
Output / unit irrigation supply ($/$m^3$)	Standardized gross value of output/ irrigation delivered
Output/unit water consumed ($/$m^3$)	Standardized gross value of output/ all water consumed
Return on investment	Standardized gross value of output/ cost of system
Financial self-sufficiency	Water charges / cost of O&M
Relative water supply	Total irrigation supply / irrigation demand
Water capacity	(Sub) system capacity / peak consumptive demand
Environmental indicators	- area lost to waterlogging and salinity - groundwater level fluctuations, etc..

2.3.2 Performance Indicators Used by the Punjab Irrigation Department

The present management information system is based on manual record keeping and data analysis, which depends on irrigation managers' skills and the experience of dealing with day-to-day operation of the canal network within the framework of the organizational structure. In order to help system managers to assess the irrigation performance and for Decision Support Systems (DSS) on operational controls, the departmental codes and manuals prescribe a systematic procedure for data collection, its analysis and reporting. The important performance indicators used by the PID include: operational indicators, accountability indicators, impact indicators, and others. These indicators are listed in Table 2.3, while graphical representation of some of the indicators is presented in Figure 2.1.

Another important dimension of the performance indicators has been that these were evolved in the context of the Irrigation Department's objectives. The main consideration in this regard has been the boundaries of the operation of irrigation schemes. The irrigation management follows a segregated system in Pakistan, whereby the irrigation agency's responsibility is limited to operation and maintenance of barrages, canals, drains, tubewells and flood works. The policy formulation related to agriculture, marketing and pricing mechanism that greatly influences irrigation management goals of higher order on one end, and the watercourse maintenance, farming practices, cropping patterns and use of non-water inputs that affect productivity on the other end of the spectrum, are beyond the jurisdiction of the irrigation agency. Therefore, it can be understood that output indicators involving yields, crop production and socio-economic impacts of irrigation have not been included for performance assessment.

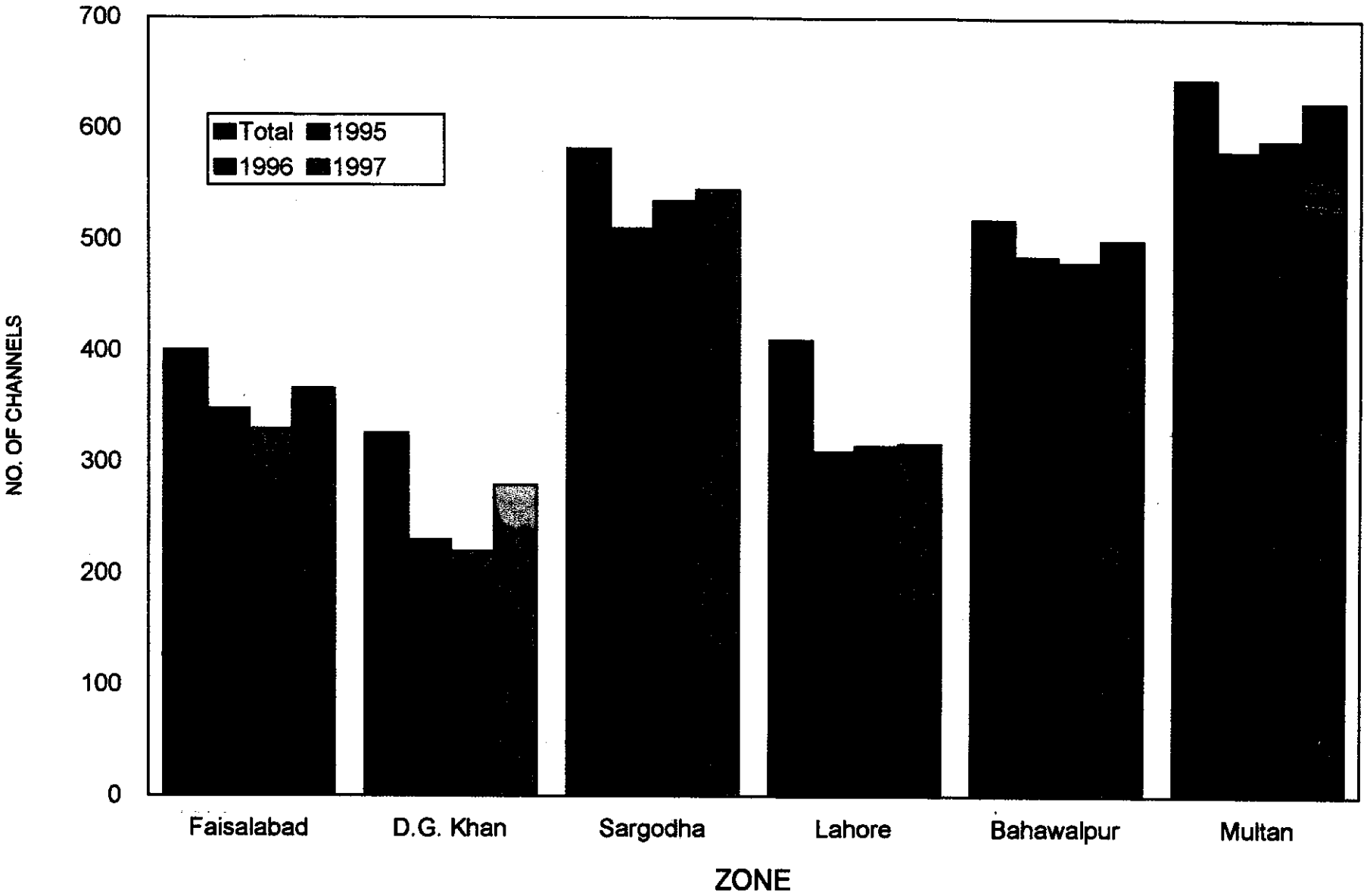

Fig. 2.1(a) . Conventional Performance Indicators of the PID:
Status of Equitable Distribution.

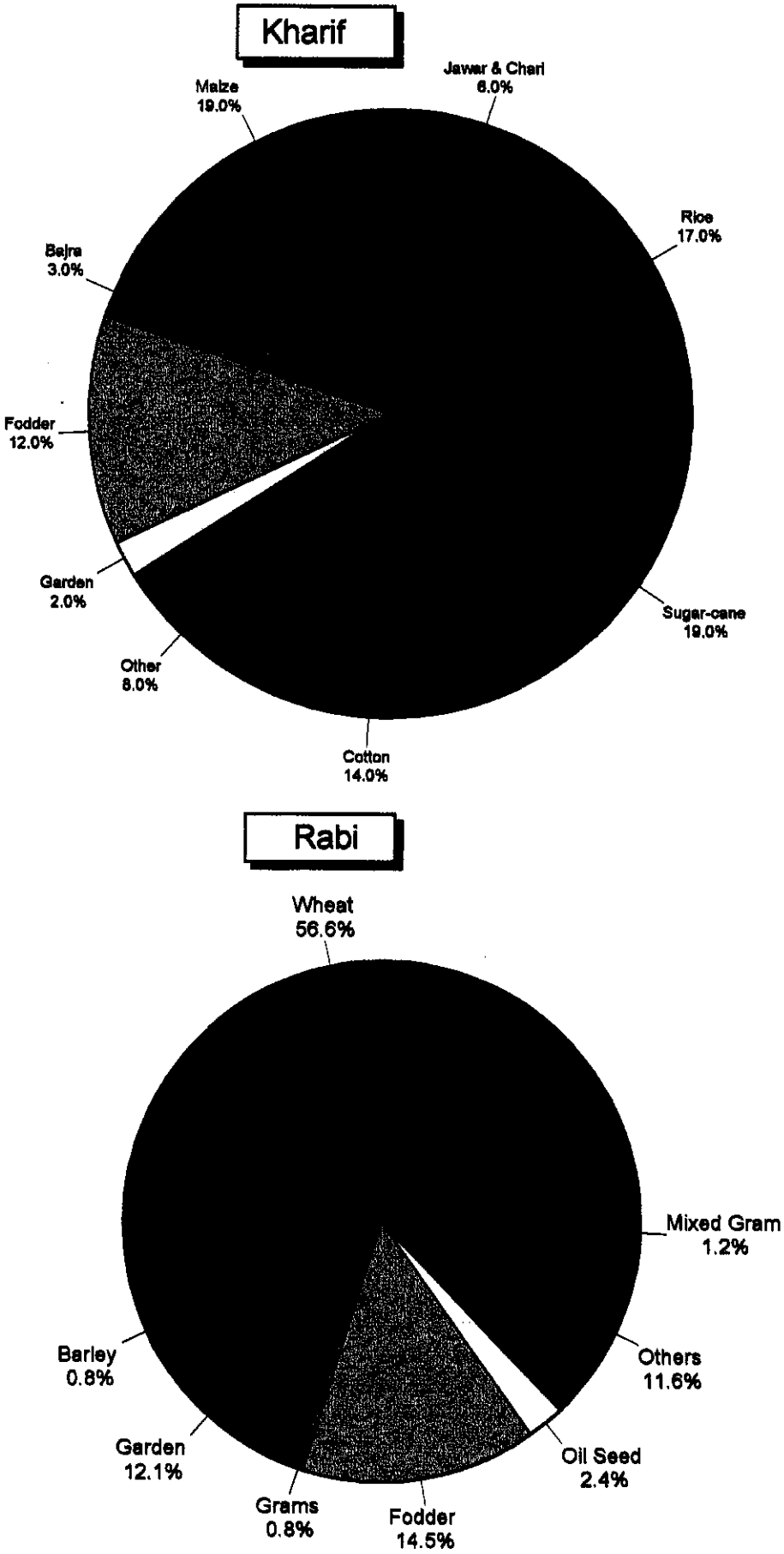

FIG. 2.1(b). CONVENTIONAL PERFORMANCE INDICATORS OF THE PID: CROPPING PATTERN (PIE DIAGRAM) FOR THE LOWER CHENAB CANAL (1978-82).

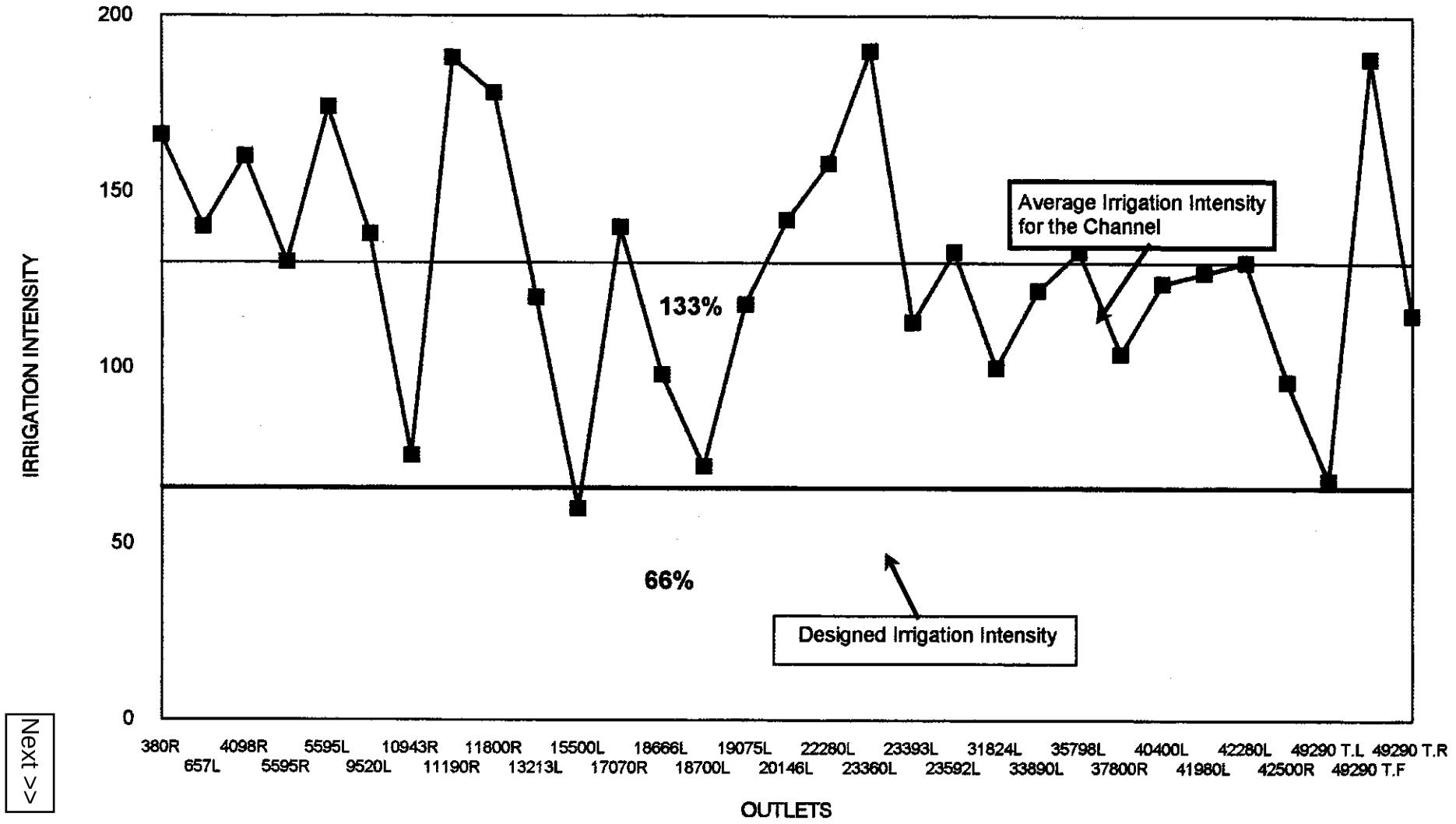

FIG. 2.1(C). CONVENTIONAL PERFORMANCE INDICATORS OF THE PID: ARURI DISTRIBUTARY (1988-89) EFFICIENCY DIAGRAM.