PAPER NO.584

IRRIGATION MANAGEMENT INFORMATION SYSTEM: THE FRAMEWORK AND IMPLEMENTATION STRATEGIES FOR PAKISTAN

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IRRIGATION MANAGEMENT INFORMATION SYSTEM: THE FRAMEWORK AND IMPLEMENTATION STRATEGIES FOR PAKISTAN

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ABSTRACT

This paper describes the framework of Irrigation Management Information system and strategies for its application to irrigation agencies in country. It identifies ways and means of using information as decision making tool while dealing with irrigation management and distribution or irrigation supplies to the farmers. The paper highlights the need for an effective information system along with an efficient monitoring and evaluation mechanism. The paper also discusses the present state of irrigation management information system in Pakistan in the context of existing institutional set-up, management practices and performance indicators.

The effective and efficient irrigation management depends upon timely flow of management data and information. Given the dynamic nature of irrigation systems, the interventions involved and its wide-ranging implications, great deal of data has to be collected by Irrigation Agencies. Managing the flow of data and its integration across the organization is a critical activity for optimizing the interventions. This is accomplished through the design and use of Irrigation Management Information System (IMIS).

Based on the review of the existing systems, the need for rationalizing and updating the existing information system is indicated. The main areas requiring attention include redefining information framework, as well as, improving reporting systems, communication network, quality of data, and Monitoring and Evaluation (M&E) systems. There is also need to more clearly define the goals and objectives of various field units agencies and to set-up in built mechanisms/communication systems and more responsive institutional network can help quite a great deal in setting up an effective IMIS in Pakistan, that in turn would optimize performance of the Irrigation Agencies.

INTRODUCTION

Management is the process of working with and through others to achieve organizational objectives in a changing environment. Central to this process is the effective and efficient use of limited resources. Most authorities frame their definition of management in terms of "action", "processes" or "functions". What is strikingly universal to the definition of management is that all of them relate activities and processes to a goal. In achieving an objective, the management process can be divided into four steps: goal setting, performance measurement, performance diagnosis, and corrective action.

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The basic functional areas of management include planning, organizing, staffing, leading and control. The process of planning is setting the organizational goals and selecting the courses of action that an enterprise will follow. Organizing is the process of establishing an intentional structure that an enterprise will follow. Organizing is the process of establishing an intentional structure of roles for the staff and involves filling positions for the defined roles. Leading is influencing people so that they will strive willingly and enthusiastically toward the achievement of gaols and objectives of the enterprise, while controlling involves performance evaluation and corrective measures. The control activities generally relate to the measurement of achievement against specific goals. Communication pervades the overall management process. It integrates the managerial functions and links the enterprise with its environment. Effective management requires constant scanning of the environment in order to respond to the changing context.

An organized enterprize does not of course, exist in a vacuum. Rather, it is mutually dependent on its external environment, it is a part of the larger socio-economic and political system of the society. This is particularly relevant for irrigation organizations in the developing countries, as they provide an essential input for agriculture in arid to semi-arid climates and thus have an intimate interaction with very large rural population.

In the backdrop of Pakistan's setting, the context of an irrigation system includes irrigation agency's role as manager of water resources and the farmers acting in their role as irrigators, while excluding their parallel role in other aspects of crop husbandry. This distinction is necessary to establish a clear analytical separation between the irrigation system and the agricultural system.

The overall performance of main system managers of irrigation organization depend on two complementary criteria:

- ☐ The degree to which the services offered by main system managers meet irrigation needs, within the limitation imposed by national policies and objectives and by overall resources availability; and
- ☐ The efficiency with which the irrigation system uses resources in providing these services.

MANAGEMENT INFORMATION SYSTEM

The Framework

An information system is a set of organized procedures that when execute, provides information to support decision making and control in the organization (Lucas, 1986). The basic functions of an information system are diagrammed in Fig. 1, while information processing within an irrigation organization is presented in Fig. 2.

The information systems have existed long before the development of computers. However, the explosion of information and the need to process large amounts of data to extract small amounts of information have contributed to the increasing importance of

computer-based information systems. A 'framework' is a conceptual model that helps us understand and communicate about information systems. Many computer-based information systems purport to be to be 'management information system' and an understanding of managerial activities aids in the analysis and design of sub systems.

For most organizations and systems in future, if not already, the determining factor in competition and sustainability would be the processing and analysis of information. The framework for information system proposed by Anthony (1965) includes the following types of decisions:

Strategic Planning: The process of deciding an organizational objectives and the means for achieving them; the planner focuses on the relationship between the environment and the organization.

Management control decisions: Involve a manager ensuring that resources are used optimally to achieve the objectives. Management control decisions are often subjective in their interpretation of information, interpersonal interaction is important in these decisions.

Operational control decisions: Focus on ensuring that specific tasks are completed efficiently and effectively.

Information and its Significance

Information may be defined as some tangible or intangible entity that includes our uncertainty about some state or event (Lucas, 1986). Information is also defined as data that has been processed into a form that is meaningful to the recipient, and is of real perceived value in current or prospective decisions. This means that data have to be processed in some way to produce information; information is more than raw data.

The nature of the problem influences the interpretation of information. How serious is the decision? What are the consequences of an incorrect action versus the gains from a correct one? A more important decision requires extra care in analyzing data compared with a minor decision. Other factors that influence interpretation and use of information include personal and situational factors, organizational setting, and cognitive style of decision maker.

Information can be chracterized in a number of ways. The time frame for information can be historical or predictive. Historical information can be used to design alternative problem solutions and to monitor performance of a system. Information may be expected or unanticipated. Some information system expert feel that information is worthless unless it is surprise to the recipient. However that information which confirms something also reduces uncertainty. Surprise information often alerts us to the existence of a problem, it is also important in developing and evaluating different decision alternatives.

Information may be presented in summary form or in detail. Summary information is often sufficient for problem finding; however both summary and detail information may be needed for other uses. Operational control decisions are characterized by historical

Fig. 1. The Basic functions of an Information System

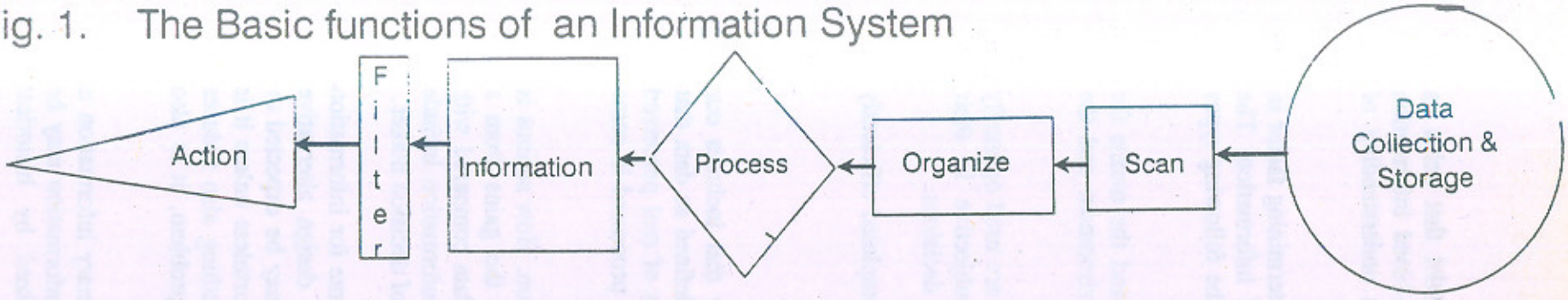
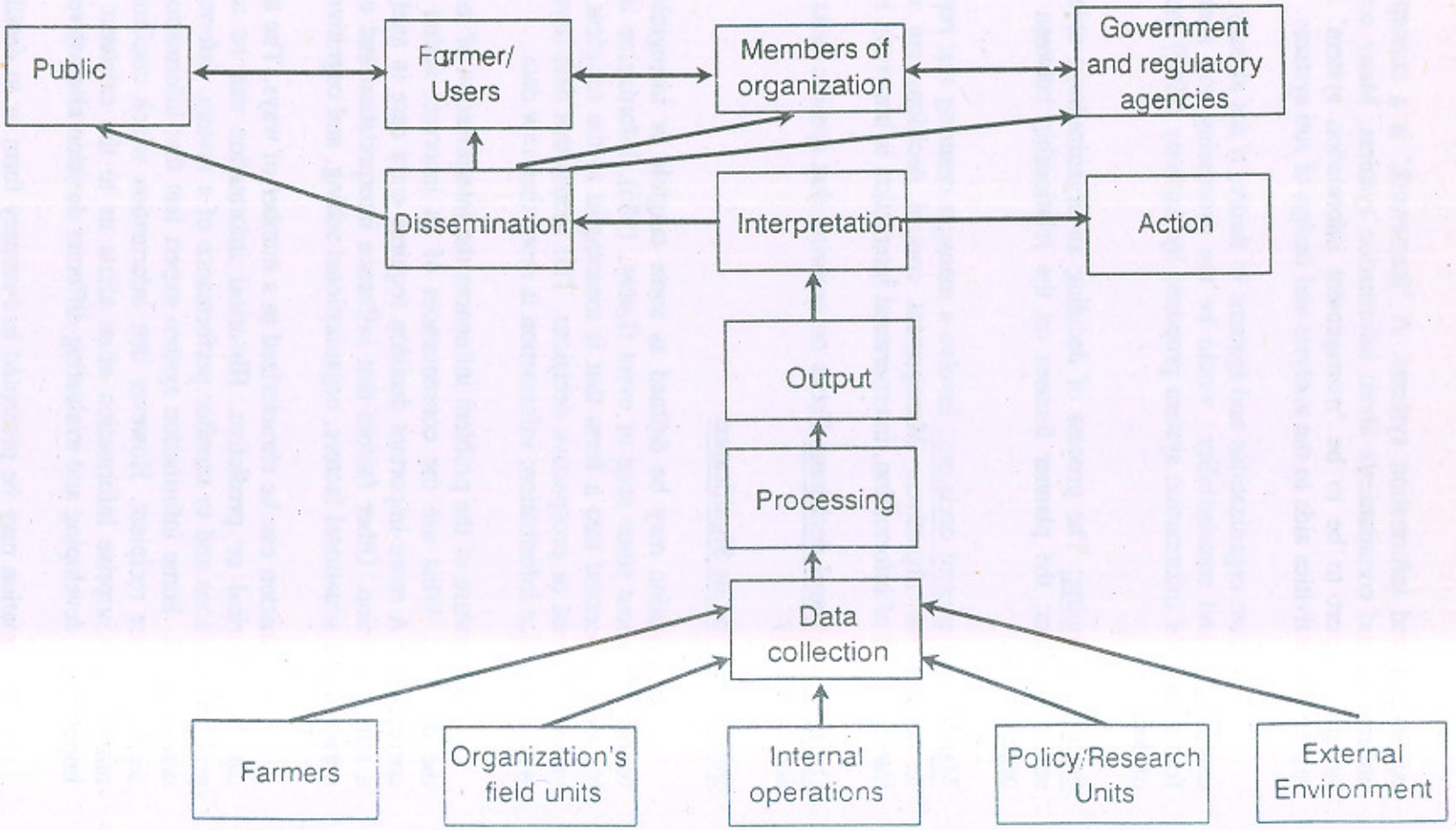


Fig. 2. Information Processing within an Irrigation Organization



information. The information must be detailed. Because we are dealing with day to day operations of the systems, operational control information is often required in close to real time scenario. Information for strategic decisions, on the other hand, tends to be more predictive and long range in nature.

Decision Making

In order to design a Management Information system for decision support system of an organization, we have to understand the mechanism of decision making in a complex system. The human beings solve problems by intelligence, design, and/or choice.

Decisions are structured or unstructured. Structured or programmed decisions have traditionally been made through habit or by routine procedures. More modern techniques for structured decisions involve operation research, mathematical analysis and modelling and simulation through computers. Unstructured or non-programmed decisions are to be solved through judgement, intuition and rules of thumb. Modern approaches to un-structured decisions include special data analysis programs on computers, training for decision makers in heuristic techniques and heuristic computer programs (Simon, 1965).

A manager must be aware of the problem before a decision can be made. A problem exists when the decision makers ideal situation differs from the reality. After noting the existence of a problem, the decision maker must decide what caused it. Having determined the cause or causes, the decision maker tries to solve the problem by developing some program to remedy the situation. In finding and solving a problem, therefore, the decision maker faces a myriad of decisions cycles. What is the problem and what is the cause of the problem? What additional data are needed, and how should the solution be implemented? Each of these major steps in solving a problem involves the solution of sub problems, and many decisions have to be made in the process.

For a manager in an organization, planning stage is important in the management system development, which requires setting objectives and specifying the steps needed to achieve them. These defining functions lead to the strategic management, through which manager establishes an organizations long term directions, get specific performance objectives, develop strategies to achieve these objectives in the light of all the relevant internal and external circumstances, and undertake to execute the chosen action plans (Lucas, 1986). The role of an executive in irrigation management system becomes that of a person making key decisions for allocating resources among the users. In the process, the manager has to deal with data received from many sources which when processed in some way serves as an information for decision support.

IRRIGATION MANAGEMENT INFORMATION SYSTEM (IMIS)

Management Structure and Objectives

The irrigated agriculture system is frequently divided according to basic functions required at various levels. At the highest level, frequently preferred to as the irrigation

sector, the primary constituents are policy makers who are concerned with overall performance of the sector viz. other sectors. This may well affect decisions on annual allocation for operation and maintenance, strategies for food self sufficiency, import substitution, poverty alleviation or the policies for water resources development. These sector level manager/planners must also have a concern for long term sustainability of the physical, financial and social systems that support sector viability as part of strategic decision making.

Below this sector is the agency level, where various institutions share responsibility for management of inputs and services that support the farming community. In Pakistan, irrigation system, there are multipurpose agencies involved in supporting farming community which are Department of Agriculture, Irrigation Department, WAPDA and On-farm Water Management. These agencies are charged with the task of translating overall government or national objectives into regional and district targets.

The third level is that of the irrigation system. Normally this is defined hydrologically because the primary function of irrigation at this level is the allocation and distribution of water. Frequently, managers are viewed as synonymous with the system level engineers within the irrigation system. Management of larger system such as the Punjab Irrigation System is normally geared towards the fulfilment of specific targets that reflect the objectives laid down at agency level.

Data Needs for IMIS

Effective irrigation management depends on timely flow of data and information to assist in controlling the day to day activities of the system, and to provide basis for long term review and performance evaluation. Given the nature of irrigation system, the interactions involved, and the wide ranging implications which flow from the irrigation activity, there is usually great deal of data collected by irrigation agency. Managing the flow of data is a critical activity and for optimizing the interventions, the processes need to be integrated across the organization. This is done by the design and use of Irrigation Management Information System (IMIS).

The content, timing and frequency of information and reports differ according to the function concerned e.g., water control information is required on a continuos basis, sometimes in a "real time" mode, whereas some financial reports will be required on a periodic basis. With the advent of mini and micro-computers of greatly increased power and capacity, the opportunity is arising to achieve significant improvements in the effectiveness of the IMIS, and for achieving economies in staff time and costs. Where communication facilities exist to provide low-cost data transmission links, it is possible to link a network of such computers throughout an organization, including regional and local offices.

Data Collection and Processing

It is not possible to define a universal set of the rules setting out what data is required for management of irrigation system, and how the data should be collected. It is fair to say that management of irrigation system can only be as good as the data it collects, processes

and analyses. Management depends on information. Poor or inadequate information seriously restrict management capability to formulate decisions and manage the system efficiently.

A major problem with field data is accuracy. If field staff are not monitored, then the collection and accuracy of data relies on the commitment of the field-man. Erroneous field data has strong repercussion not only for management of the system but also for future planning. The degree and nature of data processing carried out in an irrigation system for management of irrigation water supplies depends on the level of sophistication of the system and the concern for systems performance improvement. The following basic steps are involved in the collection and processing of data as part of Irrigation Management Information System.

- ☐ Estimation of water demand at tertiary system
- ☐ Forecast of water availability at the head of canal in the given time frame.
- ☐ Deciding on water allocation within the system.
- ☐ Communication of information between system managers/field staff.
- ☐ Monitoring of canal flows within the system.
- ☐ Evaluation of the system performance based on agreed performance indicators.

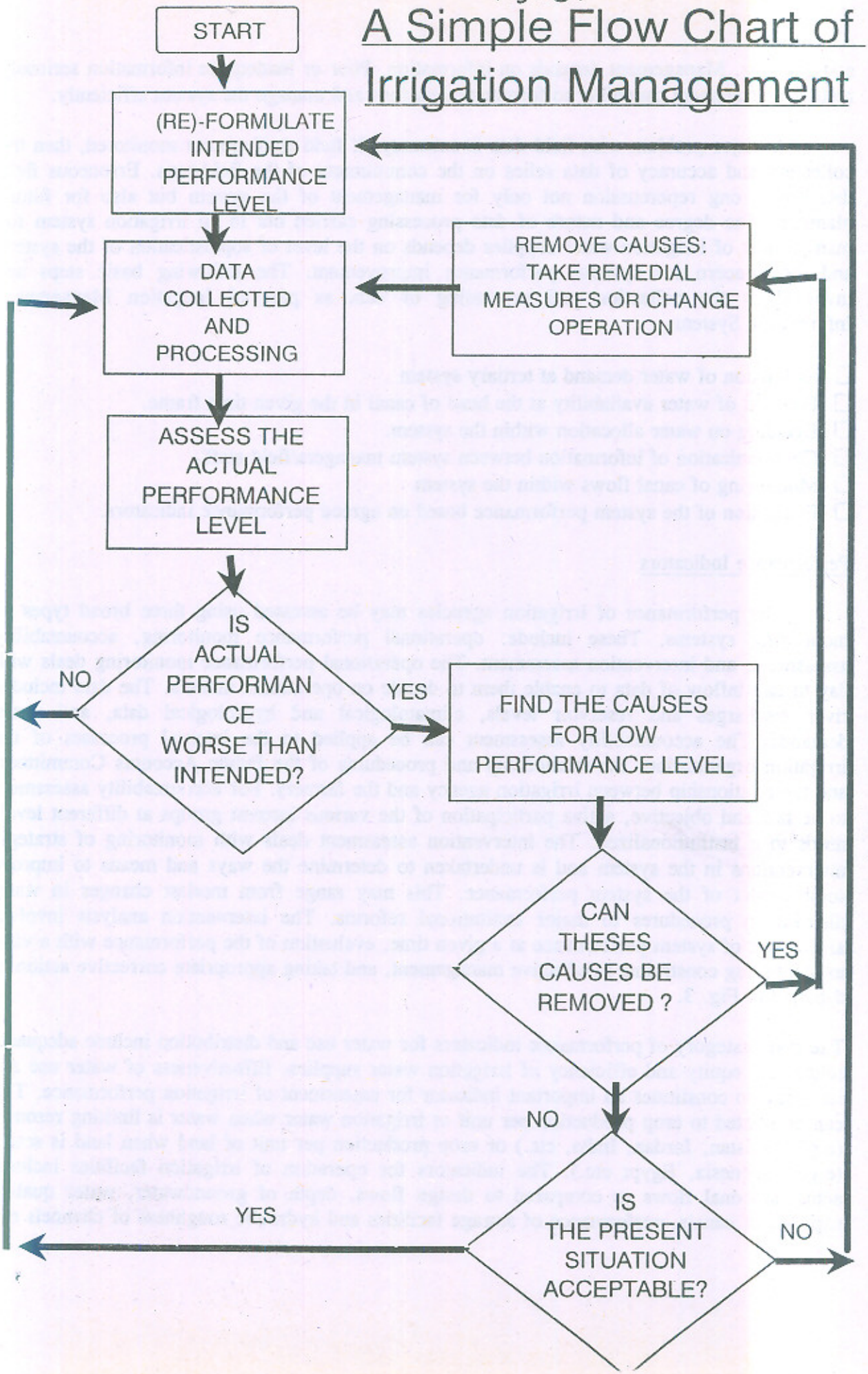
Performance Indicators

The performance of irrigation agencies may be assessed using three broad types of monitoring systems. These include: operational performance monitoring, accountability assessment, and intervention assessment. The operational performance monitoring deals with day to day inflow of data to enable them to decide on operational matters. The data includes river discharges and reservoir levels, 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 agency and the farmers. For accountability assessment to be fair and objective, active participation of the various interest groups at different levels needs to e 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 aspect of the system performance. This may range from modest changes in water distribution procedures to major institutional reforms. The intervention analysis involves assessment of system performance at a given time, evaluation of the performance with a view to identifying constraints in effective management, and taking appropriate corrective action as depicted in Fig. 3.

The main category of performance indicators for water use and distribution include adequacy, reliability, equity and efficiency of irrigation water supplies. Effectiveness of water use and its cost also constitutes an important indicator for assessment of irrigation performance. This can be related to crop production per unit of irrigation water when water is limiting resource (e.g., Pakistan, Jordan, India, etc.) or crop production per unit of land when land is scarce (e.g., Indonesia, Egypt etc.). The indicators for operation of irrigation facilities includes actual seasonal flows as compared to design flows, depth of groundwater, water quality, capacity of canals, performance of storage facilities and hydraulic roughness of channels etc.

Fig. 3.

A Simple Flow Chart of Irrigation Management



In addition, O&M expenditure Vs the yardsticks and degree of cost recovery through water charges are important performance indicators. Level of satisfaction of the users is also a measure of performance assessment and the relative number of complaints from the farmers can act as a performance indictor.

The irrigation management experts point out that there is still a lack of evidence of an effective performance assessment framework, which would help management in evaluating and improving their overall performance (Murray-Rust and Snellen, 1993). Setting a framework for irrigation system performance is a first step in analyzing the functions of the irrigation system. This framework needs to be evolved in the context of various components of the system: the irrigation services, the agriculture service, and the farmer.

Chris Perry (1995) has proposed the minimum set of indicators for performance assessment of irrigation schemes, as depicted in Table 1.

Table 1. Minimum Set of Performance Indicators

Indicators	Description
Output/unit land ($/ha)	Standardized Gross Value of Output/Area Irrigated
Output/unit Irrigation supply ($/$m^3$)	Standardized Cross 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 water logging and salinity ☐ Ground water level fluctuations ☐ Building-up of secondary salinity

THE IRRIGATION MANAGEMENT CONTEXT IN PAKISTAN

Main System Management

The Indus Basin Irrigation system has principally been designed as a gravity flow, supply-based system with low cropping intensities (60 to 75%) to benefit maximum number of users. As winter flow in the river is limited, only 9.4 Mha of area has been provided perennial (year-round) irrigation facilities and 4.6 Mha receive non-perennial (Summer season only) irrigation supplies. Canals are intended to provide equitable distribution of available water with low O&M cost and minimum interference by agency staff. Due to overall water scarcity, equity remains the focus of attention and irrigation management interventions attempts to achieve this objective. The salient characteristics of Pakistan Irrigation System are shown in Table 2.

Table 2. Pakistan Irrigation System: Salient Characteristics

Characteristic	Description
Size	Huge (14 Million ha)
Nature	High Integrated, Supply - Oriented, Little Flexibility, Long Lead Times.
Rain Fall	<5" to 10" (Scanty, Uneven)
Storage Capacity	Less than 10% of Annual River Flows
River Flows	Uneven and Highly Seasonal (70% in 3 Monsoon months).
Design Cropping Intensities	60-70% (With partial irrigation)
Actual Irrigation (in Punjab)	>120% (with conjunctive groundwater use)

The large dams and inter-provincial links are damaged by a semi-autonomous Federal Agency (WAPDA), while a Federal Indus River System Authority (IRSA) has been established to regulate and distribute river flows between the provinces in accordance with the provisions made in the Water Accord (1991). At provincial level, the canals and other irrigation infrastructure are managed by Provincial Irrigation Department (PIDs) and system management decisions are made by the officials of PIDs within Government policies, water rights, technical limitations and availability of supplies.

Water supplies in canals fluctuate in response to variation in river flows, and cannot be adequately adjusted or improved to meet steadily growing crop water requirements and increase in irrigation intensities due to system and supply constraints. The existing principal river storage at Mangla and Tarbela, besides being inadequate, are far away from the tail ends of many canal system. The inter-linked canal systems are long and quite huge by any standards. Water takes 7 to 14 days to reach the field after its release from the sources. Canal water availability for most parts of the year is nowhere near the "On Demand" or "Crop Water Requirement" needs.

Distribution System Management

The distribution off-taking from main canals/branches are generally provided with control structures in the main canal to regulate water levels and discharges. Minors and sub minors originating from distributors generally do not have gates at their heads and supplies are diverted through open masonry structures which work automatically as proportional distributors. There are no balancing storage within distribution system to respond to the demand variations. The unlined channels are designed as regime (non-silting and non-scouring) channels, requiring careful control on silt entry, and a continuous flows close to design discharges partially in summer months when river water are fairly silt laden. They are designed to distribute water equitably while flowing close to "full supply" (i.e. designed) conditions.

Organizational Structure of Punjab Irrigation Department

Administratively, Punjab Irrigation Department (PID) is headed by the Secretary to Government of the Punjab. Under him, there are six Zonal Chief Engineers with territorial jurisdictions and are based in Lahore, Multan, D.G. Khan, Bahawalpur, Sargodha and Faisalabad. Each Chief Engineer is responsible for operation and maintenance of canals and other irrigation infrastructure, including flood protection network, surface drains, and public tube-wells. In addition, there are six functional Chief Engineer, i.e. Chief Engineer, Research, Floods & Drainage, Development, Planning & Review, Co-ordination and Power. In the field, a Superitending Engineer is usually in-charge of a canal system. Where needed, Chief Engineers are also supported by Superitending Engineers for O&M of Drainage network, as well as, public tube-wells, Lower down, there are executive Engineers incharge of divisions.

A Canal Division is the basic administrative unit responsible for performing technical, financial and revenue functions of the Department. The Canal Divisions have exclusive staff for performing Engineering as well Revenue functions. For Engineering tasks, the Executive Engineers are assisted by engineering graduates (Assistant Engineers) and diploma-holders (Sub-Engineers). The Revenue tasks including assessment of water rates and cases of internal water distribution are performed by Revenue staff comprising Deputy Collectors, Zilladars, and Patwaris.

Transformation of PID into PIDA

As a consequence of the irrigation management reforms agenda agreed between Government of Pakistan and the aiding agencies, the Provincial Irrigation Departments (PIDs) are being transformed into an autonomous Provincial Irrigation and Drainage Authorities (PIDAs). The main objective of this transformation is to encourage farmers participation in the irrigation operations at all management levels to improve efficiency, equity of water distribution, financial discipline, and performance of the irrigation system. One of the canal systems would be converted into an autonomous pilot Area Water Board (AWB) and formation of Farmer Organizations (FOs) would also be supported to test the implementation of participatory irrigation management concepts. The legislation of PIDA Act has already been done by the Provincial Assemblies and the Authorities are being established.

PERFORMANCE ASSESSMENT AND INFORMATION SYSTEM; THE PAKISTAN SCENARIO

Monitoring and Evaluation System

Monitoring and evaluation is an essential activity for supporting and guiding management decision through the use of information management system. The decision support system based on information system provide means of effective irrigation system operation and management and enables the managers to anticipate and address the emerging problems and new situations.

The monitoring and evaluation of Indus Basin Irrigation System includes collection and processing of river and canal flows data on daily basis. The canal gauges and discharges

are observed at head, tail and at suitable intermediate points (falls, regulators, etc). The tail gauges are very important information in a canal flow distribution network, as they are indicative of the equity and reliability of the canal supplies and thereby are representative of overall channel and system performance. In addition outlet discharges are observed periodically to monitor actual discharges delivered the farmers at the head of the water course.

The monitoring activity at farm level includes collection of data on irrigated and cropped areas, cropping patterns and planting dates and condition of crops. The rainfall data and ground water levels are observed at designated sites. At irrigation water user level, there is interaction between farmer and irrigation manager that relates to arbitration of water disputes among shareholders, addressing the problem of shortage of canal supplies, and alteration of source of canal supply from one outlet to the other.

Monitoring and evaluation of irrigation system also involves identification of operational problem of channels such as level of free board, stability of banks, extent of siltation of channel bed, and condition of structures, etc. This helps in planning of maintenance and repairs of irrigation network. On the operational side, the irrigation manager has to respond to a host of field conditions for distribution of supplies that involves real time decision-making. These include fluctuating canal water demands, distribution criteria during water-short periods, management of excess flows during monsoon rains, sediment control and canal closures during floods and remodelling of channels and structures, etc.

Traditional Information Tools

The present management information system is based on manual record keeping and data analysis which depends on irrigation managers skills learned during undergraduate and postgraduate engineering education and training institutes/academies and the experience of the managers dealing with day to day operation of canal network within the framework of organizational structure. In order to help the 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. Various reports/statements compiled in each canal division are shown in Table 3 (Revenue Manual, 1966).

Table 3. Division Level Reports / Records

Sr. No.	Type of Report	Description
A	Monthly Reports	1. Statement of daily gauges and discharges of water received during the month. 2. Monthly Delta Statement. 3. Rainfall Statement. 4. Monthly realization of water rates by the Deputy Commissioner. 5. Monthly Irrigation Operation Statement. 6. Statement of unauthorized irrigation and waste of water. 7. Report on cuts and breaches in irrigation canals
B	Quarterly Reports	Statement of delayed revenue cases.
C	Half Year Reports	1. Statement of assessment and realization of water rates. 2. Statement of rainfall during the half year as compared to the half year of the previous year. 3. Kharba (remission of water charges) statements of both crops.
D	Yearly Reports	1. Budget Estimates of revenue receipts and expenditures. 2. Outlet efficiency diagrams. 3. Assessment and remission statement of both the crops.
E	Other Records	1. Outlet registers. 2. Irrigation registers. 3. Register of petitions regarding alterations to outlets and chaks. 4. Measurements and check measurement books. 5. Record of expenditures. 6. Register of stock, tools and plants.

Performance Indicators

The important indicators prescribed for assessing the performance of Punjab Irrigation Department are presented in Table 4.

Table 4. Performance Indicators of PID Punjab.

Sr. No.	Indicator Type	Description
1	Operational Indicators	☐ Indicators that measure/equity of canal water and actual discharge in each off-take compared to the design/authorized discharge. The specific indicators in this behalf are tail gauges and H-registers of outlets and off take. ☐ Delta statement comparing actual depth of irrigation supplies to that of the designed values. ☐ Actual Water and bed profiles of the channels compared to the design profiles. ☐ The incidence of cuts and breaches. ☐ General condition of maintenance of Irrigation channels and structures.
2	Accountability Indicators	☐ Performance Evaluation Reports. ☐ Number of public complaints. ☐ Number of disciplinary enquiry cases. ☐ Number of Audit Paras.
3	Impact Indicators	☐ Cropping intensities and patterns vs. The designed and historic trends (Efficiency Diagrams). ☐ Groundwater fluctuations (well measurements) and salinity monitoring. ☐ Revenue generated. ☐ Public complaints.

REVIEW OF THE CURRENT SYSTEMS AND FUTURE IMIS STRATEGIES

The Current System

The management Information System of PID Punjab had been evolved at the time of development of irrigation system during the British colonial rule. At that time, modern concepts or irrigation management were not in place. Therefore the performance indicators were simple representing the state of knowledge at that time. The more sophisticated indicators like relative water supply, inter-quartile ratios and potential productivity were not prescribed. Nevertheless, the indicators used were quite effective in assessing the performance of irrigation system. Some of these indicators are relevant even today despite considerable differences in the environment and the time horizon. The set of performance indicators, however, need to be reviewed, updated and made more responsive to the present day requirements in keeping with the contemporary management concepts and the current environment.

Another important dimension of performance indicators used by PID has been the boundaries of the operation of irrigation schemes. The irrigation management follows a

segregated system in Pakistan, whereby responsibility of irrigation agency is limited to operation and maintenance of barrages, canals, drains, tube-wells and flood works. The policy formulation related to agriculture, marketing and pricing mechanism that greatly influence 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 irrigation agency. It can there be understood that output indicators involving, yields, crop production and socio-economic impact of irrigation had not been included for performance assessment.

The main concern about the performance assessment of PIDs is the lack of an adequate information system. The problem areas include inadequate information/reporting framework, reporting delays, quality of data, monitoring & evaluation systems, erratic controls and inaction on the part of the managers. In a management study of the department, the consultants had attributed delays in monitoring and reports to lengthy procedures, inefficient/inadequate staff, lack of control by the upper echelons, defective format of reports and lack of staff training (UCL, 1985). In addition, PRC/CHECCHI (1986) identified that individual performance standards are non-specific and inadequately monitored, the chain of command is either ignored or proper communication is lacking, and procedures and organization for enforcement against standards of accountability are not adequately developed.

Redefining Goals and Objectives

Effective management of an organization requires a clear statement by Government or other relevant authority of organizations' mission, or purpose, its powers and those functions which the organization is to carry out and for which it is to be accountable. Management can not operate as a black box, when either the internal or external environment is changing. It is essential that managers and executive understand how to achieve particular targets under a dynamic environment, particularly the one that prevails in case of irrigation management.

Goals and objectives are the starting point of the most modern management systems. They provide endpoint which make it possible to know the level of the success of an effort. Clear definition of the goals and objectives is therefore central to the performance assessment of any organization.

In Pakistan's irrigation scenario, the most striking fact is that as a consequence of agricultural development over time, the current water requirements are far in excess of the system design capacities particularly during peak demand periods. It therefore implies that the existing infrastructure is just not capable to meet the current water requirements, as brought out in Figure 4 for LBDC system. This results in growing inequities/shortages at various operational levels, which give rise to conflicts between the Irrigation Agency and Farmers and it also reflects on the performance and image of the Irrigation Agency. Therefore, there is an urgent need to redefine the objectives of irrigation management and to optimize the resource allocation strategies. The objectives and strategies have to be compatible with the local setting and 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.

Strengthening M&E Capability and Decision Support Systems

The monitoring and performance assessment remains a low-profile activity in the PIDs. There are no in-built mechanisms or incentives that could motivate the managers to know about the level of their performance and need for improvements. They more or less play a passive role and find it more convenient to respond to the problem situations when public complaints arise rather than anticipating them and taking corrective action in advance. The reasons for this attitude of indifference can be traced to the declining morale of the irrigation agency staff triggered by the increasing external socio-political influences and the weakening internal controls of the organization.

The systematic monitoring and evaluation is very essential for supporting and guiding management decisions. This activity has to be conducted on a regular and continuing basis. The main features of M&E system and Decision Support System Framework also require periodic review in order to meet the growing needs of irrigated agriculture and to make them responsive to the dynamic external environment. The major improvements in this behalf include:

- Review the existing M&E arrangements and revive their implementation;
- Enhancing monitoring capability by installation of gauges, calibration of structures, updating discharge tables, and by timely collection/conveyance of data;
- Effective control over data collection, analysis and its interpretation;
- Refining the reporting systems, with emphasis on processing the data to convert it into useful information for the management;
- Introduction of modern information system and performance assessment techniques, as brought out in figures 5 to 7 for groundwater exploitation and water distribution patterns/equity; and
- Close review of the performance of various field units by the top management with reference to the agreed/identified objectives targets and performance indicators.

Computer Applications in IMIS

Some of the most common and interesting applications of micro-computers in irrigation management are in the realms of data storage and retrieval, data processing and analysis, simulation, and geographical information system (GIS). For planning and scheduling of irrigation water, a lot of data processing and analysis is involved. Micro-computers can greatly facilitate data analysis and processing for supporting management decisions. Computer can also be very useful to simulate events which would be dangerous, difficult or costly to attempt in real life. Packages are available which can simulate flow behaviour in canals providing opportunities to study various operation scenarios. This can be in the form of predicting operational constraints, evaluating performance, providing useful information for making management decisions, and training, etc. Shahid, et al (1993) and Shafiq, et al (1990) have reported interesting and useful applications of simulation technique for system

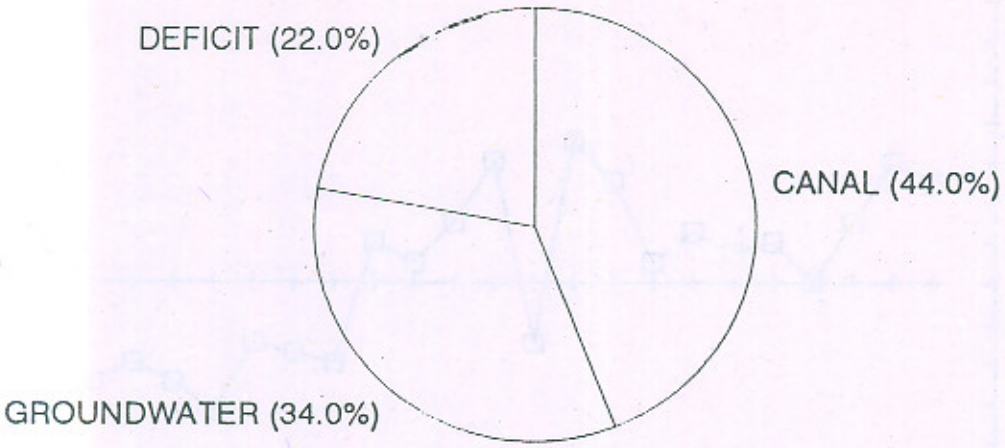


FIGURE 4: NET IRRIGATION REQUIREMENT Vs IRRIGATION SUPPLIES IN LBDC

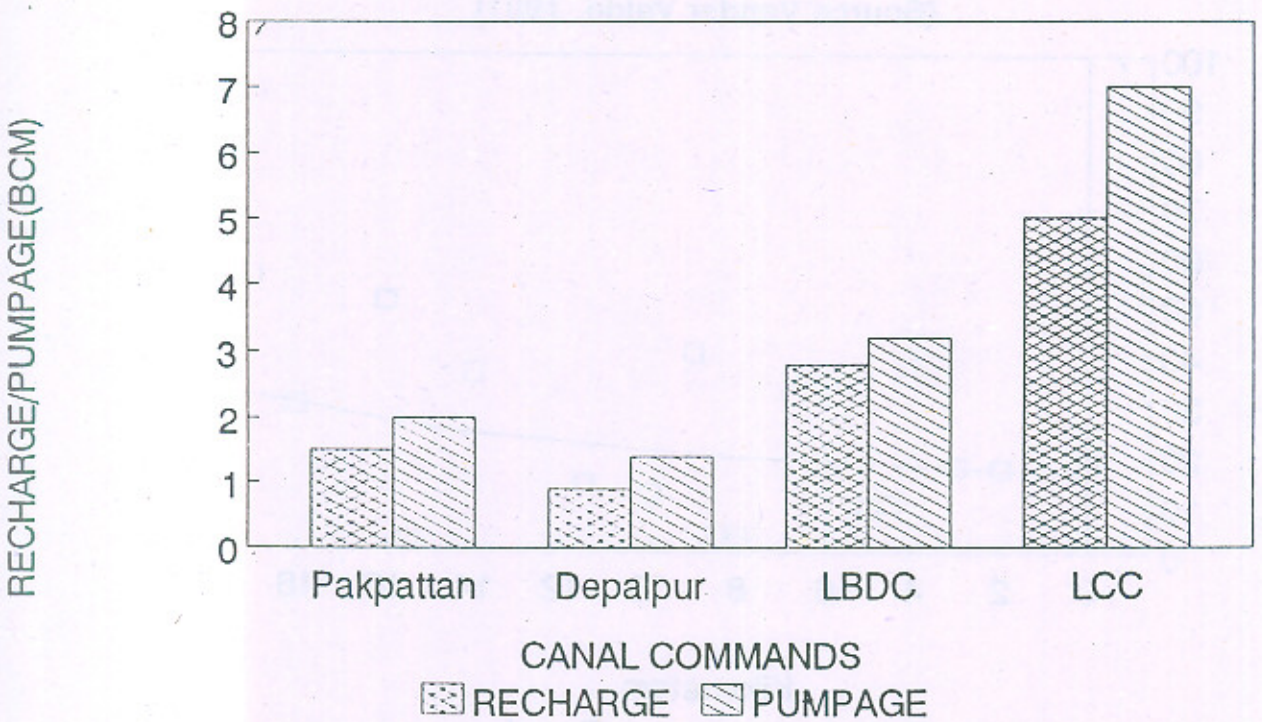


FIGURE 5: GROUNDWATER EXPLOITATION IN FRESHWATER AQUIFERS

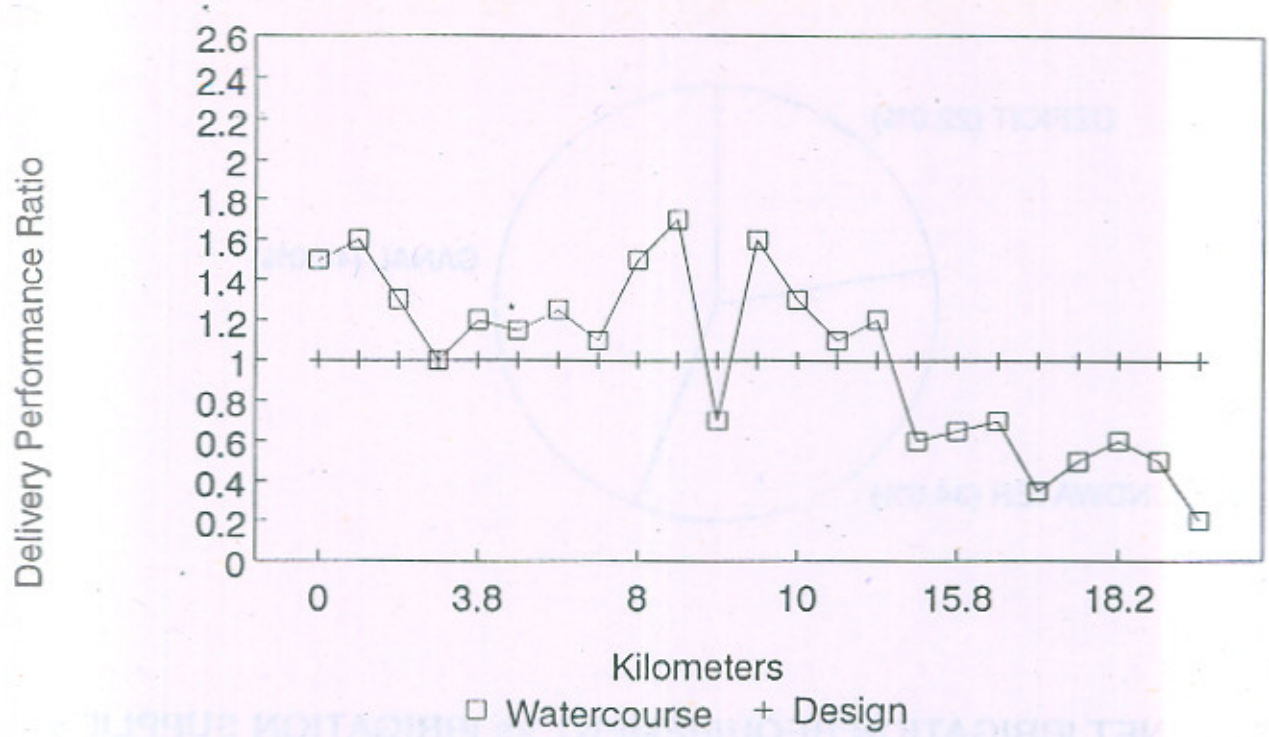


FIGURE 6: LAGAR DISTRIBUTARY WATER DISTRIBUTION EQUITY
(Source Vender Velde, 1991)

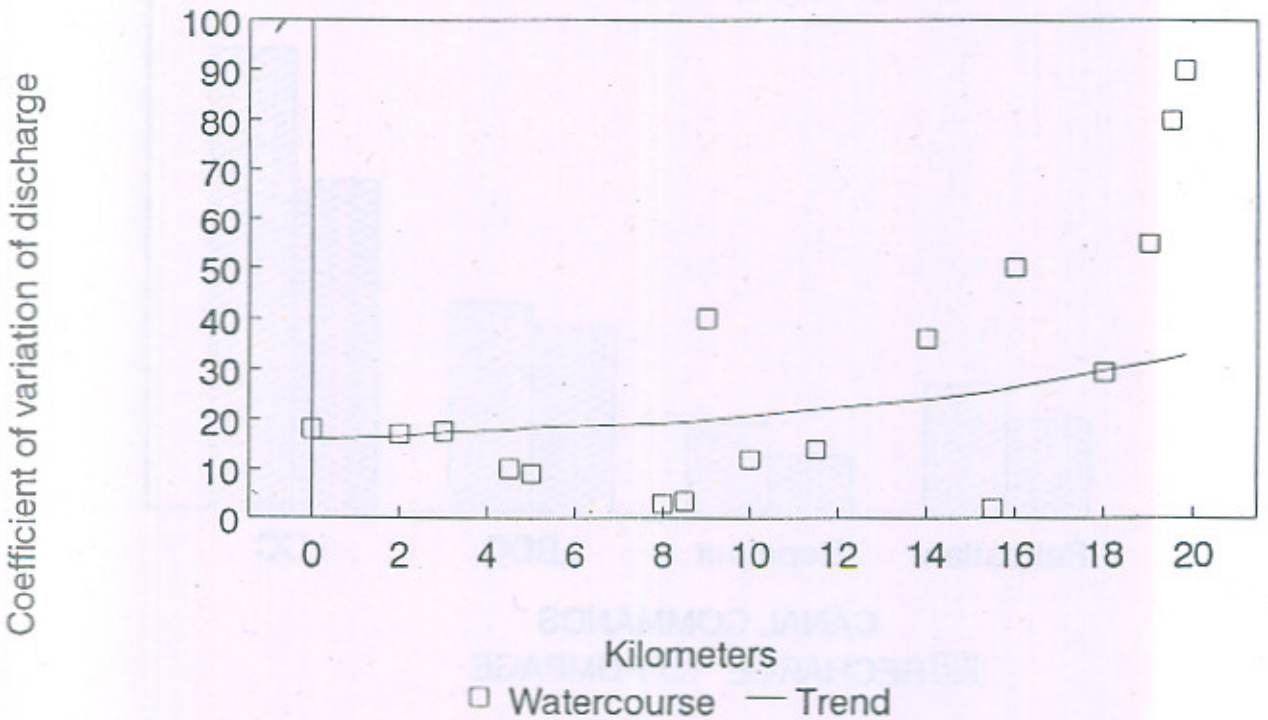


FIGURE 7: LAGAR DISTRIBUTARY: VARIABILITY IN OUTLET DISCHARGE
Source (Vender Velde, 1991)

operation, optimizing the use of limited maintenance budget and formulating good rotational programs, etc. (Haq, 1995).

The mini and micro computers with increased power of data storage/processing after tremendous opportunities to achieve significant improvements in the effectiveness of Irrigation Management Information System. In Irrigation & Power Department Punjab, there are number of micro computers being used for word processing, data base management alongwith use of spreadsheets for analysis and design purpose at Secretariat level, Zonal offices and Circle level. However at present their role in IMIS is minimal. The information processing is in the form of simple batch system, all input data is processed at one point in time to produce the desired output. The input data are collected and used to update files periodically.

There are a number of software developed by the Consultants and Research Organizations like IIMI, who are working on development of IMIS to improve the Irrigation Management System. Analytical and Simulation Tools which have been used in Pakistan are Equilibrium Software (EQ), CFLOW (Water/sediment balance model) and SIC (Simulating Irrigation Channels). WAPDA is also using various versions of "Indus Basin Model" for the irrigation and drainage sector studies. The model can be used to address critical issues of efficiency in water allocations and permits rapid evaluation of alternative interventions, such rates, and improving water use efficiency. The Consultants for Flood Protection Sector Project (M/S NESPAK) are also developing a comprehensive hydro-meteorological model for prediction of flood peaks at rim stations and for flood forecasting at downstream barrages.

There is a need to use the present state-of-the-art technologies for computer applications in simulation of canal flow, regulation, distribution of irrigation supplies within the irrigation net work and optimization of resource use need to be developed and calibrated through a process of monitoring and validation of the model predictions. This would require close co-ordination and interface among the researchers, computer programmers/users and irrigation managers/field staff. There is also urgent need to train the agency staff to enhance computer skills and development of Irrigation Management Information Systems.

Improved Communication System for IMIS

Reliable and efficient communication system is key to the success of Irrigation Management Information System. The information on monitoring and evaluation of the system is to be communicated to the managers/decision makers well in time to enable them to take operational control decisions for urgent action. The existing communication system in Punjab is grossly inadequate and need massive improvements for supporting implementation of an effective IMIS.

The PID's telecommunication system comprises dedicated telegraph and telephone network linking canal regulation points and rest houses with sub-divisions/divisions and circles, sets at the barrages. In addition, the senior and mid level managers (upto Executive Engineer level and also some sub-divisional officers) are connected through public telephone system. The canal telegraph system is however, obsolete, outdated, and mostly out of

working order. The situation becomes much worse during critical monsoon rainfall, storms and floods, when the telegraph system almost totally collapses. As a consequence, communication black-out between the managers, operators and regulation points severely hampers the system managers capability to respond effectively to the emergency situations. The need for a modern and efficient communication system is also indicated in the context of integrated management of Indus Basin Irrigation System characterized by limited flexibility, long lead times, huge size, and over-use. The communication problems in such an environment are largely under-estimated. Hafizullah et al (1996) observed that unless an efficient communication network is in place, the data will not reach the managers in time and therefore may be of little value for decision support systems.

In order to implement an effective and efficient Irrigation Management Information System, improvement and modernization of the existing communication network is of vital importance and the need for conducting a comprehensive feasibility study is urgent and long overdue. The needed improvement options may include expanding public telephone circuits to important subordinate offices/locations, providing fax transmission facility upto XEN level, developing exclusive microwave links or renting microwave channels from Railways, repairs to the existing telegraph system and its operation through private sector, extending the HF radios to cover the remote area, and use of local communication systems for canal divisions/circles.

CONCLUDING COMMENTS AND RECOMMENDATIONS

The following major points and recommendations are brought out:

- An information system is a set of organized procedures that, when executed, provides information to support decision making and control in the organizations.

- Information is more than just raw data. It represents the data that has been processed into a form that is meaningful to the recipient and is of real revived value in current or prospective decisions. The degree of data filtration depends upon the level of the use. Poor or inadequate information seriously hampers the management capability to formulate the strategies and to monitor the level of performance.

- The decision for addressing various problems are made by intelligence, design, and choice. There are two types of decisions: programmed and non-programmed. Programmed decisions are made through habit, routine procedures, operation research or computer modelling. The non-programmed decisions are made through judgement, intuition, and heuristic techniques.

- Effective irrigation management depends on timely flow of data and information to assist in controlling day to day operations and managing long-term impacts of irrigation on the physical infrastructure and environment.

- As consequence of agricultural development and population growth overtime, the current irrigation requirements and expectations are far in excess of system design

capacities. There is thus need to redefine the goals and objectives or irrigation management for optimizing use of water resources and directing the interventions towards a participatory management mode.

- The information system of irrigation agencies in Pakistan had been evolved about a century back at the time of development of irrigation system. Despite considerable changes in the context and environment of irrigated agriculture, the system is still workable provided needed improvements are implemented.

- There is an urgent need to strengthen monitoring and evaluation capability and decision support systems of the irrigation agencies. The main recommendations include review/reviving implementation of M&E activities, effective controls over data collection/analysis, and refining the reporting systems.

- The performance assessment of the irrigation agencies is the most critical activity of the management information system. Setting a framework for irrigation system performance is the first step in this direction. In the context of Pakistan's scenario, the performance indicators based on quality of water distribution provide the guidelines for performance assessment.

- The revolutionary advances in computer technology hold a lot of promise in developing an effective Irrigation Management Information System. The potential applications include simulation of canal flows, regulation or irrigation supplies, water allocation optimization, flood forecasting and database management.

- Reliable and efficient communication system is vital for implementation of IMIS. The existing communication system of irrigation agencies is grossly inadequate and needs urgent improvements. The improvement options may include expanding public telephone/fax connections to important subordinate offices, developing exclusive microwave links or renting microwave channels, repairs to the existing telegraph system, extending HF radios to cover the remote areas and use of local communication systems at division level.

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