IMPROVEMENT OF CANAL MANAGEMENT IN MALIK SUB-DIVISION THROUGH IMPLEMENTATION OF A DECISION SUPPORT SYSTEM

by

Mushtaq A. Khan[1] and Raza-Ur-Rehman Abbasi[2]
[1] IIMI Pakistan
[2] Punjab Irrigation & Power Department

Abstract

The Indus Basin Irrigation System (IBIS) of Pakistan is the world's largest contiguous system, irrigating some 40 million acres with a total canal length of 40,000 miles and a discharge of 230,000 cusecs. In addition, a vast system of link canals was constructed in the 1960's for transferring the water of the western rivers Jehlum, Channab and Indus to the canal system which used to be fed by the eastern rivers of Beas, Sutluj and Ravi.

In a changing environment, the need for research on the applicability of new developments in the irrigation sector for one of the world's largest irrigation systems is evident.

This paper tries to put forward IIMI's experience of implementing a decision support system (DSS) for main system management and will compare the existing practices of the Irrigation Department with improved procedures through utilization of the existing resources. It reflects IIMI's experience in Main System Management as obtained by working with the Punjab Irrigation Department in the Fordwah Eastern Sadiqia (South) area.

This paper highlights the existing practices for the observation of discharges and compares these existing practices with the structure formula. Limitations of the structure formula are discussed, along with the existing procedures of discharge observation, in the context of the irrigation network in Punjab. The opportunities for introducing new techniques to the Irrigation Departments are put forward.

History of Irrigation System Of Pakistan

The history of the Irrigation system in subcontinent can be traced back to the reign of Feroz Shah Tughluq, in the 14th century. At that time Western Jumna canal was constructed by means of putting stones in the river Jumna the water level was elevated to allow it to enter the canal. Inundation canals were made by the farmers and the total area irrigated by these canals was about 20,000 acres. When the British came, around 1850, they constructed more controlled irrigation systems.

History of the Pakistani irrigation system can be divided into two periods. One period is up to 1960 when all of the six rivers were giving water to Pakistan as an entitlement and the second period is from 1960 onward when India got suzerainty over the water of the three eastern rivers as a consequence of the Indus Water Treaty. To cope with this new situation two dams, eight inter river link canals, five barrages and one gated syphon were constructed, while three existing links and two existing head works were remodelled.

After the 1960's, it became a challenge for the Pakistani irrigation managers to run the system in an efficient way. To irrigate the lands in the southern Punjab, the water is released from the Mangla Dam and the water has to travel through the links under gravity for a distance of about 500 kilometers. Four headworks are involved for the diversion of the water, from dams to irrigation canals. The lag time from Mangla to the end user can vary up to six days.

With a command area of over 16 million hectares, the Indus Basin Irrigation System encompasses the Indus river and its major tributaries, three major reservoirs, 19 barrages or headworks, 12 link canals, 44 canal commands and over 107,000 watercourses. In the irrigation system of Pakistan, the water is diverted from head works to main canals, from main canals to branch canals, then to distributaries and watercourses. It was designed a century ago as a gravity flow, run of the river, system with an objective of extensive and equitable use of water. The water has to serve as large an area as possible, and to be distributed equitably to sustain as large a rural population as possible at low cost. It is a supply-based system, i.e. the water allocation and distribution is essentially controlled by the supply at the head of the canal (Haider and Khan 1996).

Agriculture plays an important role in Pakistan's economy. It accounts for 26% of the GDP, provides 80% of overall exports, and employs 54% of the labor force (Siddiqi, 1994). Since climate is arid to semi-arid and annual evaporation exceeds rainfall over much of the cultivated area, irrigation is a necessity, and 75% of the area is irrigated.

Study area

The area selected to implement the decision support system is limited to Malik Subdivision which is located in the south eastern part of Punjab Province starting from the left bank of the Sulimanki Headworks and is responsible for providing the water at the doorstep of 1.4 million acres of agriculture land.

Sulimanki Headworks is 2220 feet (673 meter) long and has a discharge capacity of 300,000 cusecs (8.5 million liters/second). The water distribution at the Sulimanki Headworks is based on the indents (water demand) placed by Executive Engineer of the offtaking canals and it is the duty of the Sub-divisional Officer of Sulimanki to meet these demands.

Basic Concept for the design of the system

The basic concept was to ensure the equitable and reliable supply to the end user with minimum human intervention. So the number of gated structures is very limited. The canal system in Punjab is very long. For irrigating large areas (17,000 to 50,000 acres), only one point of control is available.

Most of the canals in Punjab have earthen embankments causing seepage and resulting in a rise of the ground water table. Furthermore, the porcupines, rats and other living animals living in the banks of canals are a major cause of breaches.

The system is upstream control and operated by releasing the certain depth of water which results in about one foot depth of water at the tail of each distributary and minor.

The design concepts of equity and reliability necessitate effective and efficient management of the system. Regular updating of the rating tables prepared by using a stage-discharge relationship ($Q=KD^n$) is required. Lack of transfer of experience documentation and updating of the procedures are resulting in mismanagement of the system. The irrigation system is old and less flexible to modern interventions.

General Rules for Canals Operation

The Executive Engineer (XEn) and Sub-divisional Officers (SDO) are responsible for the canal operation at the Divisional and Sub-divisional levels. The gauge readers are deputed at every regulation point and are connected to the irrigation communication network through Signallers (in charge of telegraph office). The directions for the canal operations are issued from the Sub Divisional Officers from time-to-time. In case of emergency, the gauge reader passes the information to the concerned SDO through the Signaller, and the SDO directs the gauge reader in return through telegraphic message.

If the Sub-engineer, who is responsible for a part of the subdivision, wants to change the water distribution, he has to get approval from the Sub-divisional Officer for the intended intervention. After approval from the SDO, he can direct the gauge reader to change the water distribution.

The XEN keeps an eye on overall regulation in his Division. He has full authority to pass the orders for a specific regulation point lying in his division at any time for adjusting the water distribution.

The canal regulation is done on the bases of discharge tables prepared and duly signed by the SDO, Sub-engineers and approved by the Executive Engineer for implementation. Most of the discharge tables are based on the downstream gauge using a stage-discharge relationship ($Q=KD^n$). According to rules, the stage-discharge curve should be based on four discharge observations at 25, 50, 75 and 100 percent of design discharge and is supposed to be revised from time-to-time as required. In case of some gated cross structures, the discharge tables are also prepared by using the structure formula.

Canal Operations in Practice

The basic concept, while designing the system, was the equitable and reliable supply of water to the end user with minimum human intervention. So, the responsibility of canal operations was vested to the XEN and SDO to avoid unnecessary actions causing fluctuations in the system. The Sub-engineers have to get approval from the SDO or XEN for changing the water distribution.

The procedures are ideal for a well connected system having real time communication, enabling irrigation managers to make timely decisions. But, in actuality, due to an ill-maintained communication system, violation of canal operation rules are common. Sub-engineers pass the directions to gauge readers without getting approval from SDOs, while gauge readers operate the gates illegally to benefit some cultivator as a favor. These kind of activities result in fluctuations in flows and inequity within the system.

The source of knowledge for the gauge readers is their experience at the specific regulation point. The knowledge about the after effects of different interventions is very limited. A stage-discharge curve is supplied to every gauge reader. The SDO passes the order in terms of discharge to be supplied to a canal and the gauge reader transforms that discharge with the official discharge table to the appropriate downstream gauge reading. Based on his experience, the gauge reader lifts or drops the gates to maintain the targeted level in the downstream canal reach.

IIMI and PIPD started research activities in Malik Sub-division in September 1995 to look for opportunities to improve canal management. In the first stage the research opportunities in the area were explored and documented in the form of an inception report. The installation of gauges, discharge measurements and structure calibrations were done by PIPD with the assistance of IIMI. The data collection network was activated by using the existing resources. A display board was placed in the office of the SDO to present overall water distribution in his sub-division.

During the process of implementing a decision support system for main system management, the following interesting result were obtained.

The usual practice of making the discharge tables is based on a stage discharge relationship ($Q=KD^n$). Only the meter flumes and a few free flow structures are calibrated using the structure formula. This is because of the anatomy of the system, and a tendency towards simplification of methods for the field staff (Gauge Readers). The comparison of the two approaches is as under.

Structure Formula	Stage Discharge Relationship (KD^n)
Data intensive, U/S or both U/S & D/S gauge readings and flow condition is required.	Only one gauge reading (downstream (D/S)) is required.
Regular updating is not required.	Will need little adjustment from time-to-time due to change in bed level and cross-section.
Knowledge about the flow condition is required.	Independent of the flow condition.
Not accurate for the Karri (wooden batons) operated structures.	Depends only on the cross-section, not the type of offtake structure.
Only one discharge measurement may be sufficient for a mogha but four are required for a gate structure.	Four discharge observations are required for preparing a reliable rating curve.

IIMI's experience in Chishtian Sub-division is that the discharge tables prepared by using the structure formula were not acceptable by the ID staff for one or more reasons. The strategy was changed in the Malik Sub-division. Where the discharge tables were prepared jointly by the Irrigation Department and IIMI staff. The KD formula was used for the preparation of the rating table. The new rating tables are in force now. The findings of the exercise were quite interesting for the Irrigation Department Staff and IIMI staff.

Malik Branch:

Malik Branch Canal supplies water to the Malik and Dahranwala Subdivisions. The head regulator is a gated weir type having three bays, the flow condition is orifice modular type during normal flows. Its authorized discharge is 1538 cusecs and its discharge ranges up to a maximum of 2000 cusecs.

Where as the recalibration showed that it was drawing less water than what was officially being recorded according to the old rating curve. This explained why the irrigation manager was not able to feed the downstream subdivision properly . While he was of the view that Malik Branch was drawing already more than its share, this was not the fact.

Figure 1. Rating Curves Comparison for Head Malik Branch

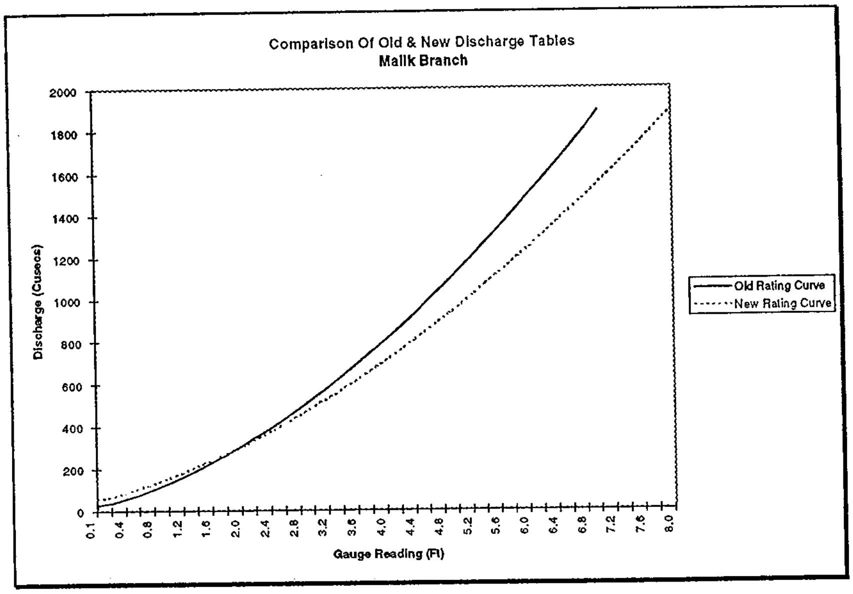
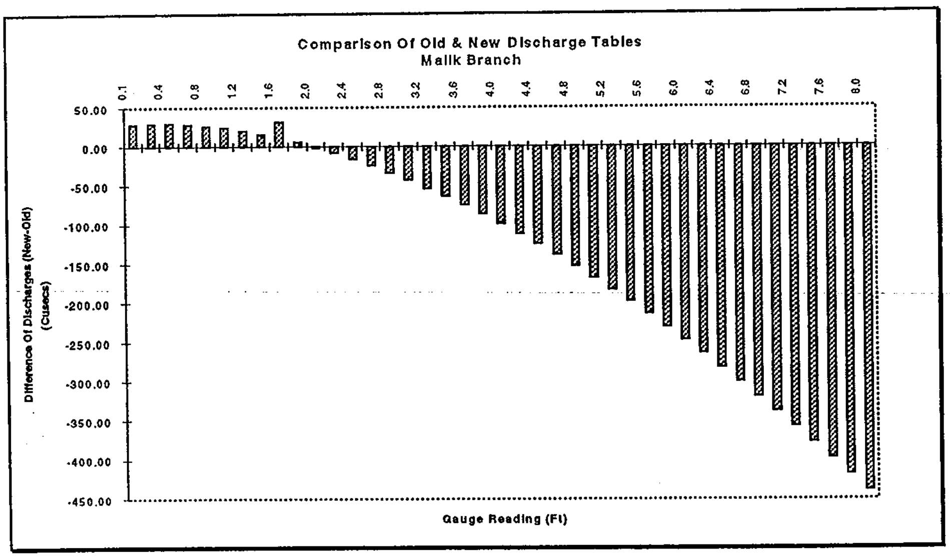


Figure 2: Difference of discharges between old and new rating for Malik Branch

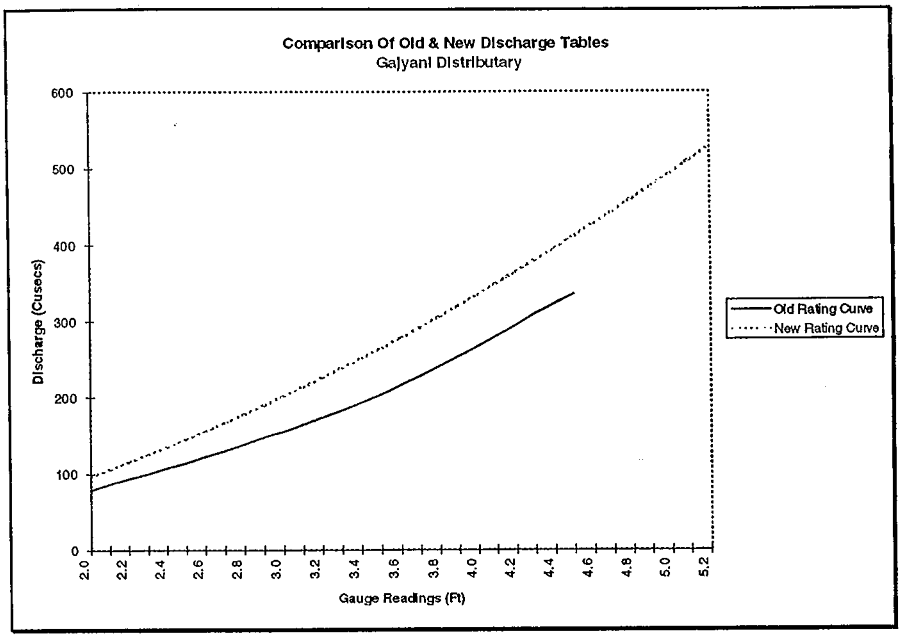


The graph shows that, at the normal flows, the discharge was about 370 cusecs less than what was reported, which is 24% of the design discharge and quite a notable quantity of water.

Gujjiani Disty

The Gujjiani Disty is one of the major distribu- taries of the Malik Sub-division. The Gujjiani disty was drawing more than the design discharge and the old discharge table was showing less. This was verified by the calibration of the canals, outlets /turnouts, and conducting inflow-outflow tests.

Figure 3. Rating Curves comparison for Head Gajyani Distributary



The curve showing the difference in discharges indicate that the Gujjiani Disty was drawing on the average 70 cusecs more than what was reported by consulting the old discharge table. This much dis-charge is enough to run a minor irrigating some 20,000 acres in the Malik Subdivision area and equals 22% of the design discharge.

Figure 4. Difference of discharges between old and new rating for Head Gajyani Disty

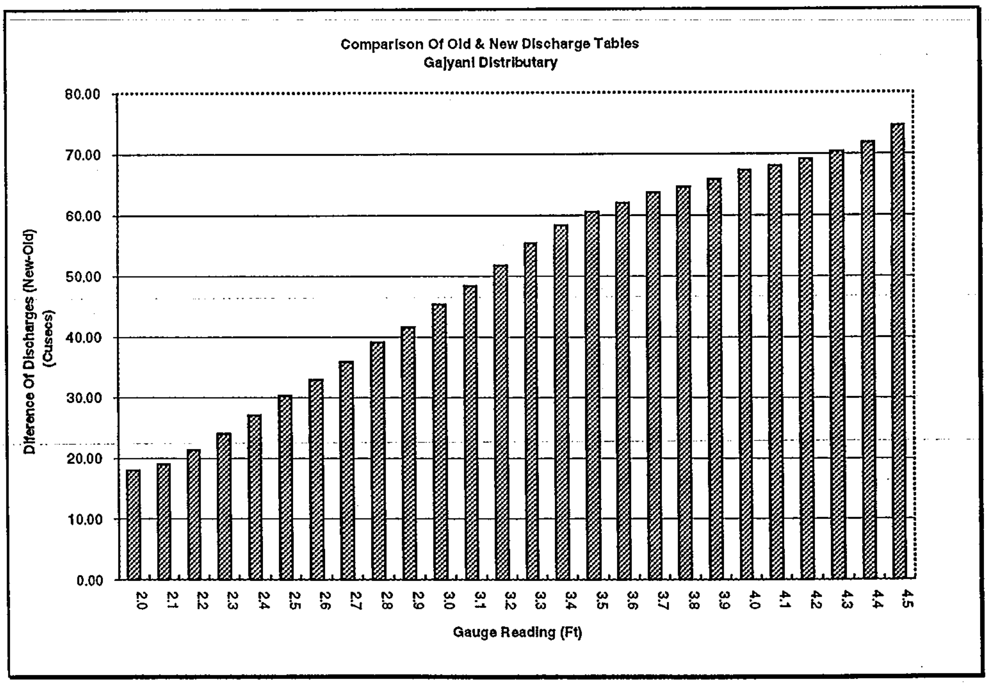
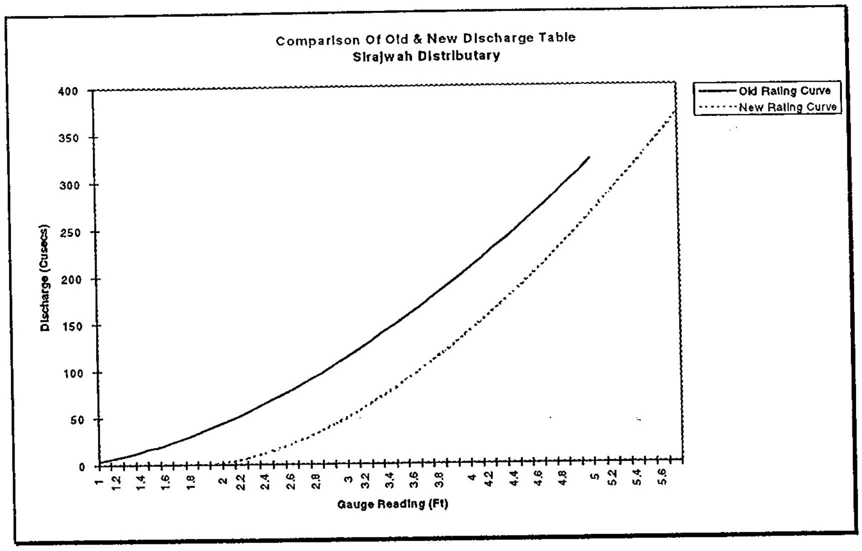


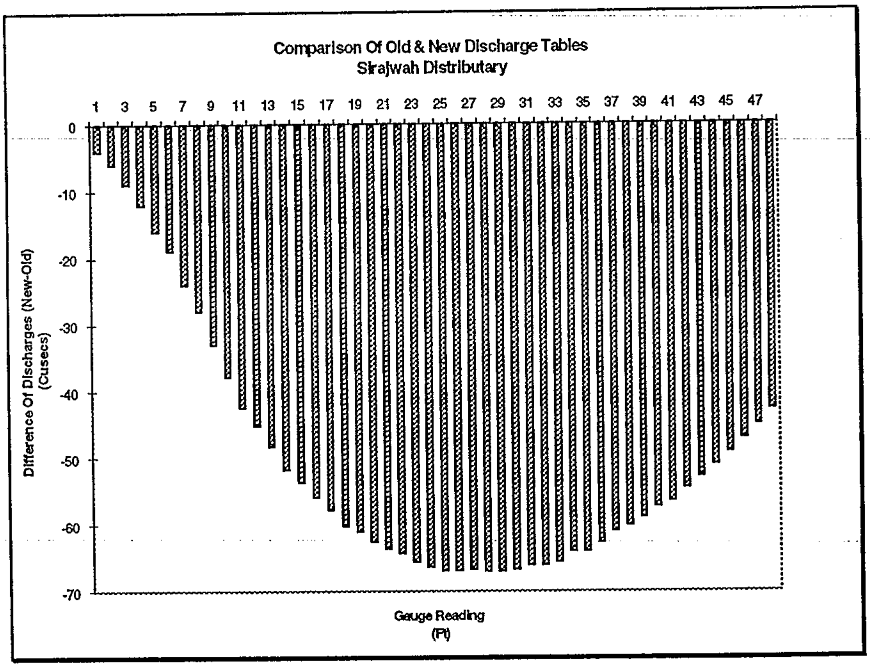
Figure 5. Rating Curves comparison for Head Sirajwah Distributary



Sirajwah Disty

Sirajwah Disty has two minors and one sub-minor. Its authorized discharge is 198 cusecs, but the SDO has to draw about 275 cusecs at the head of the disty, according to, the old discharge table, to feed the tail portion. In this case, the canal was badly silted in the head reach, resulting in reduced discharge capacity and lesser discharges for the higher water depth.

Figure 6. Difference of discharges between old and new rating for Head Sirajwah Distributary



The graph shows the difference in discharges in the old and new (correct) rating curves for the normal flows in the Sirajwah disty is up to 70 cusecs, which amounts to 35.4% of the design discharge.

The purpose of the above discussion is not to criticize anyone. The objective is to identify the factors leading to the mismanagement of the system.

Factors responsible for the mismanagement of the system

The thing that comes to mind is that if one of the SDO's is getting water more than his share, there is a possibility that he will overlook that case. But this is not the case for Malik Sub-division. The main factors leading to this situation are:

I. Change in the priorities of the irrigation manager;
II. Lack of resources (transport, equipment, etc.);
III. No documentation of the experience;
IV. Frequent transfers;
V. External factors;
VI. Weak communication; and
VII. Overburdened with work.

The above mentioned problems can be classified into two categories, one category is of the factors which can be overcome with little effort at the micro level, and the other category needs institutional changes at the macro level.

In the Malik Sub-division, during the process of implementing a Decision Support System, a lot of work has been done for improving the Main System Management. Discharge tables were prepared by the Irrigation Department including those which were depriving them of the extra water they were getting in the past, and then implemented. Analyzing the situation, the inputs of IIMI to activate these PID about the issues are:

I. Training to the PID staff;
II. Resources (Transport and Equipment)
III. Technical assistance; and
IV. Awareness development.

Improvements

The following improvements have resulted from implementing a decision support system in Malik Sub-division

1. After adopting the new discharge ratings, the tail shortages were diminished compared with last year;

2. The disty/minors gate/karries operations are minimized, which is obvious from the constant tail gauges of the minor and disties;

3. The set target has been assigned to the gauge reader by maintaining that, under existing conditions, all shareholders can get their due share without adding more, to tail shortage, or waterlogging and salinity;

4. Due to reliable and on-time data availability, the manager (SDO) had reduced frequent visits to the field and that time was diverted to other important assignments;

5. Some minor's crests were raised (putting more Karries) after identifying that these are drawing more water and tails are over-flowing (more than 1 ft reading on tail gauge);

6. Due to accurate and timely arrival of data to the SDO office, it is now easy for the SDO to satisfy the farmers/visitors and explain the actual condition of the system to his superiors by using the display board (white board); and

7. The field staff have been trained through different field training.

Conclusions

1. The procedural part of the decision support system has been quite successful and it strengthens the existing departmental practices.

2. Monitoring the system has been established, which helped the managers to identify their problems.

3. The problems of communication are largely underestimated in big irrigation schemes. Unless an efficient data transmission network with intermediate nodes and communication lines or messengers is setup with fixed routine procedures, the data will not reach the decision-making center in time and may prove to be useless for improved management.

Recommendations

1. The communication system should be upgraded.

2. The importance of documenting experiences should be realized and a network for the dissemination of experiences should be established.

3. Staff shouldn't be transferred before completion of an established minimum tenure at a station.

4. There should be sufficient resources allocated for the system.

5. Mechanisms for providing the information about new innovations and techniques for managing the system should be established.

6. The field environment should be computer-oriented to facilitate data storage and analysis.