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TRANSITION FROM CONVENTIONAL TO MODERN WATER MANAGEMENT IN PAKISTAN

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SUMMARY – The continuous supply-based irrigation system of Upper Swat Canal in Pakistan with a water allowance of 0.28 litres per second per ha and about 80 to 100 percent cropped area during a year has been remodelled and modernized for carrying increased water allowance of 0.70 litres per second per ha. The new management intensive crop-based operations of the system have not been fully ensured due to lack of understanding of the new concept, lack of commitment and political interference. Results from field data revealed that a slow departure has been made from conventional to more advanced strategies, where the average delivery performance ratio at selected offtake heads before and after introducing the new operations was 0.67 and 0.84, respectively. Farmers refused water with return flow to drains as high as 62 percent of net deliveries during summer 2003 which dropped to about 21 percent in summer 2004 due to improved operations.

Keywords: conventional, modernized, operations, warabandi, water management, cropping pattern and intensity, water saving

INTRODUCTION AND BACKGROUND

Conventional system

Irrigated agriculture has a long history in the Indian Sub-Continent, which was expanded enormously and formalized during the British rule. Central Bari Doab Canal (262,753 hectares) was the first built by the British in 1859 in the Pakistani territory and the process continues. Pakistan depends heavily on irrigated agriculture. Today, an estimated 16.50 million hectares (ha) are being irrigated by surface water supplies through a gigantic integrated canal system.

The historic design water allowance is about 0.25-0.28 litres per second per ha of the culturable command area (CCA) in major perennial canals of Pakistan. Most of these systems were built during the 19th century when the aim was to spread the available water in rivers thinly over a large area in an equitable manner. The idea was to convey irrigation water to as many farmers as possible in order to protect them from crop failure and famine due to drought. The amount of water available to each farmer during his weekly (or more than a week) turn is insufficient to meet full crop water requirements or cover all his land. The targeted annual cropping intensity varied from 80 to 120 percent depending upon water allowance and availability.

The population of Pakistan is growing rapidly at the rate of about 3.1 percent per year over the last several decades and has led to shortages in food and fibre, while droughts have further aggravated the problem. Water demands for agriculture are changing and expanding. More water is needed to grow more food along with the introduction of high yielding crop varieties.

Modernized system

The increasing imbalance between water deliveries and crop water requirements is being met by remodelling some existing systems and constructing new ones, mainly in the North-West Frontier Province (NWFP). The remodelled and new irrigation systems have been designed with sufficient capacity to meet peak crop water demands. The shift in design philosophy has been effected in three major projects; the Upper Swat Canal and Lower Swat Canal, both offtaking from Swat River, and

Chashma Right Bank Canal offtaking from Indus River. Water allowance for these systems is 0.70, 0.77 and 0.60 litres per second per ha respectively. The design annual cropping intensity has been targeted to range from 150 to 185 percent.

WATER ALLOCATION AT FARM LEVEL

Water allocation and distribution at farm level in most irrigation systems in Pakistan is based on a landholding receiving water once a week for a period proportionate to the area of the holding, usually referred to as 'warabandi'. Missing the weekly fixed warabandi turn means that a farmer will have to wait one more week for supply, which can be critical during the peak demand periods. Users can borrow or use free water outside the schedule during lean periods. This mechanism of water distribution to water users was designed for the old 'low water allowance' irrigation systems and continues in the new or remodelled systems with 'high water allowance'.

STUDY AREA

The Upper Swat Canal (USC) in the North West Frontier Province (NWFP) of Pakistan derives its supplies from the Swat River, through Amandarra Headworks, for an area of about 111,740 ha (Figure 1). The system has been remodelled by increasing its capacity from 0.34 to 0.70 litres per second per ha to bridge the gap between supply and demand while the design annual cropping intensity has been increased from 120 to 185 percent. About 75 kilometre length of USC (RD 0 to 242) was remodelled under the Swabi Salinity Control and Reclamation Project (SCARP) in 1998, while the remaining portion of about 50 kilometres was remodelled under the Pehur High Level Canal (PHLC) Project in 2002. The system remodelled under the PHLC Project uses automatic downstream control gates (AVIS and AVIO type) installed at about five kilometre intervals. These gates are sensitive to water level and open or close when level falls below or rises above a fixed level. This study has been conducted in the area under the PHLC Project.

Table 1 gives details of the three offtakes selected in the upper, middle and tail reaches of Maira Branch of Upper Swat Canal system. Three outlets were selected along each offtake for detailed crop monitoring.

All the three offtakes are different from each other in some respect. The Dagi Disty command soil lies on clay loam, Yaqubi Minor has silt clay loam and Pirsbaq Disty has silt clay loam and sandy loam. Dominant crops are wheat, maize, tobacco and sugarcane with varying degrees of cultivation of each crop in each command. Dagi and Yaqubi command are better drained than Pirsabaq.

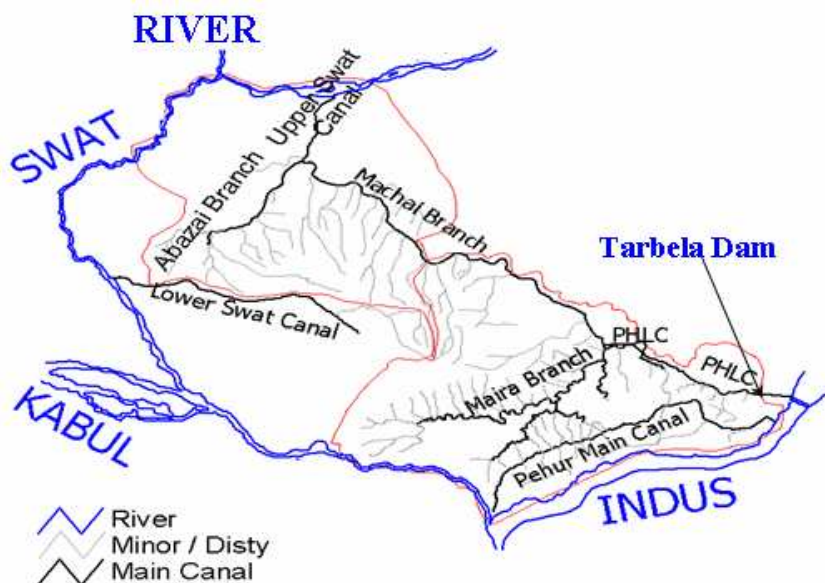


Figure 1. Upper Swat and Pehur high level canal (PHLC) system
 Table 1. Capacity of selected offtakes and outlets.

S.NO.	Selected channel	CCA (ha)	Discharge (cum)	Selected outlets		
				Outlet No.	CCA (ha)	Discharge (cum)
1	Dagi Disty	2464	1.920	3485-R	35.22	0.025
				10450-L	55.87	0.039
				15850-L	61.94	0.043
2	Yaqubi Minor	1354	1.000	2095-R	86.23	0.060
				6300-R	87.85	0.061
				16300-TF	139.68	0.098
3	Pirsabaq Disty	3181	2.391	19020-R	122.67	0.086
				4200-L	31.58	0.022
				15000-TF	103.24	0.072

IRRIGATION SYSTEM MANAGEMENT

The operation of the conventional irrigation system is rigid, supply-based and upstream-controlled, where continuous deliveries are provided throughout the year, if available. This system provides minimum opportunities for human intervention. The design and specific type of infrastructure provided in this system control the water distribution arrangements (warabandi) among farmers. Delivery schedules are governed by flows available in a reservoir or river. In principle, all the canals are run at full supply level, however, rotational operation of the main canal is introduced when supplies fall below 75-80 percent of full supply level for whatever reason, usually seasonal low flows in autumn-winter. The performance of most of these systems has been poor. Widespread inequalities in water distribution and inadequacies arising from capture and monopolization by well placed (head end) and influential farmers have encouraged groundwater exploitation in canal commands for meeting crop water demands and substitute for the erratic nature of surface supplies.

The infrastructure and capacity given in the remodelled and new systems provide better opportunities for flexible and management intensive control. The demand for water by the farmer is dictated by the climatic conditions and stage of crop growth and varies markedly during the season. The flexibility provided by the design and capacity of the lower part of USC under the PHLC Project can accommodate such demand by arranging weekly delivery schedules so that each farmer could irrigate his farm during his weekly turn; the prevalent water distribution arrangements in Pakistan. A new concept of "Crop-Based Irrigation Operations (CBIO)" is being test-implemented under the PHLC Project whereby supply schedules that are responsive to crop water requirements for system operation are being implemented.

The main canal under the project area (40,485 ha) provides in-system storage facilities for minimizing travel times for demands at secondary offtakes. The flexibility provided at the main system level allows full supplies to be withdrawn from the system at the manager or user's convenience.

OPERATING RULES

The system operation is in transition, moving slowly from the old traditional rules to the new modes more appropriate modes for productive irrigation. However, the operating agency has not yet adapted to these changes. Ironically, a more modern, and more flexible system, especially one in which only the main canal, but not the secondary canals have been modernized, demands more intensive management, more vigilance and monitoring of all aspects of the system including crop water demand and usage by the farmers. A comparison of the traditional as well as new rules has been given in Table 2.

OBJECTIVE

Moving from the ninety year old set of operational and management rules to a more complex and management intensive mode is a time consuming process in a big irrigation system. Putting physical infrastructure in place is easier than establishing the new concept of operation and management into the minds of operating agency staff and water users. This study analyses a period of two seasons; one with traditional rules of operations and one with new procedures. The results are compared to assess;

1. canal operation and water usage,
2. cropping pattern and intensity, and
3. constraints associated with the new operations.

Table 2. Comparison of traditional and new rules for irrigation system operation

Traditional rules	New Rules
Run the system at full supply discharge continuously throughout the system.	Run the system at full supply discharge when a channel is open.
Regulate flows in main canal according to water availability in the source, river.	Main canal maintains near constant water level to feed its distribution system. Water availability is not a constraint.
Introduce rotation when water availability/supplies falls below 70-08 percent of full supply discharge.	Introduce rotation when water requirements are lower than design full supply.
Keep offtakes/outlets always open as their closure floods tail reaches of main or secondary canals.	Keep offtakes/outlets open only when water is needed. Main canal has capacity for ponding extra water.

METHODOLOGY

Data collection

Crop data

Crop data of the sample nine outlets on selected secondary offtakes (Table 1) has been collected during two kharif (summer) seasons, kharif 2003 and 2004; one with traditional operational rules and one with modernized operational rules. The survey was done in July during both seasons by visiting each plot of each outlet command.

Rainfall

The average monthly rainfall in the study area varies from 16 mm in November to 222 mm in August based on 20 to 30 years record from meteorological stations (Mardan, Risalpur [Pirsabaq] and Tarbela) in the vicinity of the project. The daily rainfall data for the months of May to August 2003 and 2004 was collected from two different meteorological stations in Mardan and Tarbela. These stations are run by the Survey and Hydrology Organization of Water and Power Development Authority (WAPDA) at Tarbela and by the Sugarcane Research Institute at Mardan. There is another station operated by the Cereal Crops Research Institute at Pirsabak, towards the tail of USC system, however, data for July 2003 was missing and, therefore, was not used.

Operations (flows before and after CBIO)

Conventionally, most irrigation systems with low water allowances in Pakistan are operated continuously with full design supplies throughout the year. Flow shortages occur usually during winter (October to March) due to decreasing snowmelt and low rainfall, whereas summers usually have

sufficient flows to meet design standards. The remodelled Upper Swat Canal system has been provided with higher allowances, which fulfil the crop water demand of the command and the offtakes are supposed to be rotated for closure during low demand periods. Water deliveries in this canal now have a reliable water source from the Indus River via Tarbela Dam reservoir under an Inter-provincial water accord (641 mcm).

Offtake deliveries

The remodelled system has been provided with Crump weirs downstream of the head regulators with a good calibration. The calibrations were field checked against measurements with current meter. Water delivery data were collected at the head of selected secondary offtakes two or three times a week during Kharif 2003, while daily data were collected during Kharif 2004. The delivery performance ratio (DPR), which is the ratio of actual discharge at the head of offtake to the full supply design discharge of the channel, has been used to analyze withdrawals during the two seasons. The higher the value of DPR, the higher the actual discharge and vice versa.

On-farm water use

A survey was conducted to investigate the actual practice of warabandi in the nine selected outlets, twice a week over the two seasons. Field visits were not fixed for certain days but were rotated each week i.e. Sunday in one week was followed by Monday of the following week and so on. The surveyors observed whether water was being distributed according to the formal warabandi schedule and determined the fate of un-used irrigation water, since the natural topography of the area is such that most of the watercourses end in or have been connected to natural drains.

Role of water users

The regulation of irrigation canals is under government control through the irrigation department; however, irrigators have started playing an informal but important role during the recent years. Requests to open or close secondary offtakes are a common phenomenon now and sometimes local users act on their own initiative too. The locks at head regulators of secondary offtakes can be easily tampered with and water users can take control of the head regulators. There are many instances of lock breakage by farmers.

RESULTS

Cropping pattern and intensity

Flows were first released into PHLC from Tarbela in February 2003. Crop surveys on the sample outlets show that overall cropping intensity was 86.6 and 97.5 percent in Kharif 2003 and 2004, respectively. The lower intensity in 2003 is because of restricted supplies in the tail reach of USC due to malfunction of some new automatic cross regulators and some flow constrictions in the Maira Branch Canal, which were removed during January-February 2004. Major crops were maize and tobacco followed by sugarcane (Figure 2). Tobacco cultivation decreased from 30.6 percent in Kharif 2003 to 27 percent in 2004 due to poor market conditions in 2003 followed by almost no rainfall during the transplantation period (March 2004). In contrast, the area under maize increased considerably from 38.6 percent in 2003 to 56.2 percent in 2004 due to compensate for tobacco on one hand and due to early vacation of tobacco land on the other. The poor tobacco crop was harvested about two weeks earlier than usual. Maize is the dominant kharif crop, sown in June and July, on lands vacated by wheat and tobacco. Sugarcane area has decreased from 10 to 4.6 percent. The higher fallow area of 13 percent in 2003 was especially due to lower supplies to Pirsabaq command during 2003.

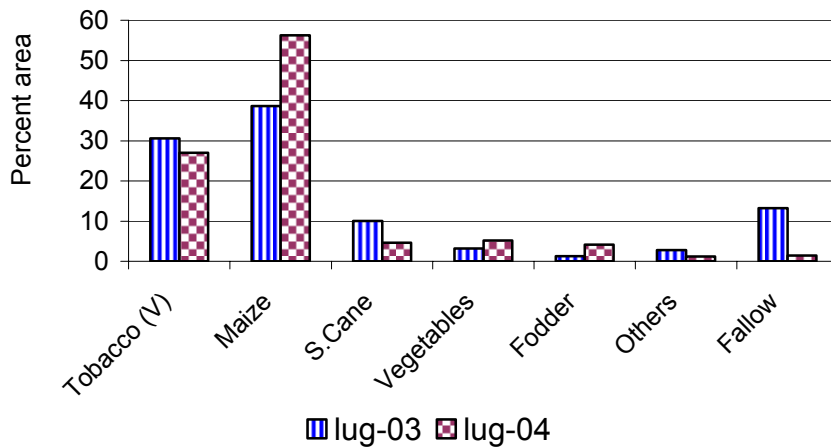


Figure 2. Cropping pattern in Kharif 2003 and 2004 of sample outlets.

Rainfall

Actual field observations suggest that rainfall was more frequent and well distributed over the study area in Kharif 2003 than in 2004. The daily rainfall of Tarbela and Mardan meteorological stations also shows that July and early August 2003 received more rainfall (Figure 3), which has substantially impacted the water use under USC system.

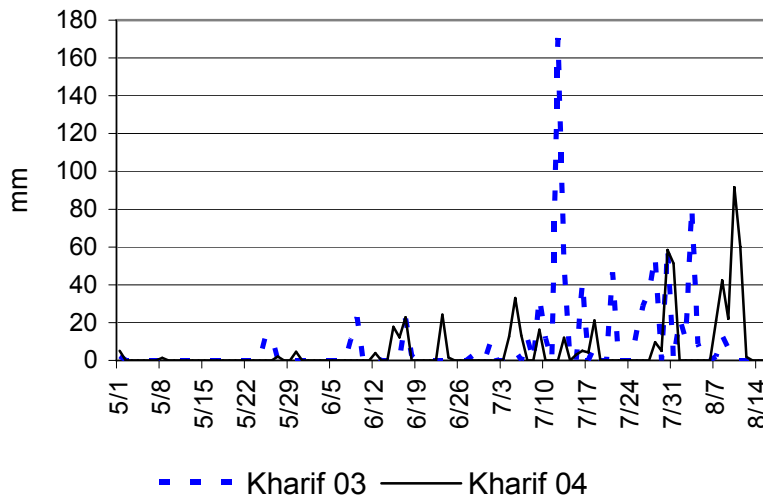


Figure 3. Daily rainfall at Mardan and Tarbela meteorological stations

Water delivery at secondary offtakes head

In 2003, the operational management at the primary and secondary level continued as it had in the past and, rains and varying crop water requirements were not taken into account. The average delivery performance ratio (DPR, which is equal to the ratio of actual discharge/design discharge) at the head of three sample offtakes in kharif 2003 shows that the offtakes have run at between 50 and 75 percent of design discharge (Figure 4). The operation of the system was carefully monitored and controlled in accordance with the crop demand in kharif 2004, when deliveries were in the range of 72 to 100 percent of full supply design discharge. Water deliveries have increased during 2004, which are in conformity with reduced rainfall and increased maize cultivation.

Water use

Every landholder within command is supposed to receive water for irrigation once a week with a specified duration and specified day. The allocated weekly turns are strictly observed during peak or water short periods, while water may be more generally available for irrigation at other times during low demand periods. The data collected during the study period shows that weekly warabandi turns were implemented by only 23 percent of farmers in Kharif 2003 but by 47 percent people in Kharif 2004, which is almost double of the previous season (Figure 5), but still a low proportion of the whole farming population. Similarly, 16.4 percent of water was used for irrigation without observing warabandi in 2003 and 32 percent in 2004, again double of the previous season. Water disposal to drains was about 21.6 percent during 2003, which was much higher than 11 percent recorded in 2004. Most of the tertiary outlets exit into natural drains, but some farmers prefer to close their outlets at the head. About 14 percent of water users had closed their outlets in 2003 when water was not required while about 10 percent did the same in 2004. The frequency of rainfall was higher and its distribution was more even in 2003 than in 2004. Water use observations were not made on rainy days and it was assumed that water was not used for irrigation, equivalent to 16 percent of deliveries during 2003. Overall, 39 percent deliveries were actually used and 61 percent was refused during 2003 as compared to 79 percent used and 21 percent refusal in 2004.

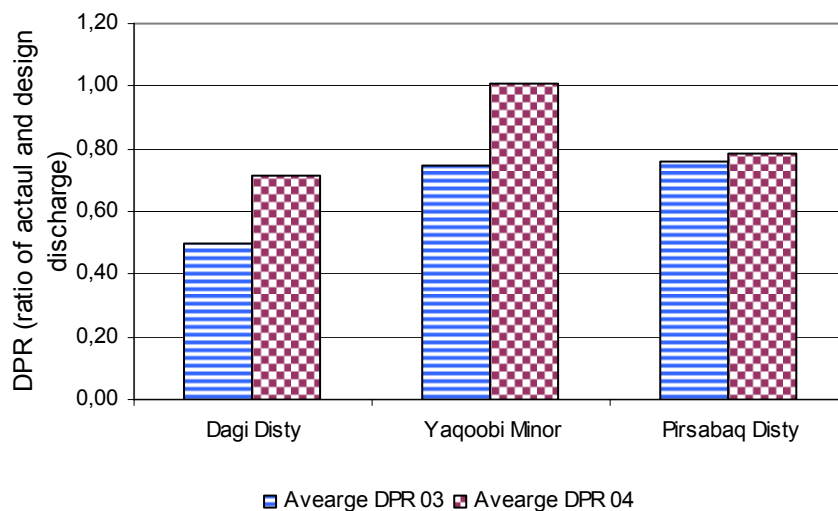


Figure 4. Average DPR of sample offtakes - Kharif 2003 and 2004

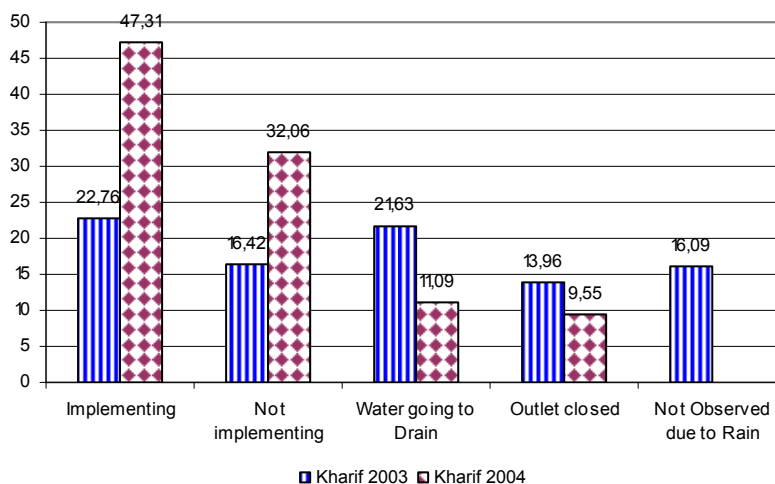


Figure 5. Comparison of water use by warabandi turn
CONSTRAINTS

A number of constraints to improved operations of a modernized system can be seen in this work.

Lack of understanding of new concept

PHLC is the first system in Pakistan to be operated according to “Crop-Based Irrigation Operations (CBIO)”, where water supply is matched to estimate crop water demand through rotational water supply. During the lowest demand periods, selected offtakes are closed alternately for one week. The duration of cycle is then varied according to crop water requirements from one week closed one week open, one week closed two weeks open to 1 week closed 4 or 5 weeks open. Continuous full supplies are provided during peak demand periods.

Many years or life-long experience with traditional and relatively rigid system operations mean that it is going to take quite some time for users to adapt to the new flexible and more management-intensive concept of operations. The field staff who has worked on the same system for years without exposure to other experience found it even more difficult to adapt to new situations. The CBIO schedules, which resulted in water saving and better management, have been implemented by the operating agency with the support of IWMI research team.

Field operations staffs are the key people who can effect an easy shift to modernized operations. Their close and strong linkages with the farming community can play an important role in this regard. They are being trained about the new concept of operations and their field implementation. The involvement and support of the field staff has played an important role in the success of CBIO exercises during the study period.

Willingness to accept a change

Bringing a planned change is not impossible, but is not easy either. The nature and culture of human society is not usually willing to accepting a quick change unless strong personal interest or strong leadership drives it. The shift from an easy to a more laborious and complex system makes it even more difficult and time consuming. Lectures and training can only change the minds of older people rather slowly.

Water users are happy to see increased supplies, which not only save their time but also increase their income by bringing more area under cultivation. Based on previous experience, they are used to continuous supplies whether less or more, and want water in watercourse even if it is required for domestic or cattle needs. However, an extensive training and education program through audio-video aids regarding the new concept of operation has been initiated for irrigators, which has received an encouraging response. Full understanding and realization of the new concept is taking its time.

Institutional interventions

The role of every staff member involved in the day-to-day operations is important in effecting a change under the new rules. Transfers of trained staff for personal, political or any other reasons are a real handicap to continuity and embedding understanding. Three out of four trained people had been transferred to other places during the one and a half years that the operations support project has been active. Moreover, the involvement of irrigation system managers with administrative functions has adversely impacted the shift from conventional to modernized operations. The four deputed staff members from DoI were supposed to spend two days a week, however, high staff turnover and conflicting responsibilities are limiting factors.

Complicated system

The complex nature, physically as well institutionally, of the irrigation system under study makes it more difficult to move from one system of operations to another. The situation is further complicated in that the downstream controlled parts of the system (PHLC canal from Tarbela and Maira Branch) require modernized operations, whereas the Machai Branch continues to operate under upstream control and under warabandi and rotational operation when supplies are low. Since water availability in the Machai Branch is enhanced because flows are no longer necessarily committed to Maira Branch downstream, new lands and new offtakes can be developed. There is also great potential to improve operations in Machai branch through better water level control using the radial gates installed some years ago. The ultimate objective is to improve supply reliability and adequacy throughout the system, taking into account fundamentally different operating conditions. . In fact, the traditional supply based nature of the Machai Branch, with higher water duties, is highly suitable for the implementation of CBIO.

Deliveries from Swat River to the USC are controlled by the provincial department of irrigation (Dol) while WAPDA, a federal organization, is in charge of Indus River supplies. WAPDA is supposed to run the PHLC system in auto-mode to match crop water requirements but this does not happen all the times. Manual adjustments for one reason or another is currently a frequent phenomenon. Similarly, supplies from the upper USC are always fluctuating without information being transmitted to the downstream mangers. The originators' idea, of the conjunctive use of Swat and Indus Rivers with proposed maximum withdrawals from Swat River to avoid power loss at Tarbela Dam, has hardly been digested by the concerned parties. In fact the principle is even actively contested by NWFP personalities who are bent on utilizing "all of their share", even if this means that the inevitably unused water returns to downstream provinces via the drainage system and the Kabul River.

Political involvement

Political interests or links with politicians are in conflict with rules of business. Pressures to release water in a certain channel for the sake of one or a few individuals continue to be applied. In one example, an influential person did not arrange for their watercourses to be cleaned to accommodate increased supplies, and then interfered with the main canal operation to raise water levels in an attempt to receive more water. Since the concept of downstream control has not been internalized, the malefactor does not understand (or perhaps wish to understand) that raising the water level simply closes the upstream gates and restricts supplies further.

DISCUSSION

The cropping pattern was similar during both seasons but the cropping intensity has been affected by rainfall, water availability and market conditions. The frequency, timing and distribution of rainfall were more favourable in 2003 than 2004. Water deliveries from Indus River started in February 2003, but better service was limited to farmers of the upper and middle reaches. The tail reach did not get proportionate increased supplies during most of Kharif 2003 due to problems with the operation of automatic gates and other constrictions in the main canal, resulting in lower cropping intensity during that season. Rainfall has a soothing effect on tobacco. Poor markets in 2003 coupled with thin or no rains in February-March 2004, adversely affected tobacco cultivation and production in 2004, leading to increased cultivation of maize.

Water supplies have considerably increased into Dagi and Yaqoobi canals in 2004 mainly due to less frequent rainfall and cultivation of hybrid maize varieties, which require frequent irrigations along with increase in area. Withdrawals by Pirsabaq Disty have remained almost the same during both seasons. Better management at head regulator, lower tobacco cultivation (only 5 percent) and consistent monitoring helped save considerable volumes of water. Pirsabaq Disty command is silty and sandy loam where cultivation of tobacco is not encouraged.

Water use efficiency has substantially improved during Kharif 2004, though water supplies had increased. Disposal of excess water into drains was halved along with considerable reduction in outlets closures by farmers. Following traditional operations with increased water supplies and frequent rainfall in 2003, 61 percent of delivered water was wasted. This wastage was brought down

to about 20 percent in 2004 when supplies were higher than the previous season and rainfall was less frequent.

Irrigation system operations according to the new concept of CBIO, coupled with active and vigilant monitoring in the field have saved about 42 percent of delivered water in 2004 as compared to 2003. Further improvement would also be possible if field staff of the operating agency had not ignored the instructions of their senior staff. There are many examples of unwanted manipulations with head regulators by regulation staff or water users.

CONCLUSION

The shift from conventional to modernized operational management is taking place with a slow pace but leading to better service and reduction in water wastage. Further water savings are however urgently needed to avoid drainage problems and high water table development. Complete adoption of new procedures by the operating agency is a time consuming process, which requires will, commitment and training of the concerned staff.

RECOMMENDATIONS

1. Staff deputed or involved in a new project should not be transferred until the completion of the project and should have minimum involvement with other administrative activities.
2. Large-scale awareness, training and participation of the stakeholders about the new concepts and activities should be an integral part of the project plan of activities.
3. The design of modernized projects should recognize the limitations of staff availability and capacity, and as far as possible design around them, and in consultation with both users and operators.
4. CBIO procedures should be introduced in Pakistan to other irrigation systems such as Chashma right Bank Canal where higher water allowance has been made in order to save water and to control groundwater recharge.

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