Evolution of Managing Water for Agriculture in the Indus River Basin

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Abstract

The weir controlled irrigation system development of the Indus Basin started in the mid 19th century and has limited capacity for further development now. Groundwater has also been developed and even over-exploited in many parts despite having quality (salinity) problems. However, the management of surface water is weak, lacking transparency and accountability, leading to inequitable and unreliable supplies in the lower reaches of the system, while there is no rule or control over groundwater use. The cropped area and production of major crops has increased greatly but both land as well as water productivity is much lower than potential. Improved and innovative management techniques and technologies should be employed at all levels to meet the food requirements of the increasing population and supporting the 70 per cent of the population dependent on rural livelihoods, and the national economy.

Irrigation development in the Indus River Basin

Though the Indus River waters have been in use for irrigation for centuries through inundation canals but most of the present irrigation system was developed during the 19th and 20th centuries with the introduction of modern engineering and diversion works across the river beds (Khan 2000). The construction of two major reservoirs and a network of inter-river-link canals during the 1960s and 70s not only increased water supply and its reliability but also increased the cropping intensities and productivity. The average annual water available in the river system is 165 bcm, out of which 130 bcm is diverted into irrigation system and 35 bcm is released to the sea for environmental reasons. The boom in groundwater development going on for the last three to four decades has not stopped despite groundwater depletion and quality problems in many areas (Habib, 2004). The number of tubewells has swelled from a few thousands during the creation of Pakistan in 1947 to more than 0.9 million in 2004. Most of these tubewells are concentrated in Punjab (91 percent) where more than 99 percent are privately owned and operated by farmers (Pakistan 2004).

This paper is looking into various developments that have taken place in water sector of the Indus Basin, how has it helped increase production and brought more area under irrigation and what are the challenges being faced to overcome the food crises and livelihood issues of the dominant rural population of this basin.

Water management in the Indus Basin Irrigation System (IBIS)

The design of IBIS is protective in nature with less flexibility in operations for covering about 80 to 100 percent of the total command area in a year or two crop seasons. The provincial irrigation departments are responsible for managing the available waters of their share while the Water and Power Development Authority (WAPDA) has been operating the Mangla and Tarbela reservoirs under the Indus River System Authority (IRSA) instructions. Severe shortages in irrigation supplies during Rabi (winter) season have been checked to a greater extent after Mangla and Tarbela reservoirs operations as given in Table 1.

Table 1. Water supply (bcm) improvement after Mangla and Tarbela reservoirs.

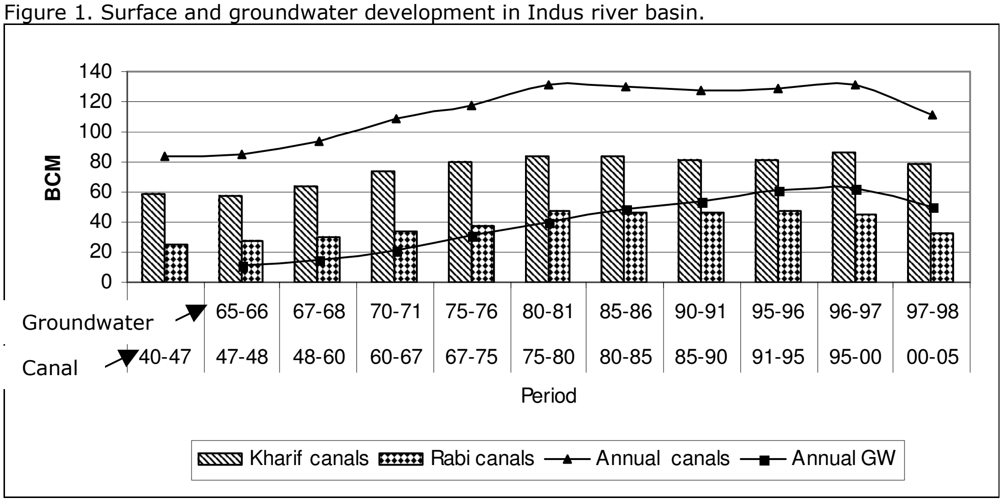
	Pre-Mangla (1940-41 to 1966-77)	Post-Mangla (1966-69 to 1976-77)	Post-Tarbela (1976-77 to 1993-94)	% increase post-Mangla	% increase post-Tarbela
Kharif	63.96	81.18	83.64	26.92	30.77
Rabi	29.52	36.90	46.74	25.00	58.33
Annual	93.48	118.08	130.38	26.32	39.47
				Average	42.86

Source: Water resources management directorate, WAPDA

Water supplies increased by about 25 percent after Mangla reservoir while the Indus river contribution increased by more than 58 percent during the critical Rabi season after the construction of Tarbela reservoir. Post-Mangla increase in the average seasonal discharge has not been varying much and has been 25 percent in Rabi and 26.92 percent in Kharif (summer), while post-Tarbela discharge increased by 58 percent in Rabi and 31 percent in Kharif. Since their completion, the two reservoirs have lost about 4.9 bcm or 23 percent of their combined original gross storage capacity (WAPDA, 2002).

Canal withdrawals have been increasing during both seasons from 1949 to 1967, mainly due to the construction of new irrigation canals. Canal diversions during the 1940-75 for Rabi season have been less than half of the kharif season which improved by more than 10 percent after Tarbela reservoir operation (Figure 1). Kharif diversions have increased from 58.8 bcm in 1940-47 to about 82.7 bcm in 1975-95, an improvement of about 41 percent. Rabi supplies have almost doubled from 24.9 bcm in 1949-47 to 46.47 bcm after 1975 showing an increase of about 87 percent. Similarly, annual withdrawals have improved by 55 percent.

Figure 1. Surface and groundwater development in Indus river basin.



(source: Water resources management directorate, WAPDA and Agricultural statistics of Pakistan, Ministry of Food, Agriculture and Livestock, 1998.)

Figure 1 also shows that groundwater irrigation has been progressively increasing from 11.3 bcm in 1965-66 to 52 bcm in 1996-97, an increase of more than 450 percent over a period of about 31 years. A decline of 13.6 bcm was observed during 1997-98 due to withdrawal of government subsidy on electricity tariff and increase in diesel prices along with abandonment of public tubewells due to high operation and maintenance cost (Randhawa). Steady increase in groundwater irrigation continued from 28 percent in 1967-68 to more than 400 percent in mid 1990s despite substantial surface water irrigation system and storage development. The contribution from tubewell irrigation was about 10 percent of canal diversions in 1965-66 and gradually increased to about 48 percent in 1996-97.

Effect on cropped area and production

As a result of surface and groundwater development, cultivation of major selected crops increased from 10.76 mha during 1971-75 to about 15 mha during 1991-95, an increase of 39 percent. Sugarcane cultivation has substantially increased from 0.61 to 0.93 mha, an increase of 52 percent. Cotton area improved by 44 percent while wheat and rice area improved by 39 percent each (Table 2). Similarly, the production and yield of the four major crops (wheat, rice, sugarcane and cotton) have substantially increased over the last three to four decades. Wheat production increased by 438 percent, rice 291 percent, sugarcane 107 percent and cotton by 368 percent. Yields of these crops have also improved considerably but is proportionately much lower than production. Wheat has the highest increase in yield of 228 percent during 1965-66 to 1999-2000 while sugarcane has the lowest increase of 23 percent during the same period (Table 3).

Table 2. Cropped area of selected crops in Indus Basin irrigated agriculture

Crop	Cropped Area (mha)					Increase (%)
	1971-1975	1976-7980	1980-1985	1986-1990	1990-1995	1971-1975 to 1990 - 1995
Wheat	5.93	6.49	7.24	7.60	8.06	36
Cotton	1.92	1.91	2.22	2.53	2.76	44
Rice	1.51	1.88	1.98	2.01	2.10	39
Sugarcane	0.61	0.76	0.90	0.82	0.93	52
Oilseeds	0.59	0.53	0.41	0.41	0.61	4
All Fruits	0.20	0.26	0.36	0.44	0.50	150
Total Area	10.76	11.83	13.11	13.91	14.96	39

Source: Agricultural statistics of Pakistan, Government of Pakistan.

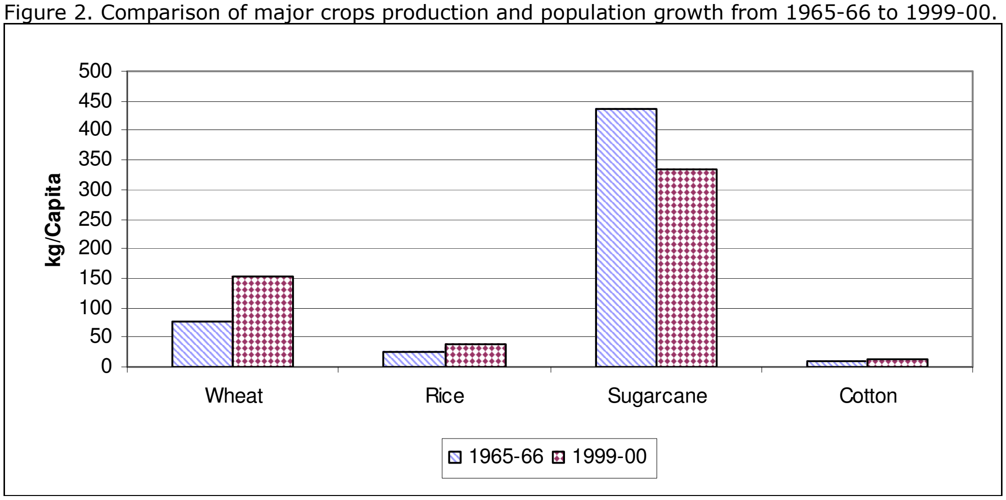
Production of major crops has kept pace with the population growth as shown in Figure 2. In cereal crops, wheat production has almost doubled that has increased from 77 kg per capita in 1965-66 to 153 in 1999-00. Rice has increased from 27 to 36 kg per capita during the same period. In cash crops, sugarcane production has not been matching the population growth while cotton has increased from 8 to 14 kg per capita during 1965-66 and 1999-00.

Table 3. Increase in production and yield of major crops (production million tones, yield tones/ha).

	Wheat		Rice		Sugarcane		Cotton	
	Prod.	Yield	Prod.	Yield	Prod.	Yield	Prod.	Yield
1965-66	3.92	0.76	1.32	0.94	22.31	37.37	0.41	0.25
1999-00	21.08	2.49	5.16	2.05	46.33	45.9	1.92	0.64
% increase	438	228	291	118	107	23	368	146

Source: Agricultural statistics of Pakistan 1999-2000.

Figure 2. Comparison of major crops production and population growth from 1965-66 to 1999-00.



Contribution of irrigated agriculture to Pakistan economy

Irrigated agriculture of Indus Basin is termed as the backbone of the economy for earning about 60 percent of foreign exchange every year. Cotton, rice, textile and leather products are the major exports of Pakistan from the agriculture sector. It contributes 24 percent to the country's economy, feeds almost the entire population and provides employment to more than 47 percent of the total work force (www.economyofpakistan.com). The rural population, which makes about 70 percent of the total population, is predominantly relying on agriculture for its livelihood.

Interventions

Besides the construction of new irrigation canals, reservoirs and inter-river link canals, Pakistan implemented several salinity control and reclamation projects (SCARPS) of vertical and horizontal drainage for lowering water table and controlling salinity in the waterlogged areas (Hussain et al 2001). The massive projects of National Drainage Program (NDP), Left (LBOD) and Right (RBOD) bank outfall drains are recent efforts for providing the essential drainage to the irrigated lands. The 0n-farm Water Management (OFWM) program for partial lining of the tertiary irrigation canals has been going on since mid 1970s for controlling seepage and improving water delivery to the lower reaches. The creation of IRSA in 1992 is aimed at fair regulation and distribution of water among the provinces according to the Water Apportionment Accord of 1991. Provincial Irrigation and Drainage Authorities (PIDA) have been established in 1997 for involving water users in water management and introducing financial autonomy through creation of water user associations (WUAs) farmer organizations (FOs) and area water boards (AWBs), but are moving very slow for lack of commitment. Water conservation technologies like bed-furrow, raised beds, zero-tillage, laser land leveling and dry-seeding of rice have been introduced but are going at a very limited scale. Many attempts have been made for introducing pressurized irrigation system but have not been successful in large scale adoption.

Issues and Constraints

Pakistan has become a water stressed country where most of the surface and groundwater resources have already been exploited and apparently there is no feasible intervention which would mobilize additional water (World Bank 2005). The immense contribution of groundwater to agriculture in Punjab is faced with serious challenges of declining water table, quality issues and increasing cost of operation and maintenance of tubewells. The population of Pakistan has been increasing at an alarming rate of more than 2 percent during the last decades where per capita water availability has declined from about more than 5000 m^3 in 1947 to about 1200 m^3 in 2006. At the same time, competition from municipal and industrial users is increasing from 7.2 and 2.7 bcm in 2000, respectively, to 15 and 4.8 bcm in 2025 (Draft National Water Policy, 2002). All this along with climate change effects on water availability pose serious challenges to water planners and managers for effectively managing the available resources.

Lower than potential productivity of land and water due to lack of availability and access to modern technology, poor management practices and availability of key inputs is one of the key issues. Conservation technologies like zero tillage, bed and furrow irrigation and laser land leveling have been introduced but their initial cost and lack of skilled manpower is constraining its large scale adoption. Absence of integrated water resources management approach and continuing with the conventional supply-based operations are impacting productivity. Uncontrolled groundwater development and absence of any legal instrument for its management is facing both quantity and quality challenges. Intrusion of saline water into fresh water aquifer, pollution due to agricultural, industrial and municipal waste is taking place for a long time now without any imminent check or control. Poor maintenance of physical infrastructure, financial un-sustainability and negligence have deprived the water users of the lower reaches of their due share of water for many years now. Lack of trust and transparency, lack or absence of coordination among key stakeholders in the government and the private sector are different factors affecting water management.

Major initiatives

The Government of Pakistan has initiated a slow going program of new dams (Basha, Akori, Kurram Tangi) for water and power development. A rehabilitation and modernization program of barrages and irrigation system has been initiated by the Punjab, Sindh and North West Frontier provinces. Also, the federal government has launched two major projects of tertiary canals lining (US$ 1.1 billion) and pressurized irrigation system (US$ 300 million) to improve productivity of agriculture sector. The Punjab province has also introduced a crash program of providing 2500 laser land levelers at 50 percent subsidy to the farmers in order to have at least one unit in each union council of the province.

Conclusion and recommendation

Scope for further development of water resources in the Indus basin is limited but there is tremendous potential for improving productivity of both water and land by employing conservation technologies. A paradigm shift from supply-based to demand based and integrated water resources management approach is essential in order to cope with increasing food demand, environmental issues and economic pressure. Development of a legal and regulatory framework for managing groundwater is essential and should be based on detailed pilot studies and ground realities. The half-hearted approach of involving end users in management and decision making process needs to be implemented with full thrust in letter and spirit using lessons learned locally and internationally.

Acknowledgements

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