Chapter 18

Irrigation System Issues and Options

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Abstract

Like other irrigation systems of the world, Pakistan's surface irrigation system, which is the largest constructed surface irrigation system, has been facing several problems related to the water use efficiency and system management such as system operation, maintenance, interaction between stakeholders and warabandi (On Farm water distribution system). These issues can be generally divided into five main categories:1) international, 2) national/provincial, 3) river reach, 4) canal reach and 5) farm level. Before independence, water disputes existed mostly between upper Punjab and lower riparian of Sind province. The national problems in some form existed till the Water Apportionment Accord 199, while the issues of management still exist to be solved among the provinces. The issues of water sharing at provincial level, among the provinces of Pakistan, were addressed and solved through Water Apportionment Accord of1991. To monitor the river water distribution, the Indus River System Authority (IRSA) was established in 1992. The canal and farm level problems include improper maintenance of canals, distributaries and watercourses, improper monitoring of irrigation water discharge and distribution, low irrigation efficiencies, inequitable distribution among users, over-exploitation of surface and groundwater, water logging and salinity and desertification of valuable fertile land are some of the issues that need to be considered and resolved for achieving the true benefits of the irrigation system.

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Water sharing problems of international level emerged after the division of the subcontinent into India and Pakistan, mainly because of Indian violation of disrupting water supplies to the command areas of eastern rivers. To resolve these issues between India and Pakistan, the Indus Water Treaty was signed in 1960 with the technical and financial help of the World Bank. These problems not only originated but also intensified when India started building many controversial dams such as hydropower projects of Salal Hydroelectric, Baglihar Hydroelectric Dam, Kishanganga Hydroelectric project on the rivers that were assigned to Pakistan under the Indus Water Treaty 1960. This chapter focuses on the historical developments, nature and gravity of the irrigation water issues between India and Pakistan, provincial water sharing issues, operational and management as well as performance issues. Some suitable options towards dispute resolution, remodeling and upgrading of the system, capacity building of managers and stakeholders, use of marginal water sources such as reclaimed wastewater and rainwater harvesting etc. are also discussed

Learning Objectives

- To learn about irrigation water issues and their solution options at international, national, and provincial levels.
- To summarize the system's operational problems and solution options at the river, canal farm and watercourse levels so that the readers may be facilitated with sufficient information to plan, design and improve the system to its potential efficiency.

18.1 Introduction

Pakistan's Indus Basin Irrigation System is the unified and the largest irrigation system on the earth. The system comprises of 3 major reservoirs (Chashma, Tarbela and Mangla), 18 headworks and barrages (Ferozepur, Sidhnai, Islam, Panjnad, Kalabagh, Balloki, Sukkur, Sulemanki, Marala, Trimmu, Kotri, Guddu, Chashma, Mailsi, Qadirabad, Taunsa, Maralaand Rasul), 12 link canals and 45 irrigation canals. This also contains over 107,000 watercourses and millions of farms and field ditches. The main canal system has an estimated length of 585,000 km and the length of watercourses and field channels surpasses 1.62×10^6 km (Rizwan, 2008).

The irrigation system has been operating for more than a century and has been a source of water for domestic and agricultural needs of civilization settling for the huge Indus Basin. With the development of civilization, human intervention to manage the system from inundation to weir controlled system and to operate from flood irrigation to the advanced systems of border, furrow and bed irrigation, has always faced a number of problems at all levels such as basin, river, canal, distributary, watercourse and field. The problems mainly related to the water storage in reservoirs, diversions at the barrages, conveyance through the canal system and the application to the cropped fields. Conflicts also existed in sharing this important natural resource among neighbor countries, provinces, regions as well as the end users. The problems and issues may relate to the engineering structures'

performance, deliveries, system management and its professional, legal and social aspects and obligations. The most affected stakeholders may include government functionaries, farmer organizations and individual water users. As a part of the overall system each organizer, engineer, system manager as well as end-user farmer face such problems and almost all of them wish and attempt to find feasible solutions to run the system beneficially. Therefore, it is important for each stakeholder to be aware of the actual issues and possible options for successful operation of the system. Therefore, the major issues and problems relevant to the operation and management of the large and complex irrigation system of Pakistan are highlighted in the subsequent sections.

18.2 Issues of Irrigation System Scale Wise

18.2.1 International Issues

There are a number of water rights and sharing issues between India and Pakistan – the neighbor countries. The mutually agreed water sharing formula through the historical Indus Water Treaty 1960 and the Indian violations of the mutually agreed treaty have been discussed under the river based issues.

18.2.1.1 Historical Background of the Water Rights and Sharing Issues

Since the beginning of the civilization, water of the Indus River system has been used for the purpose of irrigation in the Indus Basin. In the earlier times, the demand for water was conspicuously less than its availability in the river due to smaller population. The demand for water increased with increasing population, which in turn raised more issues both at the provincial and domestic levels. During British rule in the mid of the 19th century, water clashes were mostly between lower (Sindh) and upper (Punjab) riparian, mainly because of lack of confidence between the two provinces. Sindh was afraid that Punjab would encroach upon water shares of Sindh and establish water rights over Indus river water (Sridhar, 2008).

After the creation of Pakistan, more and more disputes of international dimensions erupted between India and Pakistan, mainly due to India's attempts to gain more control of water resources of the Indus Bain. Firstly, during the partition of Punjab, Radcliffe unjustly drew the dividing line across Punjab, giving the most rich water streams of the Indus River to India (Siddiqui, 2010). Secondly, within a year of the partition of the subcontinent, in April 1948, India stopped the water supply of Dipalpur Canal originating from Ferozepurheadworks, built in 1920 on Sutlej River. Pakistan criticized India for this action and sent its delegation to New Delhi to seek resumption of the water supply. On the 4thof May 1948, Pakistan and India signed an agreement, the Inter-Dominion Agreement. According to the contract, India agreed to continue water supply for irrigation until Pakistan would be to accomplish an alternative (Sridhar, 2008).

After that, Jawaharlal Nehru, the Indian Prime Minister, asked an American professional, David Lilenthal, to review the condition. He supported Pakistan's arguments but his observations were rejected by Delhi. From 1952 to 1960, the World Bank supported a series of talks in Washington, and finally India and Pakistan

agreed to sign the Indus Water Treaty in 1960. According to this Treaty, it is not permissible for India to build dams for water storage on the Jhelum, Chenab and Indus rivers. However, India was permitted only a limited use of these rivers' water and was allowed to develop run-of-the-river projects for hydropower if required for meeting dire civilian goals. Disregarding all these observations, India continues to make an excessive use of the waters of the Indus and Jhelum rivers, and that remains an issue of discord between the two countries (Sridhar, 2008).

18.2.1.2 The Indus Water Treaty1960

The Treaty is themutualagreement between Pakistan and India to share the water of the Indus River. The Pakistanis' president, M. Ayub Khan, the Indian Prime Minister, Jawaharlal Nehru, and the President of World Bank, W. A.B. Illif, assigned the treaty in September 1960 in the city of Karachi. The Treaty explains the water rights and obligations for both countries. Under this Treaty, Pakistan has the full rights of using the Jhelum, Chenab, and Indus Rivers' water. This According to this, Pakistan was allocated about 75% of the water of the Indus system, and India was allowed, under judiciously specified conditions, to use water of three western rivers before entering into Pakistan (Nosheen and Begum, 2013).

i. The agreed Principles for Water Sharing between India and Pakistan

The following two are the main principles of water sharing between the two countries:

- "All the waters of the 3 Eastern Rivers shall be available for the unrestricted use of India. Pakistan was permitted by way of exception to take water for domestic use, non-consumptive use and certain limited agricultural use".
- "Pakistan shall receive unrestricted use of all water of the Western Rivers, which India is under obligation to follow and shall not permit any interference with these waters except for the domestic, non-consumptive agricultural use, generation of hydroelectric power and storage works" (Akhtar, 2010).

ii. The Principles of Cooperation according to the treaty

According to Treaty, both countries were agreed to exchange of the following daily data for proper development of the rivers, and to cooperate and collaborate with each other. These data have to be shared by both parties on monthly basis.

- Discharge data at all observation stations.
- Releases (withdrawals) from reservoirs.
- Extractions at the heads of all irrigation and link canals.
- Escapades from all irrigation and link canals.
- Deliveries from link canals.

(Akhtar, 2010)

iii. Merits of the Treaty

The following were the major advantages of this treaty:

- Both the countries started improving the water uses (supplies) of rivers according to their shares.
- The Indus basin system became more consistent and reliable source of water.
- The treaty provides good opportunities to the countries to use water in a better way.
- It helped reduce the tension between both the countries.
- A great institution, the Indus Commission, was also the result of this treaty to solve water disputes in future.
  (Nosheen and Begum, 2013)

iv. Demerits of the Treaty

The followings were some disadvantages of the Treaty:

- According to Pakistan's point of view, only 75% water allocation of 90% of irrigated land was the destruction of "appreciable harm" principle.
- According to India's perspective, 75% water allocation to Pakistan was a violation of the "equitable utilization" principle.
- Pakistan had to sacrifice an entire flow of 24 MAF from the eastern rivers, which was used for irrigation of the command areas of these rivers.
- Irregular flow in the eastern rivers caused silting inthechannels, resulting in frequent floods in Pakistan during higher flow periods; in addition, causing bad environmental impacts.
- Due to an irregular flow of the eastern rivers, the traditional flood irrigation disappeared in the command areas of the Ravi, Sutlaj and Bias Rivers in Pakistanand thus resulting in a large cultivated area into barren land.
- Storing water is not an alternative of continuous flow because water storage has limited life. Pakistan has already been facing silting problems in the major reservoirs (Nosheen and Begum, 2013).

18.2.2 Provincial Issues

There have been many interprovincial conflicts related to the use of water of the Indus River System that date back to the times before the creation of Pakistan, and have not been resolved completely yet. Even after the end of the British rule in the subcontinent, water from the Indus River System (IRS) still occupies the same significance and is a source of inter-provincial conflicts in Pakistan.

For the first time, the issue of water conflict between Sindh and Punjab emerged in 1901, when Indian Irrigation Commission banned Punjab to take even a drop of water from the Indus without the endorsement of Sindh. After the partition of the Subcontinent, the major interprovincial conflicts started when Pakistan, under the Indus Water Treaty 1960, acquired funds from different donor countries and the World Bank to carry on various projects to build dams, barrages, canals, etc. for better utilization of its water share. The province of the Punjab was blamed by other provinces that Punjab is using those projects to divert their share of water for its own use. In 1968, the Water Allocations and Rates Committee, under the leadership of

Akhtar Hussain, was established by the Governor of West Pakistan to examine the water allocations from barrages, release patterns from reservoirs, drawdown levels and the use of ground water in relation to surface water deliveries. In July 1970, a report from the committee was submitted, but no attention has been paid to this report since then (Mansur, 2002).

In 1970, Justice Fazl-e-Akbar committee was formed for the water allocation of the Indus River and its tributaries, which submitted its report in 1971 to the government of Pakistan. During the same time, ad hoc distribution of water from Chashma barrage and Tarbela reservoir was ordered among the provinces. No essential decision was taken on the recommendations of the Fazl-e-Akbar committee and water continued to be distributed on an ad hoc basis by the government of Pakistan. In 1977, one more commission was established by the government of Pakistan involving the chief justices of the High Courts of the Provinces, which was headed by the Chief Justice of Pakistan to observe the issue of water allotment. After that, Justice Halim Commission was set up to look into the water allocation matter. The complete recommendations of these commissions were never implemented by the Federal Government, and therefore, the conflicts among the provinces of Pakistan continued (Mansur, 2002; Feyyaz, 2011).

Lastly, in 1991, the Government of Pakistan enforced the Water Apportionment Accord to resolve the conflict related to water sharing among various provinces of the country. This accord was signed on March 16, 1991in Karachi in a meeting attended by the chief ministers of Punjab, Sindh, Balochistan and Khyber Pakhtunkhwa under the leadership of the Prime Minister of Pakistan. In 1992, the Indus River System Authority (IRSA) was established with headquarter at Lahore, for monitoring river water distribution among the provinces. According to the accord, the three reservoirs (Tarbela, Chashma, entangle dams) and inter-river link canals were stipulated as the main structures for the water management of the Indus basin. The water allocation of these reservoirs to the provinces was centralized, using 'Suggested Operation Criteria' established on a 10-daily basis (Ranjan, 2012). According to the adopted formula, the total water available in the Indus River System, 114.35 MAF, was allocated among the provinces as presented in Table 18.1. The Water discharging to the sea remained unresolved (Ministry of Water and Power, 1991).

Table 18.1 Provincial Water allocation (MAF), according to Water Accord 1991

Provinces	Kharif	Rabi	Total
Punjab	37.07	18.87	55.94
Sindh	33.94	14.82	48.76
Khyber-Pakhtunkhwa	03.48	02.30	05.78
Balochistan	02.85	01.02	03.87
Total	77.34	37.01	114.35

Source: (Rajput, 2011)

A few years after implementation, the accord became controversial in 1994 when Punjab was allegedly blamed by Sindh, for not releasing its agreed amount of water. On the other hand, Balochistan blamed Sind for not releasing water, Sindh raised

allegations that this is a one-sided agreement and Punjab violates the agreement with the support of IRSA, WAPDAand the Federal government (Mansur 2002).

After the 1994 incident, WAPDA and the Ministry of Water and Power (MWP) returned to apportionment based on historical use, rather than accord. However, IRSA stopped working in 1998. After this, the Prime Minister announced to build a dam at Kalabagh on the Indus River which proved to be a controversial plan and was strongly rejected by the KPK and Sindh. In 1999, the IRSA resumed functioning but only after shifting its headquarters from Lahore to Islamabad. It was also attached with the Federal Ministry of Water and Power (Ranjan, 2012).

IRSA had hard time to produce a compromise over water allocation during the droughts of 2001 and 2002. Protests in Sindh forced the Chief Executive (CE) of Pakistan to overturn his decision. Precisely, the solution of such clashes was a matter of the Council of Common Interests (CCI). Since CCI was inactive, the CE had to tackle this problem. Therefore, the CE took some critical decisions in a meeting with the governors of all the four provinces. In 2003, the situation changed again when the president handed over executive responsibilities to the elected governments at the provincial as well as federal levels. On the dispute of opening up of a link canal, the Chashma-Jhelum, in July 2010, Sindh and Punjab again opposed each other regarding their due share of water. Later, the issue was resolved by the interference of the Prime Minister of Pakistan (Ranjan, 2012).

18.2.3 River Scale Water Issues

The Indus Water Treaty was followed by Pakistan and India for almost two decades (1960s-1970s). After that, India, as upper riparian,began creating water problems for Pakistan. Since the birth of the treaty, India had been violating rules of the international law many times. On the other hand, Pakistan kept tolerating the Indian violations for many years. Finally, Pakistan complained to the World Bank and asked for intervention, but no worthwhile results could be attained. The following are the major controversial Indian projects, violating the treaty (Nosheen and Begum, 2013):

18.2.3.1 SalalHydroelectric Project

This was the first project from India on the Chenab River. Being located in the occupied Kashmir, the SalalHydroelectric Project created several serious conflicts between both the countries. In 1974, some information on the project was disclosed by India: Pakistan actively objected to the storage capacity and design of the dam. In 1976, both the countries started talks to resolve the dispute. The main objection of Pakistan was that India would disturb the flow of the water by building this dam and would cause flooding to the western Punjab. After incessant deliberations, India did show flexibility finally, and shared the details of the project, agreeing in principle to alter the design of the dam. In 1978, both the countries contracted an agreement on this project. In this way, the first major conflict was successfully resolved under this treaty (Siddiqui, 2010).

18.2.3.2 Wullar Barrage Project

The second controversial project from India was the Wullar Barrage (Tulbul Navigation project) which is still unresolved. The location of the project was in the occupied territory of Kashmir on the Jhelum River. India designed to build the barrage atWullar Lake's mouth. No information was provided to Pakistan on the project, as India started construction in 1984. In 1985, Pakistan came to know about the project, and upraising objections demanded to stop the work (Akhtar, 2010). Consequently, the problem was taken up by the Indus Commission, and several meetings were held to resolve this matter. However, the Commission could not resolve the issue and the construction work continuedup till September 1987, when the work was finally suspended. Then, on the Indian appeal, negotiations started at the secretary level. Up to 2008, about 13 rounds of meetings were held, but the matter is still unsolved. Although the work is suspended till date, yet India still harbors intentions to resume it (Siddiqui, 2010).

18.2.3.3 Baglihar Hydroelectric Project

The third major controversial project was construction of Baglihar Project. This was the first project that was sent to neutral experts to resolve because Pakistan raised some technical questions. In October 2008, the project was initiated in district Doda on the Chenab River. It has two stages with 450MW capacity, collectively. Six objections were upraised by Pakistan to the design to base theclaimthat the project did follow the rules of the Indus Water Treaty. Pakistani experts also raised question that India is going to weaken the defense of Pakistan by stopping the flow of the Chenab river (Akhtar, 2010).

In March 2009, the Pakistani minister for Water and Power gave detailed information to the Parliament that Pakistan wanted India either to compensate for the losses or to provide water equal to 0.2 million acre feet, so Pakistan went to the Indus Water Commissioner to raise this issue. India recognized the claim of dropping Chenab's flow during the high flow months, August and September. Two meetings were held between the High Commissioner of the two states, but with no results. India, as usual, showed traditional inflexibility, which caused loss to Pakistan (Siddiqui, 2010).

18.2.3.4 Kishanganga Hydroelectric Project

Another dispute faced by two countries was the construction of Kishanganga project. This issue was taken by Pakistan to the Court of Arbitration for a fair solution. The location of this project is upstream of Muzaffarabad at a distance of 160 km, with 300 MW installed capacity. Pakistan got information about the intentions of India to build the project in 1988. However, it was officially confirmed by India in June 1994, giving some information about the storage work. Pakistan raised some objections to the project. The fundamental objection was regarding the diversion of river water through a 21 km long tunnel towards Wullar Lake to generate power, which was against the provisions of the Indus Water Treaty (IWT). This was not only a serious threat to Neelum-Jhelum Hydropower Project (969 MW) but would also reduce the water supply for agriculture in the areas of Azad Kashmir. It is estimated that about 27% of Neelum river water would be reduced due to this diversion of water towards

Wullar Lake. Pakistan also raised objections regarding design features, specifically the draw-down technology to blush sediments.

In May 2004, due to objection by Pakistan on construction of the project, India agreed to stop all work for six months, and a meeting was arranged between two countries to resolve the issue. In the meeting, Pakistan was provided information that the foundation of the dam and the power-house were under construction. Pakistan strongly asserted that, before resuming the construction work, India must remove Pakistani objections. Five meetings were held under the Commission from November 2004 to November 2005. However, the issue remained unsolved. In addition, no data about water supply was shared with Pakistan (Siddiqui, 2010).

Recently, in 2013, the International Court of Arbitration (ICA) has permitted India to build the dam and gave permission to divert the water towards Wular Lake. Nonetheless, the court ruled that the minimum flow in the river will not be less than 9 m^3/s always, and India can use the remaining water for producing hydroelectricity (Bhutta and Haq, 2013).

18.2.3.5 DulHasti Hydroelectric Plant

The fifth issue between the two countries was the building of two-stage DulHasti hydropower project, having aninstalled capacity of 390 MW. It is situated in Doda district on the main Chenab River. India informed that it was just a hydroelectric station but Pakistan argued that it was a full-fledged dam designed to store water for irrigation like Baglihar dam. India initiated this project in 1983 at the cost of Rs. 34 billion. Pakistan got information that it was 180 m long and 59.5 m high concrete gravity dam. As compared to Baglihar and Salal Projects, the impacts of this project on Pakistan were possibly too severe. Although the stoppage of water could prolong from of 1-2 days only, it was, however, essential to discourage India from providing under-sluices type gated spillways in the body of the dam (Ahmad, 2012).

18.2.3.6 Uri-II Hydel Power Project

This location of this project is in Baramulla district (Indian occupied Kashmir) on the Jhelum River and at the downstream of Uri-I. In October 2002, India was asked to provide information about this project but no response came. In July 2004, India was again asked to provide the requested information and again no answered from India was forwarded to Pakistan. In March 2005, the same request was repeated, and finally the information about the plant was provided by India. In April 2006, Pakistan showed its objection to India. However, in June 2007, they started construction unilaterally on the project without informing Pakistan, and as usual India rejected the demands of Pakistan to stop work on the Uri-II project. Pakistan also warned India to pursue the World Bank intervention in case of not stopping the construction work. However, India continued the construction work instead of providing any adjustments on Uri-IIproject (Akhtar, 2010; Sharma, 2007). The project has been completed recently in March 2014, with the capacity to generate 240 MW of power (Kashmir-Reader, 2014).

18.2.3.7 NimooBazgo Hydro Project

This project as run of the river scheme is positioned on the Indus River in district Ladakh, with an installed capacity of 45 MW. In a meeting held by the Indus Commissionerson March 29, 2010, Pakistan was given the construction plans and maps of the project. Pakistan objected that this project might hinder smooth water supply to Pakistan. In July 2010, during the meeting with the Indus Commissioners, India stated its inability to discuss the construction plan of this project, saying that it was not part of the ongoing negotiations. Even, they did not allow Pakistan to visit the site (Akhtar, 2010; Nosheen and Begum, 2013). Nonetheless, a delegation from Pakistan visited the project in October 2011, and raised 5 main objections, which were mostly related to the height of spillways and the depth of the dam. However, these objections were rejected by the India authorities (Mustafa, 2012).

"There are two aspects to the Nimoo-Bazgar project: one, that India is guilty of violating the treaty; and second, that India is violating Clean Development Mechanism (CDM) rules and regulations under the rules and modalities of the Marrakesh Accords, article 37 B and C, which talk about stakeholder consultation regarding impacts of the project," said Shafqat Kakakhel, the former United Nations Environment Programme official and member of the international CDM board (Parvaiz, 2012). The Nimoo-Bazgo hydroelectric project was commissioned in December 2012 and is now in operational form, from where the cheaper supply of electricity is being ensured to the Indian troops in Siachen (Hindustan Construction Company, 2013; Khalid, 2012).

18.2.3.8 Bursar Dam

This is the biggest project that India intended to build on two major rivers Jhelum and Chenab. The construction work was started in 1996 and is expected to complete in 2016. This dam is being constructed on the Marusudar River near Hanzal village in Doda, which is the tributary of the Chenab River. The dam is expected to have a storage capacity of 2.2 MAF and can generate 1020 MW. This dam was considered as a serious violation of the IWT due to its high storage capacity, which is much beyond tolerable limits. The dam is proposed to have a height of about 829 feet, which is even greater than Tarbela dam (485 feet) and Mangla dam (453 feet). The main object of this project is storage of water, which will help regulate the flow to all downstream projects like DulHasti project, Baglihar dam and Salal dam.

This dam was a clear violation of IWT and international environmental convention (IEC). Not only will it result in water scarcity in Pakistan, but can also cause melting of the Himalayan glaciers. It would inundate about 4900 acres of thick forest and would cause the evacuation of the whole population of Hanzal village. The location of the project covers Kishtwar High Altitude National Park, having about 2 million acre feet which is an environmentally protected area. The park covers 15 mammals' species including the Himalayan black and brown bears as well as the musk dear and some rear birds, which need an environmental impact assessment study. Pakistan's Indus Water Commissioner hascontinuously asked its Indian counterpart to deliverinformationon this project. However, India said that they were aware of its legal obligations, and that they would inform Pakistan about the project details and

offer relevant data six months before the construction activities started, as required under the Treaty (Ahmad, 2012).

18.2.3.9 Indian Future Plan

Pakistan is highly reliant on the water available from the Indus river system. On the other hand, Indiahasplans to build 155 water projects on the western river (Indus, Jhelum and Chenab), which belong to Pakistan according to the IWT. However, the Indian authorities have notconfirmed this plan yet.

"The Permanent Indus Commission (PIWC), which provides an on-going mechanism for consultation and conflict resolution through inspection, exchange of data, and visits between the two countries has compiled a list of 155 hydropower projects dams, India plants to construct in violation of the Indus Waters Treaty of 1960" (Bhutta, 2011).

18.2.4 Canal Scale Water Issues

- The prime issue of the Pakistani canal system is that approved flow does not reach at the outlets of distributaries and mirrors. Certain issues related to the canal system are given below:
    a) Excess withdrawal of water from upstream outlets
    b) Incorrect seepage loss estimations
    c) Incorrect inflow estimations
    d) Sedimentation
    e) Use of faulty or improperly designed outlets
    f) Limited desilting
    g) Un-coordinated re-establishment of equitable distribution
    h) Lack of efficient management
    i) Sociopolitical pressures
- Lack of standard water measuring devices which can ensure planned distributions of water.
- Scheduling and delivering water in canals without considering the water demands, which leads to water losses and over-irrigation and under-irrigation. These problems can result in low crop yield, salinization, and water logging beside wastage of water.
- Inefficiency of management leads to erratic and unequal water distributions among distributaries and outlets.
- Improper operation of canals either excess or below the designed discharge can create problems in the geometry of canal sections.

- Poor communication and transportation systems can totally fail during emergency cases such as flooding and rainstorms.
- Illiterate or unskilled persons for canal system's operation and regulation can create lots of problems in planned water supply.
- Lack of interests and participation of farmers in all operation and management activities of canal system.
- Poor performance and maintenance standards.
- Frequent breaks of canal and interruptions in water supply, especially at distributaries and minor levels due to inadequate maintenance by farmers.
- Insufficient and poorly defined procedures of monitoring, evaluation, and accountability at all levels of management.
- Lack of administration during preparation of operational and maintenance plans and their implementation (Anver and Haq, 1988)

18.2.5 Farm Scale Water Issues

The followings are the major issues related to farmers:

18.2.5.1 Water Availability/ Scarcity

Recently, the water availability in Pakistan has dropped to almost 1,100 m^3/ capita since 1940-41, a decrease of over 60%. The scarcity of water during the season of the Rabi can badly disturb the Rabicrops, both in the case of productivity and area. In addition, it can also cause bad impactson the plantation of cotton crop especially in Sindh, as the crop is planted there much earlier than in Punjab.

Some significant issues related to water availability are mentioned below:

1. Seasonal and annual variability of surface water and impact of global warming
2. Decrease in storage capacity of reservoirs due to sedimentation
3. Growing crops of demanding high water quantity and giving a low-return
4. Increasing demands in domestic and industrial sectors, resulting in reduction in irrigation supplies
5. Low delivery efficiency of water supply systems, especially municipal and irrigation systems
6. Water quality deterioration due to agricultural drainage effluent and untreated urban sewage
7. Up-coning from underlying saline aquifer causing salt-water intrusion
8. Over exploitation of groundwater, resulting in depleting groundwater table
9. Increasing pumping costs due to deteriorated performance of public tubewells

10. Ecosystem degradation from seawater intrusion resulted due to low flows below Kotribarrage (Ashfaq et al., 2009)

18.2.5.2 Waterlogging and Salinity

The major factors causing waterlogging and salinity in the country are irrigated agriculture mismanagement, seepage from the link and irrigation canals, flat topography, inadequate drainageand poorquality effluent from a drainage system. This problem has already reduced the production of millions of acres of land. In spite of huge investment on Salinity Control and Reclamation Projects (SCRP)assumed since 1960s, the problem is still not completely resolved. In addition, this problem is getting more severe and severe due to the discharge of drainage effluent.

The waterlogging and salinity, currently, has affected 8% of Punjab soil and around 15% of the soil of Sind and a loss of 1/3 annual yields on slightly saline areas and 2/3 in moderately saline areas. According to a soil survey conducted in 1981, it was estimated that salinity has severely affected around 8% of the gross command area, and according World Bank, it was estimated that salt salinity has reduced potential production of about 25% of the major crops of the country. It is estimated that a land of around 2.4 million ha has a water table less than 5 feet. Increasing diversion of water from rivers and canals over the years has directed towards increasing water table, rising problems of salinity in some areas (World Bank, 1992).

18.2.5.3 Over-Exploitation of Groundwater

Since 1970s, the use of groundwater has amplified to agriculture sector. Groundwater not only supply additional water to cope the water requirements of crops but also offer elasticity. The extensive usage of groundwater in the private sector can pollute the freshwater aquifers with saline water by dropping of water tables in fresh groundwater regions. Further, due to unequal distribution of canal water, farmers mostly depend on groundwater, resulting in over extraction of groundwater.

The continued abstraction of groundwater has resulted in over-pumping and consequent depletion of water table in many areas. Recently, this problem has become more serious due to the continued and extended drought faced by the country. The more noticeable areas affected by these problems are Lahore, some parts of Balochistan, some densely populated urban parts of the Punjab as well as of Sind.

It is reported that, in 26 canal commands, the water table is getting lower with various degrees of depletion. Those canal command areas are most affected where water allowance is lower and crops are heavily dependent on tube well irrigation (Ashfaq et al., 2009).

18.2.5.4 Low Irrigation System Efficiency and Water Productivity

A significant amount of the water is lost through seepage and evaporation because the irrigation system of Pakistan comprises of rivers, a network of unlined irrigation and link canals, unlined distributaries, unlined watercourses, and irrigated fields. It is estimated that 25% and 30% is lost through canals and watercourses, respectively, and 25-40% in the fields due to application of old irrigation practices. An overall

irrigation efficiency of 30 % is hardly obtained in the whole system (Ashfaq et al., 2009).

18.2.5.5 Inequitable Distribution among the Users

Until the resolution of the water issues among the provinces through Water Apportionment Accord (WAA) of March 1991, the water of Indus Basin Irrigation System was distributed among the provinces on ad-hoc basis. The distributions of water to the provinces are based on two main concepts:

1. Protecting the prescriptive rights of the provinces acquired through actual canal withdrawals under various projects, and
2. Allocating the surplus water fairly for greater development opportunity to relatively backward areas.

WAA was a great institution for water resources policies in Pakistan. The recognition of environmental protection was measured as the most significant area by the Government of Pakistan. A freedom was given to each province to change the water apportionments within different canals system, which was a great step in the direction of allocation rationalization for agricultural productivity. It obviously did not go to cover the entire Basin, but indicated a movement from the rigidity of the historical withdrawals of each canal system to at least a sub-basin. In spite of the good intentions, the extended drought of 1998-2000 disclosed the limits in the Accord when serious differences arose between provinces over the supply of water under reduced flows. Many problems were produced at farm levels during the distribution of the reduced water flows. One of the major problems was that the tail reaches receive much less water as compared to head reaches. Interference by big landholders in the distribution of water and theft of water were the major reasons for the poor state of affairs. Command Water Management (CWM) and On Farm Water Management (OFWM) projects have given emphasis to the need for equitable distribution of supply between the head and tail of distributaries and watercourses (Ashfaq et al., 2009).

18.2.5.6 The surface water and Groundwater Pollution

The quality of ground and surface water is rapidly deteriorating. The undiscriminating domestic and industrial wastewater into all water bodies is the main threat to the water resources of the country. The main reason for this water quality deterioration is the lack of application of legislative measures and standards. The problem is getting more severe due to increasing contamination from industrial, agricultural and municipal wastes into many aquifers and open water bodies like lakes, rivers and streams of the country. It is estimated that the Ravi River ‘pollution due to sewage discharge from Lahore city reduces about 5,000 tons of fish every year (Ashfaq et al., 2009).

18.2.5.6 Poor System Operation and Maintenance

The poor operation and maintenance of the whole irrigation system are the major management issues of the water sector, starting from the rim stations and ending up to the farmers’ fields. Water and Power Development Authority (WAPDA) manages the operation of the reservoirs, and Provincial Irrigation Departments (PIDs) take

care of the operation of the canal and drainage facilities. Accordingly, PIDs, water resources of Pakistan are greatly vulnerable and under high pressure. Discharge observational structures are not of good quality on the major canals. PIDs are also responsible for the maintenance of the Indus Basin Irrigation System (IBIS) down to the watercourse. On the other hand, the farmers are mostly responsible for maintaining the watercourse and the farm channels.

The maintenance efforts for the large Indus system are insufficient. The significant deterioration in the system performance has major adverse implications. For example, the inequity in water distribution has caused salinization in the tail areas. PIDs lack development budgets, which can cover the cost of maintaining its establishments (staff costs) and the cost of maintenance. Since the amount available for maintenance is not enough, some repairs are affected under the Annual Development Program (ADP) including major programs of renovation under Irrigation Systems Rehabilitation Project (ISRP).

PIDs also cover the maintenance of SCARP tube wells and tile drainage pumps. The SCARP tubewellshave many installation problems and also have high operation and maintenance cost. To deal with these problems, the Government started a rehabilitation program knows as Irrigation Systems Rehabilitation Project phase I (ISRP-I) in 1983. In the framework of ISRP-II, the provinces agreed to maintain FY88 levels in real terms, using FY88 funding level as a benchmark for the existing facilities with appropriate increases to cover any new facilities. However, actual expenditure fell short of FY88 level in all provinces except KPK. In Balochistan, it was as high as 90 percent (Ashfaq et al., 2009).

18.2.5.7 Water Pricing and Valuation

In Pakistan, water is traditionally considered a public good. However, it is widely known that the water supply charges are much below than its opportunity value. Recently, water charges in irrigated agriculture are only 5% of the production input values. Further, the main view on price of irrigation water is that, even when it is considered a ‘public good’, its supply should not be subsidized (Ashfaq et al., 2009).

18.2.5.8 Sea Water Intrusion Issues

The Indus river discharges into the Arabian Sea that repels the salt water to encroach into the surface and subsurface water. This issue is getting severe due to a shortage in the water of the Indus River. Salt-water intrusion has been explored up to 100 km. The salt-water intrusion badly affected theLar area of Sindh. Drinking of brackish water resulted in various diseases. For example, throat swelling was observed in the coastal areas due to drinking of brackish water. Furthermore, it caused loss of fertility of agricultural lands, resulting in economic loss. Hundreds of villages in Badin and Thatta districts have been become deserts, and people have been forced to migrate to some other places. Pakistan National Institute of Oceanography (PNIO) and National Science Foundation (NSF)have recognized that salt-water intrusion into the lower Sindh plains is directly linked to reducing the flow of Indus River. Until adequate water is released to Indus downstream of Kotri, seawater intrusion, combined with raised level of Arabian Sea due to climatic changes will convert Badin, Thatta and

some southern parts of Hyderabad district of Sindh into waterlogged land (Memon 2002)

Table 18.2 Main Issues and Possible Remedial Options for Pakistan Irrigation System

Issues	Possible Remedies
Overall scarcity of water	• Enhancement of rainwater harvesting by Collaboration & partnerships with development organizations. • Increasing the Capacity of groundwater recharging system through catchment restoration, Delay action Dam or retarding Damrecharging wells, flood management, and other efficient and effective means of sustainable water infrastructure development. • Define demands and identification of proper ways and means for reduction of high water demands
Waterlogging and salinity in irrigated areas	• Through understanding of irrigation systemsandcurrent cropping pattern, keeping in view the economic aspect by carrying or performing the cost-benefit analysis and also adaptation to Better crop water management approaches or practices according to geographical distribution. • Restoration of environmental flows to flush out salts in the Soil
Overexploitation of fresh groundwater in upland and desert areas	• Review policies and incentives for over-exploitation, and promote better equity and environmental cost charging systems • Help restore the traditional and natural regime of groundwater Systems
Low efficiency in delivery and use in both domestic and agriculture sectors	• Awareness programs for efficient water utilization among farmers, • Capacity building programs should also be devised for partner organizations including the government and civil society to improve the efficiency level in delivery and use
Inequitable distribution among water users at the provincial and local levels	• Review economic aspects of distribution policies, carry out cost-benefit analysis, and identify local interests • Promote multi-stakeholder dialogues • Policy level initiatives, which lead through recommendations for incentives to promote equity among all stakeholders. • Solid initiatives or steps to develop local water management systems and reforms.
Pollution of fresh water bodies and natural rivers/streams particularly those near urban centers	• Identify pollution sources, type and levels of pollution • Improve the capacity of government institutions to plan and monitor projects and conduct EIA studies • Work with the private sector as well as promote public-private partnership to look for alternatives or to seek remedial action
Poor maintenance of the irrigation and distribution system; and insufficient cost recovery from supplies made for irrigation and domestic use.	• Not an IUCN issue, but need to raise awareness in order to improve the systems. Investigate incentive schemes for performance improvement • Look at alternative pro-poor financing mechanisms for aquatic ecosystem management
Conversion of natural wetlands into other land use types	• Economic assessment of costs and benefits and recommendations for economic incentives for wetland conservation
Floods and droughts	• Improved geo-physical planning and introduction of Flood &Drought management policy initiative
Loss of downstream flows in Indus during winter	• Restore environmental flows for maintaining the natural regime of rivers and other water bodies

Source: Ashfaq et al. (2009)

The estimations in this study are partial and ignore a number of substantial environmental subjects because of incomplete data. Perhaps, the most important omission is that of the mangroves of the Indus Delta. The interaction of riverine and deltaic ecosystems created a rich resource that has continued coastal communities. According to a survey conducted by the International Union for Conservation of Nature (IUCN) in two districts of Sindh (Badin and Thata), sea water intrusion may have affected over 135,000 people and resulted in losses in excess of $125 million.

18.3 Proposed Solution Options

There are many issues related to irrigation systems in Pakistan as discussed above. Most of these issues relate to the operation and performance of the system. The issues and the proposed options to solve are described in the Table 18.2.

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