7 Water Sustainability in Pakistan – Key Issues and Challenges

7.1. Overview

Water is a crucial resource for the livelihood of people and sustained development of any economy. For Pakistan, it takes on more significance, as the economy is agrarian in nature and depends on a single source, the Indus basin, to meet most of its water needs. Hence, water availability and its efficient utilization lie at the heart of any strategy aimed at ensuring food security and achieving a sustained long-term economic growth.

In this backdrop, this chapter provides an overview of water availability in Pakistan; identifies key issues and constraints to efficient water management; and highlights future challenges to water sustainability. In our view, the widening gap between water demand and supply has now become a major social and economic concern that requires a comprehensive national policy, formed with the consensus of all provinces and the federal government. The focus of reforms should be on improving efficiency in water consumption and management, and building the capacity of relevant regulatory institutions.

Undoubtedly, designing a reform agenda that is acceptable to all stakeholders may appear challenging, as people are generally sensitive to any forced change in their water usage rights. However, any delay in reforms would only compound the concerns, as the water deficit would expand on account of growing demand (stemming from population growth, urbanization, and economic development) and a decline in available supplies (owing to pollution and climate change).

Table 7.1: River Flows and Water Availability (1979-2015)
million acre feet

	Average
Total river inflows (a)	143.3
Ground water available (b)	50.0
Total water supply (a+b)	193.3
Average withdrawal through canals	101.0
Escapage below Kotri	26.7
Evaporation and other losses	15.6
Water availability (agriculture)	
Average withdrawal through canals	101.0
Losses (from canal head to farm gate)	24.3
Water available at farm gate (c)	76.7
Groundwater withdrawal (d)	47.0
Overall water availability (c+d)	123.7

Data source: Water and Power Development Authority

7.2 Current Situation

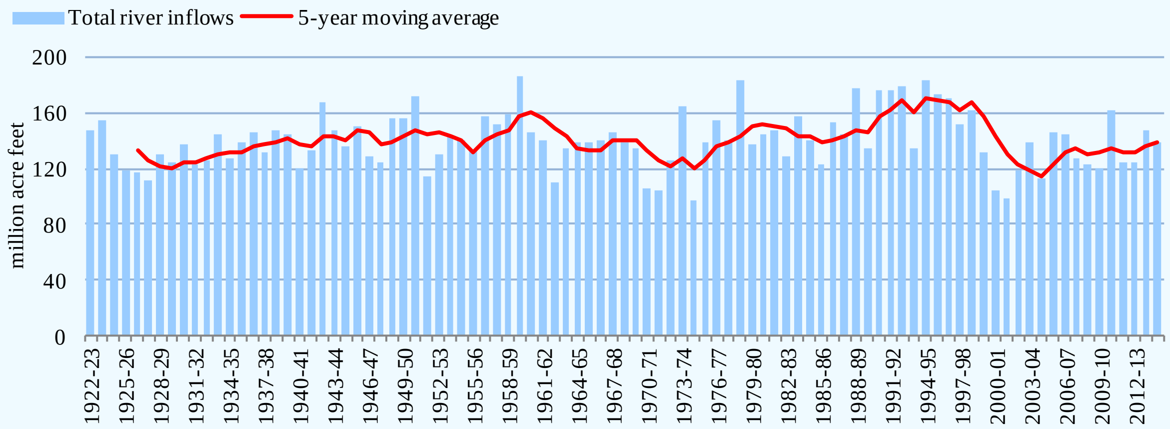
The current water supply in Pakistan is not only limited, but also quite erratic in nature. More importantly, the overall availability faces significant risks from increasing pollution and climate change. The water demand, on the other hand, is rising rapidly on account of growing population and urbanization. Thus, the resulting imbalance is pushing the country towards severe water shortage.

Water supplies are vulnerable and suffer from extensive losses

Being a semi-arid country, Pakistan relies heavily on the Indus River and its tributaries (Kabul, Jhelum, Chenab, Ravi, and Sutlej) for water supplies, which together contribute over 140 million acre feet (MAF) per annum (**Table 7.1**).[1] This reflects the country's vulnerability to a single basin, which itself is subject to insecurity due to continuing water disputes with India. The high dependence compares unfavorably with other regional countries that either rely on multiple basins or receive sufficient rainfall (**Box 7.1**).

[1] Approximately 90 percent of Pakistan's land area is classified as semi-arid. The overall volume of rainfall is low, with large seasonal and regional variations. While the average rainfall remained at 494 mm per annum for the period 1962-2014, it varied from less than 150 mm in Sindh and Baluchistan to 1,500 mm in Gilgit-Baltistan. In addition, around two-thirds of the annual rainfall is concentrated in the three summer months, i.e., July to September.

Figure 7.1: Water Inflow at Rim Stations - Historical Trend



Data source: Water and Power Development Authority

Vulnerability to erratic water supplies is further compounded as variation in rainfall and melting of snow result in wide seasonal changes in river runoff during the year. Indeed, more than 80 percent of the annual inflow is realized during the April-September period. Another important factor adding to the uncertainty in river inflows is the multi-year cyclical weather pattern, which affects the intensity of wet and dry seasons (**Figure 7.1**). These patterns, which are quite significant for Pakistan, explain a very large gap between the minimum river inflow of 98.6 MAF (realized in 2001-02) and the maximum inflow of 186.8 MAF (in 1959-60).[2] The concerns on water flows have recently increased due to climate change, which has exacerbated the seasonal river fluctuations, and may even reduce the overall supply of water to the country in the future.

Box 7.1: Water Availability – A Regional Comparison

A comparison with South Asian countries reveals that Pakistan, being an arid country, derives most of its water supplies from river flows. Other South Asian countries are comforted with tropical monsoon climate, receiving average annual rainfall exceeding 1,000 mm. Pakistan, on the other hand, receives rainfall of less than 500 mm per annum.

To add to Pakistan's water constraints, the country solely relies on the Indus River and its tributaries. In comparison, India relies on several river basins, such as the Ganges River, Godavari River, included in the 12 major river basins and hence has a comfortable annual river flow supply. Similarly, Bangladesh's river flow supplies are derived from 3 major basins.

Table 7.1.1 Water Availability in South Asia (2011)

	Precipitation	Ground water	River flow
	(millimeters)	(million acre feet)	
India	1,083	350	1,515
Bangladesh	2,666	17	978
Nepal	1,500	16	170
Sri Lanka	1,712	6	42
Bhutan	2,200	6	63
Maldives	1,972	0.02	0
Pakistan	494	45	194

Data source: Human Development in South Asia 2013 – Issue of Water from the Perspective of Human Development (MHHDC 2013)

The challenge to water resource management becomes more difficult, as not all of the water supply is available for consumption. Besides inevitable evaporation losses and the required flows into the Arabian Sea (to prevent intrusion into the delta region), there are extensive system leakages due to limited storage and weak irrigation infrastructure.

Groundwater pumping, another crucial source that contributes 40 percent to total supplies at farm gate, also faces sustainability concerns. A greater control on timing and the available amount has

[2] The Water Resource Institute computes interannual variability indicator, which is the standard deviation of annual total water divided by the mean of total water from 1950 to 2010. This index ranges from 0-5, where 0 represents the lowest variability and 5 the highest. The index for Pakistan is 2.37, which is considerably higher than that for China (1.97), India (1.72), Sri Lanka (1.59) and Bangladesh (0.07).

encouraged reliance on extraction of groundwater. While this is beneficial where fields are waterlogged or salinized, the over-exploitation in certain areas has led to depletion of this valuable resource. In a few areas, the excessive use has resulted in the intrusion of saline (brackish) groundwater into the fresh aquifers, thereby making it then unusable.[3,4]

Stress on water resources is high, and going to worsen

The extent of stress on water resources in the country is evident from the high pressure on its renewable freshwater resources and the low number of people with access to drinking water and sanitation facilities (**Table 7.2**). According to a more broad-based indicator, Pakistan is categorized as being close to *water scarcity***,** level with per capita availability of 1017 cubic meters (**Figure 7.2**)[5]. In comparison, India is in the group of *water stress* countries with water availability of 1,600 cubic meters per capita.

Table 7.2: Indicators for Demand Pressure on Water Resources

percent

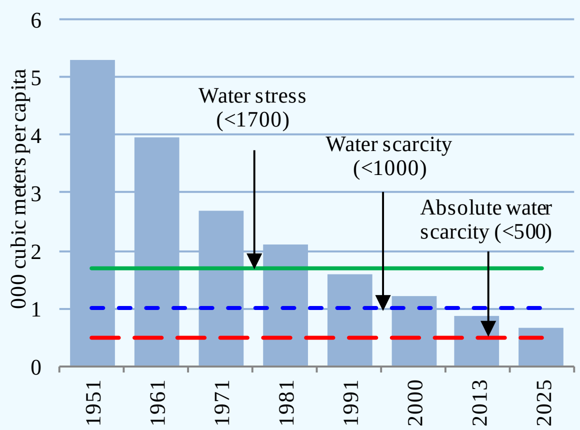
	Pressure on water resources[1]	Dependency ratio[2]	Access to safely managed water 2015
Malaysia	2	0	92
Bangladesh	3	91	56
Nepal	5	6	27
Thailand	13	49	--
Maldives	16	0	--
Sri Lanka	25	0	--
India	34	31	--
Iran	68	7	91
Pakistan	74	78	36

Data source: FAO-AQUASTAT database, March 2013; and WHO/ UNICEF Joint Monitoring Program (JMP) for Water Supply and Sanitation (http://www.wssinfo.org/)

1. Proportion of total actual renewable freshwater resources withdrawn;
2. Dependency ratio is the share of water originating outside the country;
3. Safely managed water services accessible on premises, available when needed, and free from contamination.

More importantly, the stress is going to increase further due to growing demand, mainly coming from rising population, rapid urbanization, and adverse impact of climate change, and the continuing degradation of water quality. This pressure will push the country very close to the threshold for *absolute water scarcity*. According to The World Resource Institute, Pakistan is going to face a *high* level of water stress by 2020.[6] By 2030, the ranking will worsen further to *extremely high* level, thus pushing Pakistan to the list of top 33 countries under extreme water stress.

Figure 7.2: Water Stress Level in Pakistan



Data source: Draft National Water Policy

7.3. Issues in Water Management

Limited storage capacity resulting into canal water shortages and excessive losses to the Arabian Sea

The current storage capacity is inadequate as the three major water reservoirs in Pakistan, i.e. Mangla (1967), Tarbela (1978) and Chashma (1971), have a total designed capacity of 15.75 MAF, which has been reduced to 13.1 MAF due to sedimentation. These reservoirs can store water

[3] The withdrawals from groundwater account for 83 percent of total renewable groundwater available.

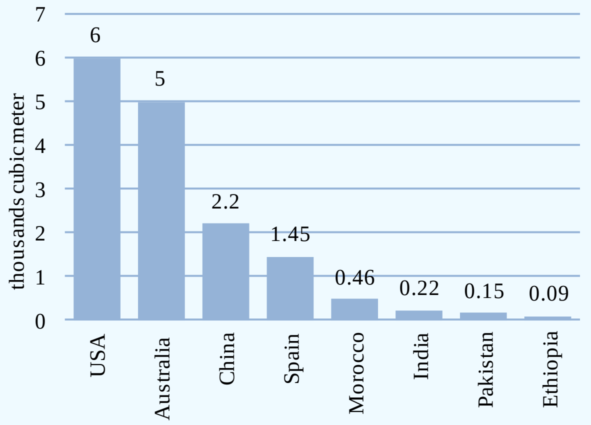
[4] Under normal situation, intrusion of saltwater to inland areas is limited due to pressure from higher level of freshwater. However, lowering of freshwater levels due to its excessive abstraction allows denser saltwater to move into inland aquifers.

[5] Prof Malin Falkenmark, who proposed the indicator, defined three thresholds for per capita water availability on the basis of consumptive needs for an economy with decent growth; i.e., water stress (less than 1,700 cubic meter per capita); water scarcity (less than 1,000); and absolute water scarcity (less than 500).

[6] The World Resource Institute has ranked countries after considering a wide range of variables (such as temperature, precipitation, and wind speed and soil moisture absorption from supply side; and water withdrawals from municipal, industrial and agricultural sources from demand side). For details, see World Resources Institute http://www.wri.org/publication/aqueduct-projected-water-stress-country-rankings

equivalent to 30 days of consumption, whereas the standard minimum requirement is 120 days; most of the advanced countries have capacities of 1-2 years.[7] Furthermore, Pakistan's live storage capacity is 150 cubic meters per person, with Ethiopia the only country that has a lower per person live storage (**Figure 7.3**).[8] The storage capacity is also low in terms of available water, as the country's reservoirs can store less than 10 percent of the annual river average flows against the standard of 40 percent.

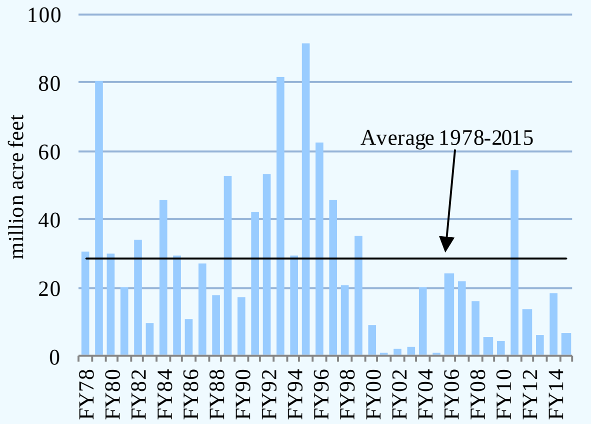
Figure 7.3: Water Storage Capacity - A Country Comparison



Data source: World Bank (2006)

The continued excess flows to the Arabian Sea also suggest that the country requires additional storage capacity. The below Kotri escapages averaged around 28 MAF during 1978-2015, which is considerably higher than the downstream Kotri requirement of 8.6 MAF (5,000 cusecs year around) **Figure 7.4**.[9] The key reason for such high flows in the sea is the limited storage capacity and seasonality in river flows, as around 80 percent of the flow in the upper Indus occurs July to September. The average flows to sea increase significantly during floods.[10] The water losses are likely to increase further as climate change may hasten the glacial melting.

Figure 7.4: Escapage Below Kotri Barrage



Data source: Handbook on Water Statistics of Pakistan

The current storage capacity is also inadequate to provide provincial canal diversions in line with the Water Apportionment Accord 1991, which assumed average annual water availability of 114.35 million acre feet. This included 10 MAF of water to be derived from future construction of storage dams. While the additional storage did not materialize, the continuing sedimentation, as mentioned earlier, continued to eat into the existing capacity. As a result, the canal withdrawal that reached 106 million acre feet after construction of Tarbela is now averaging 99.58 MAF. Thus, additional storage is needed to ensure canal withdrawal, in accordance with The Indus Water Apportionment Accord 1991.

Transboundary disputes intensifying river supply vulnerability

The Indus System Rivers flowing into Pakistan originate in India;[11] hence, for peaceful water management, the Indus Water Treaty of 1960 prevails between the two countries. According to the treaty, the western rivers (Indus, Jhelum, Chenab) are reserved for Pakistan, whereas the eastern rivers are reserved for India. Despite its sole dependence on The Indus basin, Pakistan was allocated 75

[7] In comparison, India has a capacity for over 120 days, whereas Egypt has the capacity of 1000 days.

[8] Source: Pakistan Water Resources Sector Strategy (2006) by World Bank. The data is based on comparison of Semi-arid countries.

[9] Source: Fernando J Gonzalez, Thinus Basson, Bart Schultz (2005), "Final Report by International Panel of Experts, For Review of Studies on Water Escapages Below Kotri Barrage".

[10] Human Development in South Asia 2013, Issue of Water for the perspective of Human Development; published by Mahbub ul Haq Human Development Centre Lahore; available at http://mhhdc.org/?p=40

[11] Indus and Sutlej originate in China and flow through India, whereas Ravi, Jehlum, Chenab and Beas originate in India.

percent of Indus water. Moreover, the treaty allows India some limited use of water in western rivers for irrigation, storage and for generating hydroelectric power, but under a condition that the use would neither affect the quantity of water in rivers, nor alter the natural timing of flows.

However, in the past disputes have emerged over the treaty when India started developing a number of power projects on the western rivers, e.g., Baglihar dam and Ratle Project on the Chenab, and Kishanganga Project, on tributary of Jhelum.[12] Pakistan claims that these projects do not follow the specifications and criteria provided in the treaty, and would therefore affect the hydrology and ecology of western rivers flowing into Pakistan. For example, the Kishanganga dam is expected to divert 10-33 percent of river flows from Neelam River and hence affect water availability for the Neelum-Jhelum hydropower plant. Pakistan has been pursuing its legitimate objections to a number of such Indian projects on western rivers at platforms defined under the treaty.

As for Afghanistan, (Pakistan also derives water from the Kabul River), the construction of hydropower projects on the river has also raised concerns. Being the lower riparian state in this case, Pakistan reserves certain rights; however, no such water sharing agreement exists between the two neighbors. Construction of storages and hydropower projects is expected to lead to decrease of around 17 percent in the annual river flows.[13] Hence, there is a need for an official agreement between the two countries that defines the terms of sharing and construction of hydropower and other water storing facilities on the Kabul River.

Outdated distribution system results in low productivity and inequitable distribution of water

The inefficient distribution system (also known as warabandi) has resulted into low water productivity in Pakistan. For instance, over 90 percent of total annual water available in the country goes to agriculture. Furthermore, the supply of water is linked to the canal command area, and farmers are required to consume water even when it is not required. Thus, the output produced against a unit of water remains extremely low.[14]

This unreliable and rigid water distribution system also explains the low productivity of water (defined as the average crop product per unit of water consumed). According to a study, water productivity for cereal crops in Pakistan is almost one-third of that in India, and one-sixth of the productivity realized in China (**Table 7.3**).

Table 7.3: Water Productivity Comparison (kg/m^3)

Country	Water productivity for cereal crops	Water productivity for wheat crop
Pakistan	0.13	0.5
India	0.39	1.0
China	0.82	-
USA(California)	-	1.5

Data source: Kumar, M. D. (2003). *Food Security and Sustainable Agriculture In India: The Water Management Challenge*. Colombo, International Water Management Institute (Working Paper 60); and International Water Management Institute (2000), *Water Issues for 2025, A Research Perspective*. Colombo Sri Lanka.

Furthermore in the current irrigation system, the proximity of the land to the water course is crucial for adequate supply of water. Thus, farmers at the tail-end remain at a disadvantage, whereas those at the head benefit. The growers near the canal-head sometimes apply water 4-5 times each season as compared to tail-end farmers.[15 16] This places

[12] Shaheen Akhtar, “Emerging Challenges to Indus Waters Treaty: Issues of Compliance and Transboundary Impacts of Indian Hydoprojects on the Western River,” Institute of Regional Studies Islamabad, *Focus* 28, no. 3 (2010).

[13] Iffat Pervaz & Dr. M. Sheharyar Khan (2014), “Brewing Conflict over Kabul River; Policy Options for Legal Framework”, Institute for Strategic Studies and Research Analysis Papers (The Journal of Governance and Public Policy), Volume VI, Issue No. II.

[14] Under this system, irrigation department officials record the cultivable command area, and the water is then provided to one-third of this area during a year. A farmer receives and utilizes water for 10 days before yielding flow to the next grower. As mentioned in the Canal and Drainage Act 1873, this provides key legal framework for distribution of water at canal level and allocates a fixed rotational period of distribution.

[15] Latif, Muhammad (2007), “Spatial Productivity along a Canal Irrigation System in Pakistan”, Irrigation and Drainage 56 (5): 509-521.

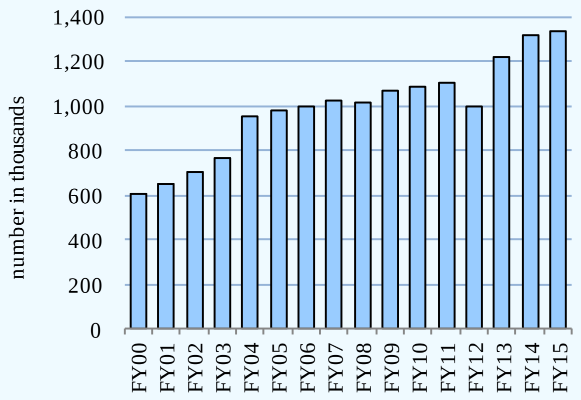
tail-end farmers at a disadvantage, adversely affecting the crop quality and yields. Hence, such inequity leads to reliance on groundwater pumped through private tube-wells, which is costly. As a result, tail-end farmers pay up to 30 times more for water access.

Domestic water distribution is also characterized by inequity and several inefficiencies. In the country's largest province, Punjab, only 18 percent of the population in rural areas relies on tap water as source of water and rest utilizes groundwater, as compared to 51 percent of urban population with access to tap water.[17] This indicates that a large number of households have to rely on other expensive sources of water,such as underground water and tankers.

Groundwater resource depleting rapidly due to over-pumping

Due to the unpredictability associated with canal water supplies, farmers have turned to groundwater pumping. Thus, the number of tubewells installed has increased sharply over the years (**Figure 7.5**), and groundwater has now become a significant source of water, as its contribution to irrigated agriculture has doubled in the last 40 years from (25.6 to 50.2 MAF). This is equivalent to 50 percent of overall canal water withdrawal for irrigation. Industries and domestic sector also relies on groundwater resources for water supply.

Figure 7.5: Number of Tube wells



Data source: Agriculture Statistics of Pakistan, Ministry of National Food Security and Research

Even in the domestic sector, unmonitored groundwater exploitation is on the rise due to improper water provision. In Faisalabad for instance, households have turned to groundwater due to inefficient supplies and non-monitoring by local WASA.[18]

It is true that precipitation and river flows constantly recharge most of these groundwater aquifers – a process that enables people to have reliable access to this key water resource even for a very long period. However, no matter how large these aquifers may be, excessive pumping would also deplete this valuable resource. This is what is happening in many regions across Pakistan, where unregulated and excessive use of groundwater is leading to falling water tables and reduced quality. For instance, Lahore has seen reduction in water tables at 0.5 meters annually for past 30 years (**Table 7.4**).[19] This is despite the fact that Lahore is provided water by the river Ravi and has an extensive canal system. The situation is a lot worse in Balochistan where there are no major rivers or canals to

Table 7.4: Average Annual Rate of Groundwater Decline in Lahore

	Rate of Decline	
Period	**Feet/year**	**Meter/year**
1960-1967	0.98	0.30
1967-1973	1.80	0.55
1973-1980	1.97	0.60
1980-2000	2.13	0.65
2007-2011	2.60	0.79
2011-2013	3.00	0.91

Data source: S.Kanwal, H.F. Gabriel, K. Mahmood, R.Ali, A.Haider, T.Tehseen. "Lahore's Groundwater Depletion-A Review of Aquifer Susceptibility to Degradation and its Consequences, Technical Journal UET Taxila Pakistan, Vol.20 No.I-2015

[16] World Bank (2005), "Pakistan Country Water Resources Assistance Strategy—Water Economy: Running Dry", South Asia Region, Agriculture and Rural Development Unit, Report No. 34081-PK.
[17] Asif M. Bhatti and Seigo Nasu (2010) "Domestic Water Demand Forecasting and Management Under Changing Socio-Economic Scenario", Society for Social Management System.
[18] Shabbir Ahmed, Saleem H. Ali, M.Usman Mirza and Hina Lotia (2017), "The Limits of Water Pricing in Developing Country Metropolis: Empirical Lessons from an Industrial City of Pakistan", International Growth Center,
[19] World Bank (2005), "Pakistan Country Water Resources Assistance Strategy—Water Economy: Running Dry". South Asia Region, Agriculture and Rural Development Unit Report No. 34081-PK. Washington, DC: The World Bank

recharge the water table. Thus, water tables in Pishin district have receded down to 1,000 feet.[20] In Sindh, cities like Hyderabad and Benazirabad are also facing decline in groundwater levels on a similar scale.[21]

The unsustainable pumping rate has even led to intrusion of brackish water into fresh water resources, thereby reducing the availability of quality ground water as per the standards of World Health Organization (WHO). In KP, Kohat, Bannu and D.I Khan are some regions where over pumping has lowered water tables and resulted in contamination from deep saline groundwater. In Balochistan, there are reports of intrusion of saline water into aquifer zones in coastal areas.

Extremely low water tariffs are distorting incentives for water conservation
Ideally, water prices should reflect the value that users generally place on their consumption. In this way, a proper pricing strategy can be used as a tool not only to recover the cost of operation and maintenance of the system, but also to contain water losses and promote conservation.

In Pakistan, canal water charges, also called *abiana*, are very low, as the canal irrigation cost stands negligible when compared to its close alternate, say tube well irrigation.[22] Furthermore, *abiana* rates have no link with the amount of water being consumed. Currently, provincial governments charge a flat rate as abiana on the basis of cropped area. As a result, once the cropped area has been determined, the incremental cost of applying extra water falls to zero. Similarly, the tariffs are unreflective of the water intensity of various crops. For example, rice and cotton on average are charged at Rs 85 per acre; even though rice consumes 60 percent more water than cotton.

The prevailing pricing structure, which has no link with consumption, discourages water conservation. Thus, in agriculture, where farmers do not have an incentive to invest in simple and cheap technology (e.g., laser leveling of land and bed-furrowing), the use of more advanced technologies (e.g., drip irrigation and sprinkler) becomes out of question.[23] Thus, large quantities of water are allowed to flow in the fields allowing for wastages through evapo-transpiration.[24]

Low recovery and underfunded water infrastructure contributing to high water losses
Water tariffs are also extremely insufficient to maintain the water infrastructure, which is already in precarious condition.[25] To put this in perspective, even if we assume the maintenance cost at around one percent of the value of the stock of infrastructure, this would translate into water charges of Rs 1,800 per hectare. In comparison, the *abiana* rate varies in the range of Rs 85 per hectare in Punjab to Rs 617.8 in KP.[26,27]

More importantly, the recovery remains considerably short of the assessed amount (**Table 7.5**). One reason is the absence of any legislation to penalize defaulters. The revenue recovered also remained

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[20] Pakistan Water Resources Sector Strategy (2004)
[21] The depletion in groundwater also increases the abstraction cost to users.
[22] The canal cost in Sindh in FY16 was Rs 181.9 per acre whereas tubewell cost was Rs 1,837.5 per acre. Similarly in KP, the canal cost was Rs 836 per acre and private tubewell cost was Rs 1,827 per acre.
[23] Drip irrigation is the application of small amounts of water at the base of plants (surface drips) or directly at the roots. This is an efficient method for water application which reduces labor, saves water, involves less soil erosion, and results in increased productivity.
[24] Even in the domestic and industrial sector, there is unplanned water exploitation. Water is generally not saved and used inefficiently in cooking, cleaning and sanitation uses.
[25] In most developing economies, water charges hardly recover operation & maintenance (O&M) costs, whereas in advanced economies (e.g., Austria, Denmark, Finland, and New Zealand), water charges cover capital costs besides the interest on capital.
[26] Canal Water Pricing for Irrigation in Pakistan: Assessment, Issues and Options. A report by Planning Commission, Government of Pakistan, June 2012
[27] In Punjab, a full recovery in water charges of Rs 135 annually would generate revenues equivalent to less than 45 percent of the O&M costs of the system.

lower than the cost of operation and maintenance (O&M) of the irrigation system, which led to its heavy dependence on government support for its functioning.[28] Often the budgetary constraints resulted in maintenance delays; sometimes maintenance work suffered as a large share of O&M expenditure was made on operational heads such as salaries.[29]

Table 7.5: Abiana Assessment and Recovery

	Assessed amount (million rupees)			Recovery to assessment ratio
	FY01	FY10	% change	
Punjab	2,260	1,662	-26.5	63.4
Sindh	453	261	-42.4	89.3
KP	197	229	16.2	63.6
Balochistan	45	200	344.4	15.1

Data source: Canal Water Pricing for Irrigation in Pakistan: Assessment, Issues, and Options; Planning Commission, Government of Pakistan June 2012.

The gradual crumbling of water infrastructure contributes to extensive conveyance losses. According to estimates, canal conveyance efficiency is 78 percent, i.e., over one-fifth of canal water is lost before reaching the farm gate; an additional one-fourth of the water is wasted during its application in the field.

An almost similar situation prevails in water delivery to households, where the operating cost is significantly higher than the revenue. For example, operating expenses of The Karachi Water and Sewerage Board (KWSB) in Karachi were 13 percent higher than its revenue. The revenue bill collection is also very dismal: the average recovery is around 64 percent, and it ranges between 21 percent for Quetta and 98 percent for Lahore.

This situation results in a vicious circle where insufficient funds deteriorate the quality of water delivery service, which means that users are less willing to pay, and leading to fewer funds being available for maintenance. Large investment to upgrade the water infrastructure and recovering its maintenance cost from users is one of the possible options. It may be noted that farmers already pay exorbitant amounts on diesel pump for tubewells, as this ensures them reliable supplies of water and results in higher productivity.

Waste discharge into drains and rivers has resulted into deteriorating water quality

According to a study, 50 million people in the country are at risk of arsenic poisoning from contaminated groundwater.[30, 31] Specifically, the underground water samples had arsenic level of over 200 micrograms per liter, which was considerably higher than the WHO's recommendation of 10 micrograms and the Government's limit of 50 micrograms. Another source of pollution stems from direct discharge of waste from households and industries into nearby rivers, drains, streams and ponds and the unregulated and heavy use of chemical, fertilizers, and pesticides in agriculture. For example, around 90 percent of industrial and municipal waste, which is largely untreated and toxic, is dumped into open drains and filtrated into aquifers.[32] The waste water does not stay in fresh water bodies but is also seeped into the groundwater aquifers. Hence, this pollution is directly affecting the quality of drinking water, and in turn adding to health concerns.[33] There is absence of monitoring of adequate waste disposal to water bodies or facilities to treat waste water. Finally, the overexploitation of groundwater has also resulted in an increase in arsenic content in areas where groundwater pumping is a source of clean drinking water.[34]

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[28] Abiana revenue as percentage of O&M cost hovers at an average of 20 percent in Punjab, 36 percent in Sindh for the period from 2000-2001 to 2009-2010.
[29] For example, in Punjab, only 33 percent of O&M spending was used for maintenance; a large part was spent on salaries.
[30] Joel E. Podgorski, et al. (2017), "Extensive Arsenic contamination in high-ph unconfined aquifers in Indus Valley", Science Advances, Vol.3, No.8.
[31] Arsenic ingested over time causes thickening of skin and lesions, leading to skin cancer.
[32] Daanish Mustafa, Majed Akhter, and Natalie Nasrallah (2013), "Understanding Pakistan's Water Security Nexus, Peaceworks No. 88. eISBN:978-1-60127-184-6, 2013 by the United States Institute of Peace.
[33] According to World Health Organization, Pakistan ranks 80 among 122 nations in terms of drinking water quality.
[34] Weak water provision infrastructure through Public Health Engineering Department(PHED) departments has resulted into reliance of households to turn to groundwater extraction.

Gaps in governance leading to inefficient management

The overall governing structure of the water sector in Pakistan is characterized by multiple authorities with overlapping responsibilities and duplication of work. Such a structure is mainly the result of unsuccessful reform in the past. For example, as part of a major institutional reform in water, the new Provincial Irrigation and Drainage Authorities (PIDA) were setup. The broader aim was to replace the provincial irrigation departments and decentralize the irrigation system management through public and private partnership. The private participation was ensured through the establishment of the Farmer Organization and Water Area Board.

Besides other responsibilities, PIDA was tasked with assessing and collecting water charge (abiana) – a function previously performed by provincial irrigation departments. Furthermore, as the implementation of reforms remained incomplete, provinces could not phase out their irrigation departments. As a result, at the moment, two irrigation management bodies exist simultaneously, with overlapping responsibilities and unclear demarcation of areas of management. Punjab offers an interesting case where the irrigation department assesses abiana in certain areas but other areas are managed by the Punjab Irrigation and Drainage Authority.

Interprovincial disputes continue to dominate the policy debate on water reforms. Although the Water Accord 1991 divides water among provinces as per a given formula, the disagreement prevails on sharing shortages.[35] Indus River System Authority (IRSA), the implementing body for the accord, lacks its own telemetry system to gauge surface flows on continuous basis and hence has to rely on provinces for information regarding river flows. This absence of own monitoring system erodes IRSA's ability to act as a mediator between provinces in the event of water-related disputes.[36] Hence, grievances among provinces have persisted over time and even postponed the development of new major water storages on the Indus River.[37]

Besides this, the management of domestic and industrial water supply also faces shortcomings. The issue in fact is not of the availability of water rather the system of governance. One such example of a major city facing erratic supplies is Karachi, where at least half the population relies on tankers for water supply. The issue is less of availability and more of water management and governance.

Governance issues are also widespread in the domestic sector, particularly in major urban centers. For example, Karachi, the biggest metropolitan city of the country, faces serious issues related to water supply and quality. In fact, the outdated and deficient supply infrastructure, weak administration, and limited financial resources, have led to a situation where shortages are common. Unfortunately, these shortages are often plugged by supplies from illegal hydrants, which charge exorbitant rates from the end-consumers. As a result, the underprivileged suffer the most, as they are unable to get adequate and affordable water due to limited financial and infrastructure support. Finally, the weak governance also results in the poor quality of water being supplied to the masses.

7.4 Climate Change – a Major Emerging Challenge for Water Sustainability

The long-term water sustainability in Pakistan is also vulnerable to shifts in the weather pattern. According to the task force on climate change in Pakistan, the average temperature has risen by 0.6 ^{0}C over the period 1901-2000. Similarly, mean precipitation has also increased by 25 percent over the previous century. More importantly, the pace of warming is increasing with each passing year,

[35] For example, one disagreement is on the use of historical data for the period 1977-82 as a basis for water sharing. Sindh argues this period favors provinces that already had water infrastructure by 1977. Sindh also raises concerns on the transfer of water by Punjab from Indus to tributary zone. While Punjab claims that the Water Accord establishes its right to transfer water from Indus, Sindh argues that Punjab cannot draw water from Indus as long as there is shortage in Sindh.

[36] IUCN (2014), Institutional Analysis in the Water Sector of Pakistan

[37] IUCN (2010), "Pakistan Water Apportionment Accord for Resolving Inter-provincial Water Conflicts – Policy Issues and Options".

further going forward in line with the global trends.[38] In addition, climate change will increase the variability of monsoon rains and enhance the incidence and severity of extreme events such as floods and droughts.

Keeping in view the country's vulnerability to climate change, the Global Climate Risk Index of 2017 ranked Pakistan at 7th out of 181 countries (in 2015, the country ranked 11th).[39] Similarly, Maplecroft Index of Climate Change Vulnerability (2017) has placed Pakistan in the extreme risk category by ranking it at 16th out of 170 countries (in 2010, Pakistan ranked at 29th position).

The climate change will impact the water situation in the country through multiple channels. For example:

- *Climate change will enhance the demand for water:* while a number of factors (e.g., rising population, rapid urbanization, increase in income, etc.) will push up the demand for water in the country, a strong impetus would come from the climate change. Specifically, the rise in temperature would require more water for irrigation due to prolonged dry and warmer season; for farm animals to meet their hydration needs; for individuals to cope with higher atmospheric temperature; for industries to take care of increased cooling requirements; and for discharge into the sea so that intrusion of saline water into delta regions could be prevented.

- *Climate change is expected to affect the ice and snow accumulation patterns in the zones that supply Indus basin with its flows*. The overall river supplies would come under pressure as rising temperatures would increase evaporation losses in the system. At the same time, the climate change would shift the peak flow points in time.[40] Rising mercury levels in the upper Indus basin would result in earlier seasonal melting of the glacial ice sheet. This effect would lead to a shift in peak river runoff towards winter and early spring.[41]

- *Another impact of climate change is the unpredictable future water outcomes in the Upper Indus Basin due to precipitation variability*.[42] Specifically for South Asia, El Nino-Southern Oscillation (ENSO) events are likely to disrupt monsoon patterns and may cause extreme weather events.[43] El Nino events of 1997-98 triggered heavy rainfalls throughout Pakistan followed by extreme dry condition in its later phase. The 2014-16 El Nino episode triggered similar effects. These oscillations have become more frequent and intense in recent history.

- *Heightened rainfall variability in the catchment areas of the Indus Basin is expected to affect groundwater resources*.[44,45] Variability in spatial distribution and intensity of precipitation under rising mercury levels will alter the recharge and discharge patterns. This will affect the

[38] This change is broadly in line with the global trends, as average temperatures in 2016 were higher by 1 ^{0}C when compared to twentieth century mean. This made 2016 the warmest year on record, breaking the previous record for the third successive time in each of the past three years (Source: NASA, NOAA).
[39] The Global Climate Risk Index (CRI) reflects the level of exposure of a country's vulnerability to extreme events.
[40] Yu et al. (2013), "The Indus Basin of Pakistan – The impact of Climate Risk on Water and Agriculture", Washington DC: World Bank
[41] Barnett, Adam & Lettenmaier (2005), "Potential Impacts of a Warming Climate on Water Availability in Snow-dominated Regions". *Nature* 438, 303-309.
[42] Lutz et al. (2016), "Climate Change Impacts on the Upper Indus Hydrology: Sources, Shifts and Extremes", available at http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0165630
[43] World Bank (2016),"High and Dry: Climate Change, Water, and the Economy"
[44] Almost one-third of overall surface availability percolates into groundwater resource of Indus Plains.
[45] The country depends on groundwater as much as its surface water diversions. Almost 40 percent of irrigation needs are fulfilled through groundwater resource in Pakistan (Source: World Bank 2005, "Pakistan Country Water Resources Assistance Strategy—Water Economy: Running Dry". South Asia Region, Agriculture and Rural Development Unit Report No. 34081-PK.

quality of the water due to salt intrusion in Indus Basin Aquifer.[46] For example, in times of low surface flows, there would be less recharge available which would increase the demand for ground water, creating an imbalance. Net discharge would deteriorate quality of water through intrusion of saltwater into freshwater areas.

7.5 Need for Policy Reforms

Water resource management requires policies to ensure more productive, equitable, and sustainable uses through reallocation across sectors. However, Pakistan is still awaiting its first National Water Policy despite the fact that its draft was formulated in 2003. The task of structuring a policy became more complicated after the 18th amendment when water distribution for agriculture, domestic and industrial purposes became a provincial subject. Accordingly, the draft water policy is awaiting approval from the Council of Common Interest. In comparison, neighboring countries such as India, Bangladesh, Nepal and Sri Lanka all have water policy in place for more than a decade, which defines the goals regarding water conservation, storage and distribution at the federal and other levels.

The delay in announcing this policy is a major setback as the current policies are inadequate in addressing the upcoming water challenges. Further delays would only damage the long-term growth prospects of the economy. Any policy on water should focus on measures to augment supplies and manage demand. This would require reforms in multiple directions, e.g., to revamp the pricing mechanism; to develop institutional capacity; and or invest in infrastructure.

- *Raising water rates to bring at par with the operation and maintenance cost:* Within the pricing structure, focus needs to be on raising *abiana* rates within agriculture and tariffs within domestic and industrial sector to bring them at par with the cost required to operate and maintain the water supply system. Besides, it would help in encouraging a more rationale use of water. At the same time, regulatory policies are needed to ensure sustainability of underground aquifers.

- *Developing supply infrastructure through metering and ensuring connections so as to charge volumetric pricing:*
    - Urgent lining, repair and maintenance of canals are required to minimize the most extensive source of water losses in the system.

    - There is a need to charge volumetric pricing that is to charge each crop and area as per the unit of water consumed. This would be possible through separating the charge of water from the land area and connecting it to the quantity of water consumed.

    - Within the domestic and industrial sectors, proper provision of water connections to households and industrial units, along with metering devices, is also crucial to regulate the quantity consumed and charge rates accordingly. This would also regulate the use of water and reduce issues of equity between households. In addition, the unregulated use of groundwater needs to be contained.

- *Revamping the system of water rights (Warabandi):* A system of water rights should be introduced which allows for trading of water rights, as a result head end farmers could sell their right to tail end farmers and increase productivity and efficiency.

[46] Even the current levels of groundwater mining are unsustainable due to lack of regulatory oversight, which may result in degradation of natural buffer to climate change. Pakistan is pumping 58 MAF water from its aquifers in the basin whereas the sustainable threshold is estimated to be 50 MAF.

- *Strengthening the role of IRSA as a mediator to ensure development of storages:* The role of IRSA as a mediator between provinces needs to be strengthened through provision of proper telemetry system to the organization and enhance its conflict resolution capacities. Conflict resolution is compulsory for development of future storages.

- *Proper waste management and regulation:* Focus on proper disposal of household, industrial and agriculture waste is crucial to ensure adequate quality of water. Penalties and fines shall be imposed for non-compliance.

- *Disseminate awareness regarding the rising stress on water resources:* Since water is a sensitive issue in the country, there is a need to focus on raising awareness about the importance of conservation.