TECHNICAL PAPER 8

WATER & IRRIGATION

8 WATER & IRRIGATION

8.1 INTRODUCTION

8.1.1 Background

Almost 70% of our planet is covered by water but one could not be misled by this fact that it will always be plentiful. Because, freshwater (the portion we can use for drinking, bathing, irrigation of farm fields etc.) is remarkably scarce. Only 3% of the world's total available water is fresh water, and two-thirds of that is tucked away either in shape of frozen glaciers or otherwise unavailable for our use. Resultantly, almost 1.1 billion people worldwide lack access to water, and a total of 2.7 billion find water scarce for at least one month of the year. Water quality is another issue and almost two million people, mostly children, die each year from diarrheal diseases alone. Furthermore, the existing water consumption patterns are not sustainable. For instance, at the current consumption rate, this situation will only get worse. By 2025, two-thirds of the world's population may face water shortages. And ecosystems around the world will suffer even more (World Wide-life Fund, 2018)[1].

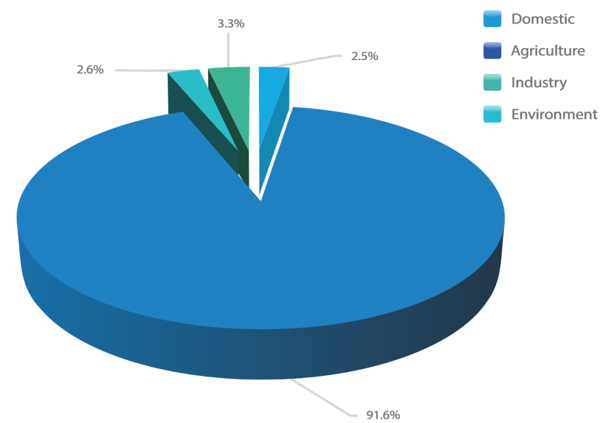
All the imminent challenges that Pakistan and Punjab are facing, water crisis is the most critical problem of the country. According to the world resource institute, the country is among the leading five that face extremely high water scarcity. The United Nations Organization has categorized Pakistan amongst those few unfortunate countries where water shortage destabilizes and jeopardizes its existence in the next few decades. In Pakistan, quarter to third of Pakistan's population lacks access to safe drinking water. Both the urban and rural areas suffer from water scarcity, water contamination and water-borne diseases.

The aforesaid situation deliberations call for efficient and sustainable water management. Poor water management poses major risks to agriculture, industry, human settlements and local communities. Nevertheless, there is a critical lack of information available about local water conditions – making better management difficult.

8.1.2 Historical context

The Indus River system is one of the largest rivers on the Asian continent, which is the main source of surface water in Pakistan, most likely was created some fifty million years ago, when the Indian Plate (Gondwanaland) first collided with Eurasia Angaraland). Between the two plates was the Tethys Sea, which was shallow and sandy and up-folded to form the great Himalayan Mountains in the Mesozoic era. These mountains, their an unbroken snow cover have become the primary source of water to the Indus system[2]. Primarily, the system comprises of 6 main rivers including Indus, Jhelum, Chenab, Ravi, Beas and Satluj. But in The Indus Water Treaty with India, in 1760, the control of the three western rivers Indus, Chenab and Jhelum with the average flow of the 80 MAF were given to the Pakistan and the control of the three eastern rivers Ravi, Beas and the Sutlej with the average flow of the 33 MAF were given to the India. But, the water problem stated from the day when India violated this treaty and constructed the dams on the River Chenab and the River Jhelum. Due to the construction of the dams on these rivers the water which was supposed to be available for the Pakistan was now consumed by the India and this lead to the minimizing the water supply in the Pakistan. Mostly, the water is used for agricultural purposes in Pakistan. The breakup of the water usage in given as below.

Figure 8.1: Water usage by scetor in Pakistan (2016)



Source: Ahmad (2016)[3]

Due to above mentioned facts and climatic changes, Water supplies are vulnerable and suffer from extensive losses in Pakistan. Currently, the Indus River contribute almost 149 million-acre-feet (MAF) per annum of which around 35 MAF goes to sea. Out of rest of 114 MAF, Punjab gets 55.94 MAF. From available water flow of 55.94 MAF, 91.6% (51.24 MAF) is available for agriculture in Punjab. After addition of water pump age from ground, the gross availability becomes around 100 MAF. But, in Punjab, net water availability, after excluding 22.89 MAF water conveyance losses in canal and 21.3 MAF field

[1] World Wildlife Fund (2018). Water Scarcity. Accessed from https://www.worldwildlife.org/threats/water-scarcity

[2] Water Info (2018). *Water Resources of Pakistan.* Accessed from http://waterinfo.net.pk/?q=node/19

[3] Ahmad S. (2016). Water Sector of Pakistan: A Situational Analysis. Development Advocate Pakistan, 3(4): 1-9

application losses, becomes 55.88 MAF resulting in water efficiency of 55.75% in Punjab depicting water conveying and field losses of 44.25%. This situation shows that in Punjab we are losing 44.19 MAF and 35 MAF in Arabian Sea. Punjab needs to work on managing the water losses[4]. In addition to the scarcity of surface scarcity, the Punjab is also facing scarcity and shortage issue in other sources of water i.e. rainfall, ground water etc. because of climate change and growing demand due to increased population.

PSS Strategic Objective

"Efficient use of resources, to enhance productivity and generate value addition in the agriculture and other sectors for economic wellbeing of people especially rural communities"

In backdrop of the aforesaid discussion, the present section deals with the existing situation of water, issues & challenges of water and possible solution & options. Because, one of the PSS Strategic objective is the efficient use of resources, to enhance productivity and generate value addition in the agriculture and other sectors for economic wellbeing of people especially rural communities

8.2 SITUATION ANALYSIS OF PUNJAB

8.2.1 Surface water

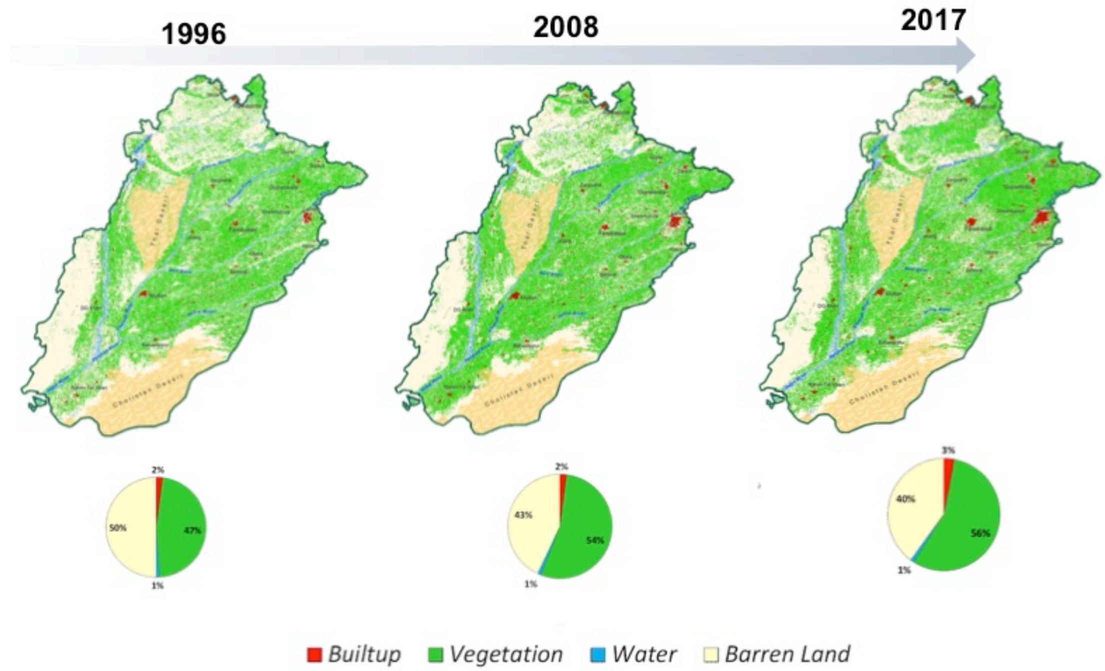
Pakistan relies heavily on the Indus River and its tributaries for water supplies, which together contribute over 140 million-acre-feet (MAF) per annum. The total annual water availability and supply. The water losses of surface water in Pakistan also a major problem, as Randhawa (2002)[5] highlighted that our overall efficiency of irrigation system is 36% depicting that 64% of the water losses due to various inefficiencies (Canal conveyance losses, watercourse conveyance losses and field application losses).

The availability of surface water is more or less constant. Whereas, the demand of water is increasing with population. So, actual problem is to sustain this water for the future, because, other sources ground water and rainwater are on decline.

[4] Water Statistics are taken form Indus River System Authority (IRSA) and Irrigation Department, Government of Punjab

[5] Randhawa, H. A. (2002). Water development for irrigated agriculture in Pakistan: Past trends, returns and future requirements. Food and Agricultural Organization (FAO). FAO Corporate Document Repository. Available from www.fao.org/DOCREP/005/AC623E/ac623e0i.htm.

Figure 8.2: Land cover change in Pakistan



Source: Urban Unit Remote Sensing data (1996, 2008 & 2017)

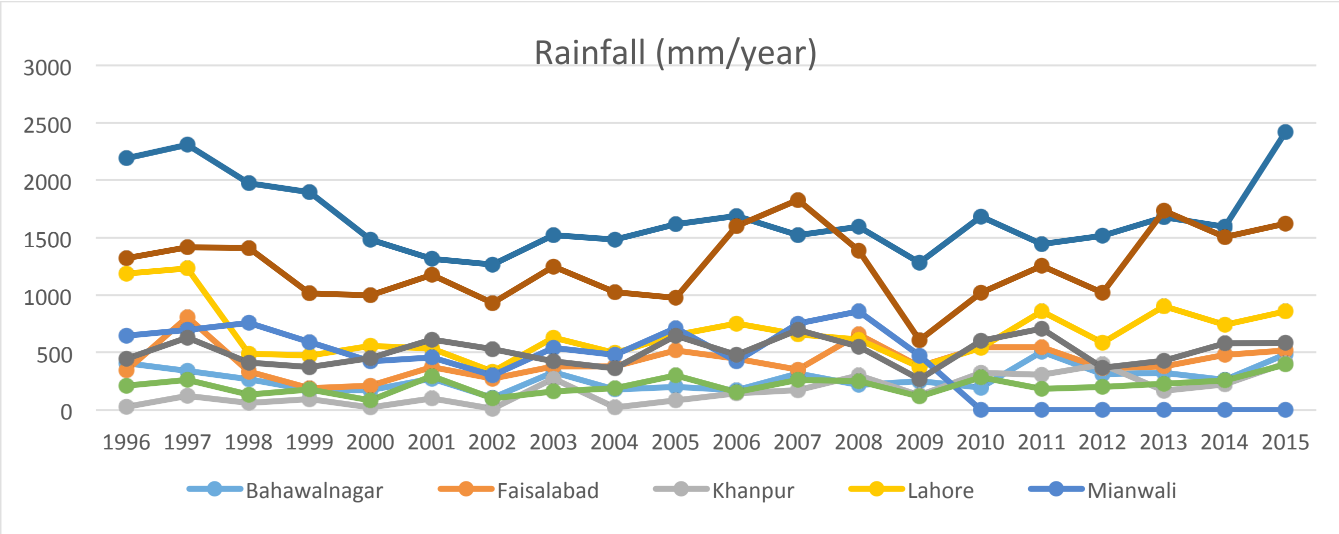
The surface water land cover analysis is shown by the figure 8.2, which depicts that land, cover of surface water is stable whereas the vegetation and built up area will grow over time. This increased built up will put up a huge pressure on freshwater usage. Similarly, the vegetation cover increase would also increase the demand of water as the climate change is affecting rainfall and ground water table is also declining.

8.2.2 Rainfall

Rainfall is also a major source of water. In some countries when it rains a large amount of the water is available and what if this large amount of the water is consumed for the useful purpose. This water storage of the rainwater and then its utilization is very beneficial. This excessive water can be used to improve the vegetation cover and reduce urban flooding. This can also be used to raise the water levels in water wells that are drying up. Furthermore, it can also be used to remove bacteriological and other impurities from sewage and waste water so that water is suitable for reuse. It can also be used to improve the quality of existing Ground Water through dilution. It also reduces the power consumption.

The average rainfall in Punjab (at selected locations where it is collected i.e. where the weather stations are set up) are given in Figure8.3

Figure 8.3: River flows and water availability of Pakistan and Punjab (2013-14)



Source: Punjab Development Statistics 2016

8.2.3 Water storage: dams and reservoirs

According to the International Commission on Large Dams (ICOLD), total dams and reservoirs in Pakistan over the height of 15 m (49 ft) are 150.[6] Tarbela Dam is the largest earth filled dam in the world and is second largest by the structural volume.[7] Mirani Dam is the largest dam in the world in terms of volume for flood protection with a floodstock of 588,690 cubic hectometer[8] while Sabakzai Dam is 7th largest with a floodstock of 23,638 cubic hectometer. Most of the large dams are outside of Punjab. Two large proposed dams are 'Kala Bagh' and 'Akhori Dam' which comes in Punjab. This area has great potential for small dams. So far Punjab government has constructed 52 dams and some dams are under construction. These of dams in Punjab is given as under:

[6] ICOLD (2012). Number of Dams by Country Members". *General Synthesis*. International Commission on Large Dams (ICOLD). Retrieved 9 July 2012.

[7] Asianics Agro-Dev. International (2000). Tarbela Dam and related aspects of the Indus River Basin, Pakistan.

[8] ICOLD (2012). "Classification by Volume for Flood Protection". *General Synthesis*. International Commission on Large Dams (ICOLD).

Table 8.1: List of dams and reservoirs in Punjab

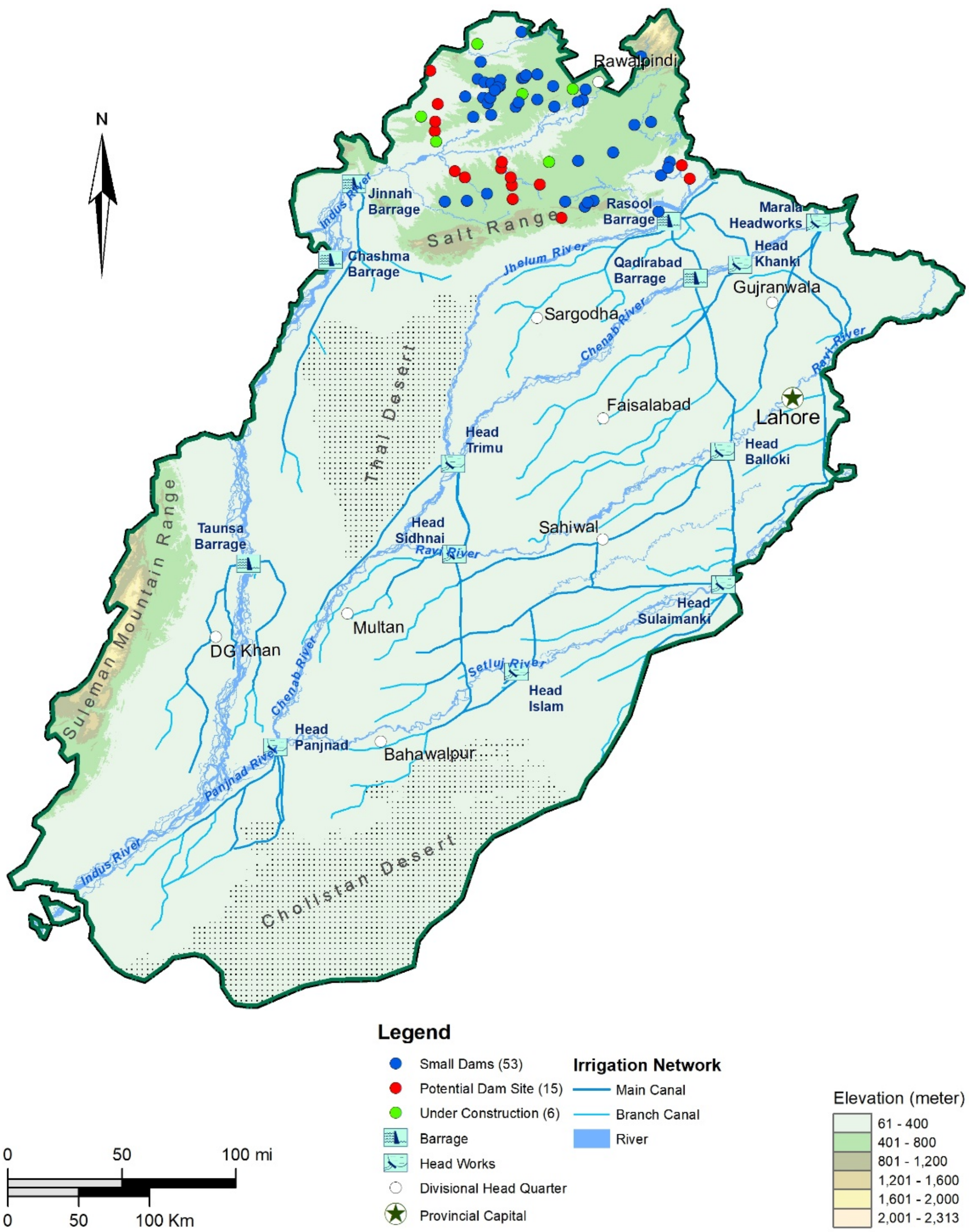
No.	Name of dam	Nearest city	River	Completed /operational since	Dam height (m)	Reservoir capacity (million m^3)
1	Basal	Attock	-	2004	18.66	2.08
2	Bhugtal	Chakwal	-	1990	22.80	1.41
3	Chashma	Mianwali	Indus	1971	-	870.00
4	Chhanni Bar	Attock	-	1979	19A.45	2.41
5	Dhok Outab Din	Chakwal	-	1991	24.62	2.14
6	Dhurnal	Chakwal	-	1967	20.67	1.70
7	Domeli	Jhelum	-	2008	36.47	10.71
8	Dungi	Rawalpindi	-	1971	21.70	2.17
9	Fatehpur	Jhelum	-	2008	26.29	2.14
10	Garat	Jhelum	-	1981	20.06	2.75
11	Ghazial	Chakwal	-	2007	22.34	2.47
12	Gurabh	Chakwal	-	1970	21.19	0.84
13	Jabba	Attock	-	2005	25.41	1.06
14	Jabbi	Attock	-	1991	10.76	3.33
15	Jalwal	Attock	-	2005	18.24	6.17
16	Jamal	Rawalpindi	-	2005	26.44	2.29
17	Jammargal	Jhelum	-	1992	16.26	3.00
18	Jawa	Rawalplndi	-	1994	25.05	1.94
19	Kanjoor	Attock	-	1975	18.62	3.50
20	Khai	Chakwal	-	2007	38.91	7.30
21	Khanpur	Islamabad	Haro River	1983	50.75	130.70
22	Khasala	Rawalplndi	-	1985	18.24	2.98
23	Khokhar zer	Chakwal	-	1979	23.40	4.08
24	Kot Raja	Chakwal	-	1991	24.05	3.51
25	Lehri	Jhelum	-	2005	33.13	7.03
26	Marala	Sialkot	Chenab	1968	5.00	-
27	Mial	Chakwal	-	2004	21.37	3.95
28	Minwal	Chakwal	-	2008	25.08	2.47
29	Mirwal	Attock	-	1990	24.01	4.64
30	Misriot	Rawalpindi	-	-	14.21	0.69
31	New Dhok Tahlian	Chakwal	-	2002	25.36	2.23
32	Nikka	Chakwal	-	1990	29A.48	1.54
33	Nirali	Rawalplndi	-	1970	20.82	0.84
34	Phalina	Rawalplndi	-	2008	22.49	4.81
35	Pira Fatehal	Chakwal	-	1995	27.34	9A.12
36	Punjnad Barrage	-	-	-	-	-
37	Qadirabad	Gujrat	Chenab	1968	22.00	178.04
38	Qibla Bandi	Attock	-	1971	21.28	2.24
39	Ratti Kassi	Attock	-	1970	14.27	2.40
40	Salial	Jhelum	-	2005	20.67	0.65

No.	Name of dam	Nearest city	River	Completed /operational since	Dam height (m)	Reservoir capacity (million m^3)
41	Sawal	Attock	-	2005	28.88	2.96
42	Shah Habib	Jhelum	-	2008	23.45	2.04
43	Shahpur	Attock	-	1986	25.84	17.66
44	Shakar Dara	Attock	-	1994	34.95	7.00
45	Sipiala	Attock	-	1964	11.42	0.70
46	Surla	Chakwal	-	1985	18.54	2.35
47	Tain Pura I	Jhelum	-	1994	25.28	7.33
48	Tain Pura II	Jhelum	-	1994	24.27	4.19
49	Talikna	Attock	-	2005	17.59	2.53
50	Taunsa Barrage	-	Indus	1958	-	-
51	Thattl Syedan	Attock	-	2005	12.96	0.74
52	Walana	Chakwal	-	1983	21.28	2.70

Source: FAO (2012). Pakistan –Water Report 37, 2012. ***AQUASTAT – Information System on Water & Agriculture***

The spatial mapping of water infrastructure in Punjab including small dams (53 existing, 6 under construction and 15 potential site), barrages, headworks and canals is given in Table 8.1. The existing total water storage capacity of these dams is almost 1 million-acre feet only.

Figure 8.4: Water infrastructure in Punjab (2013-14)

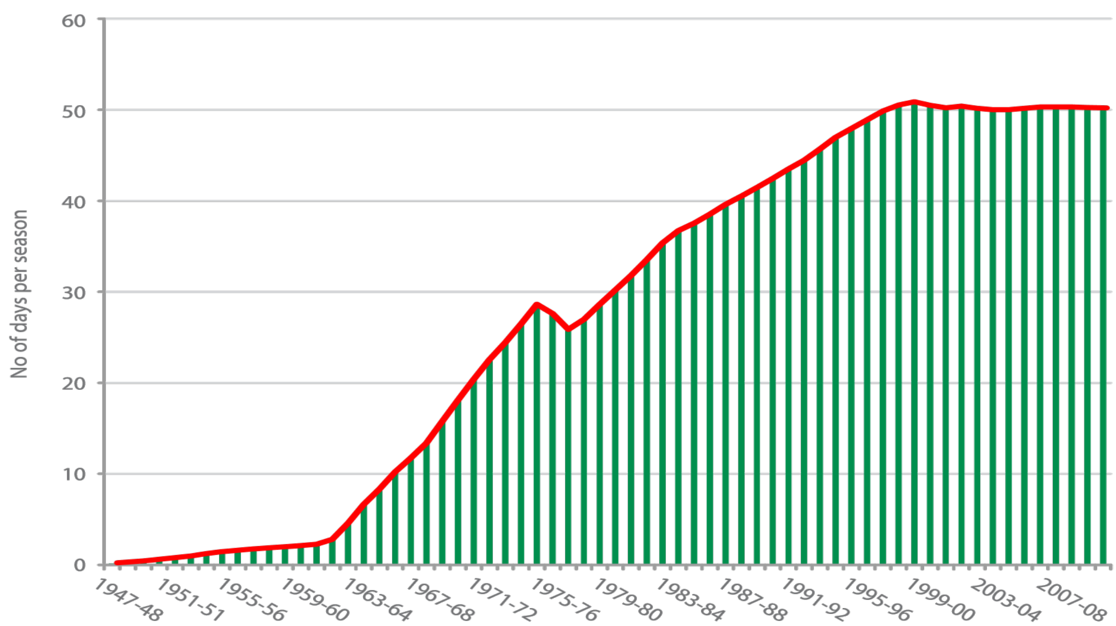


Source: The Urban Unit on Irrigation department of Punjab Statistics.

8.2.4 Ground water

Groundwater in Pakistan, being in Indus Basin aquifer, is running out on fast pace. The World Bank and the Asian Development Bank have already categorized it as a water-stressed country. If this trend continues, the ground water table will come under severe pressure. The world's most over-stressed source is Arabian Aquifer System, providing water for more than 60m people. According to Punjab irrigation department, the water table in the province is going down by three feet per year. In Lahore, for instance, water could be extracted at 20 to 40 feet 20 years ago but now drilling has to be done up to 800 feet to reach water. In 2000-01 tube-wells installed in the country were 659,278 and in 2012-13 their number had gone up to 1175,073. The ground extraction increased dramatically during 1963-1995 then become almost stagnant. And during last 15 years the ground water extraction is stable around 15 MAF per annum. As depicted by the following Figure 8.4, the number days per season for ground water extraction. According Punjab Development Statistics (2016), out of total tube wells in Pakistan, 98% are in Punjab. So, these figures and statistics of Pakistan well represents the picture of Punjab. The temporal comparison of the ground water table maps is given in following figures (Figure 8.5 and Figure 8.6) which shows that the water table in Punjab has gone lower further over time.

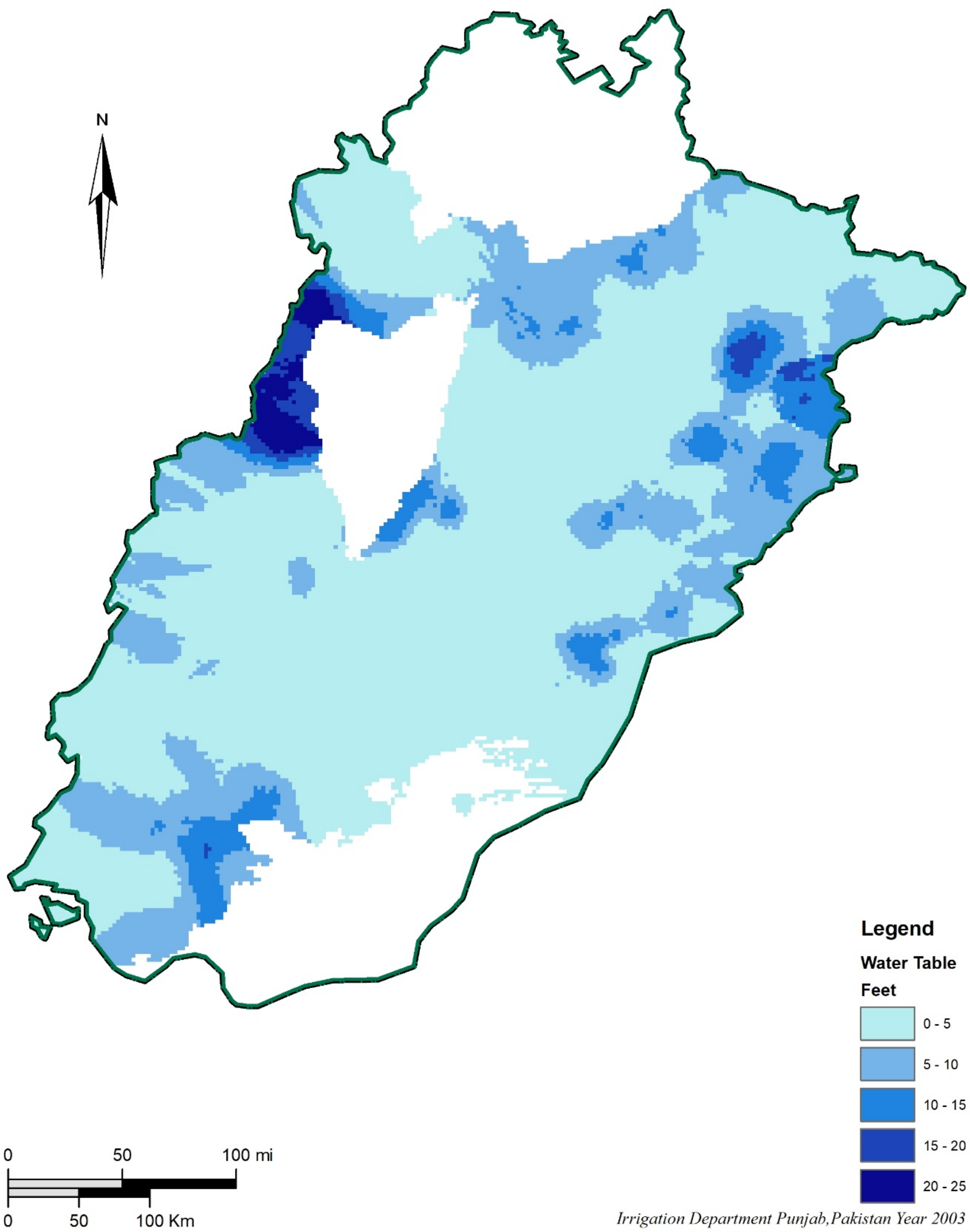
Figure 8.5: Groundwater extraction in Pakistan 1947-48 to 2007-08



Source: Ahmad S. (2016)[9]

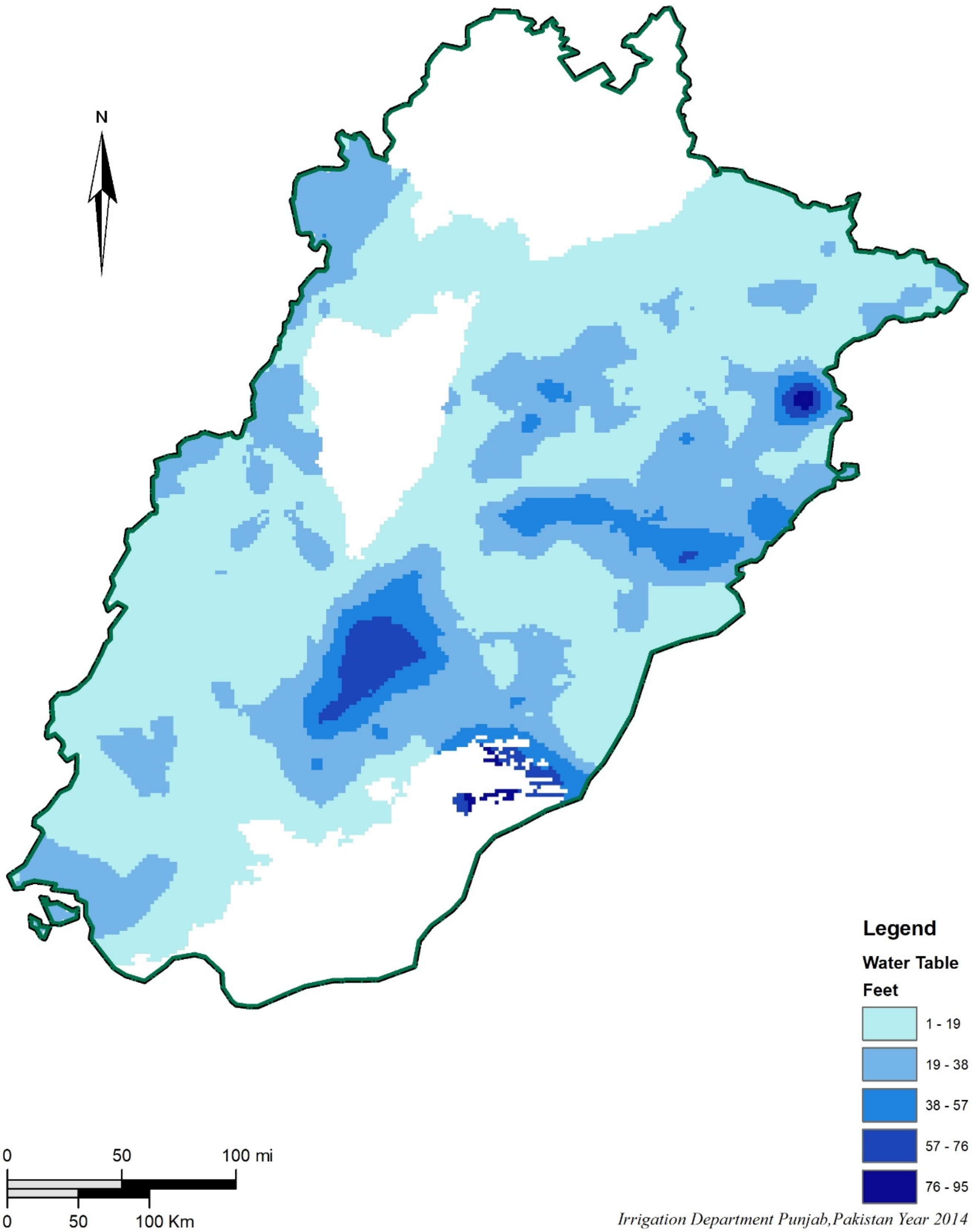
[9] Ahmad S. (2016). Water Sector of Pakistan: A Situational Analysis. *Development Advocate Pakistan*, 3(4): 1-9

Figure 8.6: Groundwater table in Punjab (2003)



Source: Irrigation Department of Punjab, 2003

Figure 8.7: Groundwater table in Punjab (2014)



Source: Irrigation department of Punjab, 2014

8.2.5 Urban drinking water

Safe drinking water is a basic necessity and basic right of every citizen. The distribution of the population by main source of drinking water is shown in Table 8.2. The population using improved sources of drinking water is that using any of the following types of supply: piped water (into dwelling, compound, yard or plot, to neighbor, public tap/standpipe), tube-well/borehole, protected well, protected spring, rainwater collection and bottled water.

Table 8.2: Access to improved water sources in Punjab by type and area (2014)

Access to improved water sources in Punjab 2014 (in %)													
	Piped Water					Other Than Piped							
Area	into Dwelling	in Yard	To Neighbor	Public Tap	Total Piped	tube well / boreOhole	Handpump	Motorized (Dunky/ Turbine)	Protected well	Protected Spring	Rainwater Collection	Bottled Water	Grand Total
Punjab	11.6	1.7	0.9	5.1	***19.3***	0.8	30.6	41.7	0.9	0.3	0.2	0.6	**s94.4**
Rural	4.6	1.7	0.8	2.6	***9.7***	0.7	41.5	43.4	1.1	0.4	0.3	0.1	**97**
Urban	25.8	1.9	1.1	10.3	***39.1***	1.6	2.1	27.7	0.2	0	0	2.6	**89**
Major Cities	38.5	1	1.1	12	***52.6***	0.9	8.6	38.2	0.5	0.1	0	1.6	**86.8**
Other Urban	12	3	1.1	8.5	***24.6***	0.2	15.6	49.6	0.7	0.2	0	0.5	**91.5**

Source: MICS, 2014

Table 8.3: Access to improved water sources in Punjab by type district (2014)

Access to improved water sources by District 2014 (in %)								
Rank	District	Access (%)	Rank	District	Access (%)	Rank	District	Access (%)
1	Bhakkar	100	13	Lodhran	98.1	25	TT Singh	95.8
2	Narowal	100	14	Rajanpur	98.1	26	Rawalpindi	94.3
3	Gujrat	99.5	15	Bahawalnagar	97.6	27	Gujranwala	94.2
4	Layyah	99.4	16	Okara	97.6	28	Attock	94.1
5	Jhang	99.2	17	Jhelum	97.5	29	Chakwal	93.6
6	Khanewal	99	18	Multan	97.5	30	Rahimyar Khan	92.7
7	Chiniot	98.6	19	Hafizabad	97.4	31	Khushab	92.6
8	Lahore	98.5	20	Sheikhupura	97.2	32	Sargodha	91.9
9	Vehari	98.5	21	Pakpattan	97	33	Nankana Sahib	91.4
10	Mandi Bahauddin	98.2	22	Bahawalpur	96.3	34	DG Khan	90.2
11	Muzaffargarh	98.2	23	Sahiwal	96.3	35	Sialkot	87.8
12	Kasur	98.1	24	Mianwali	96.1	36	Faisalabad	69.7

Source: Urban Unit analysis on MICS Statistics (2014)

The Table 8.3 Shows the disparity among the districts in terms of access to improved drinking water source. Amazingly, the Faisalabad is at the bottom. The above Table 8.4 shows the breakup of improved water sources, which depicts that only 19.3 % population in Punjab has access to piped water. Whereas, in Urban Areas, this rate become 25% and in major cities only 38.5% population has access to piped water. The access to piped water is considered as the some of the key responsibility of local government (municipality). Wherever, the piped water access is available, the quality of water and service delivery is very poor. There is no volumetric pricing system and no incentive for water conservation. Only a nominal fee/ water charges are levied. There are number of of illegal connections and most of legal connection customers are not paying even the nominal water charges. There is a need of Improvement in collection efficiency through integrated billing and revenue collection system. And this increased revenue can be used to improve the water infrastructure.

Drinking water quality

Water quality is directly linked with human survival including incidence of water borne diseases. As per draft National Water Quality Monitoring Report 2015-2016, prepared by PCRWR, indicated that around 35% water sources in Punjab are safe for drinking purposes- free from microbiological and chemical contamination (iron, fluoride, nitrates) and physical characteristics (turbidity, hardness, total dissolved solids) compared to 31% in the rest of the country. Drinking water quality tests carried out in twelve districts of Punjab showed that microbes and heavy metals (arsenic) were major contaminations in almost 40% water sources in these districts . As per drinking water quality reports by EPA, UNICEF, PCRWR, PHED department in last few years arsenic (As), fluoride (F) and nitrate (NO3) levels are found to be more than the permissible limits as mentioned by WHO and national drinking water quality standards . The Government has been addressing water quality issues through installation of water filtration plants. Spatial representation of water quality vulnerable areas and contaminants in ground-water in Punjab is presented in figure 8.8 & 8.9:

Figure 8.8: Water quality vulnerable areas in Punjab

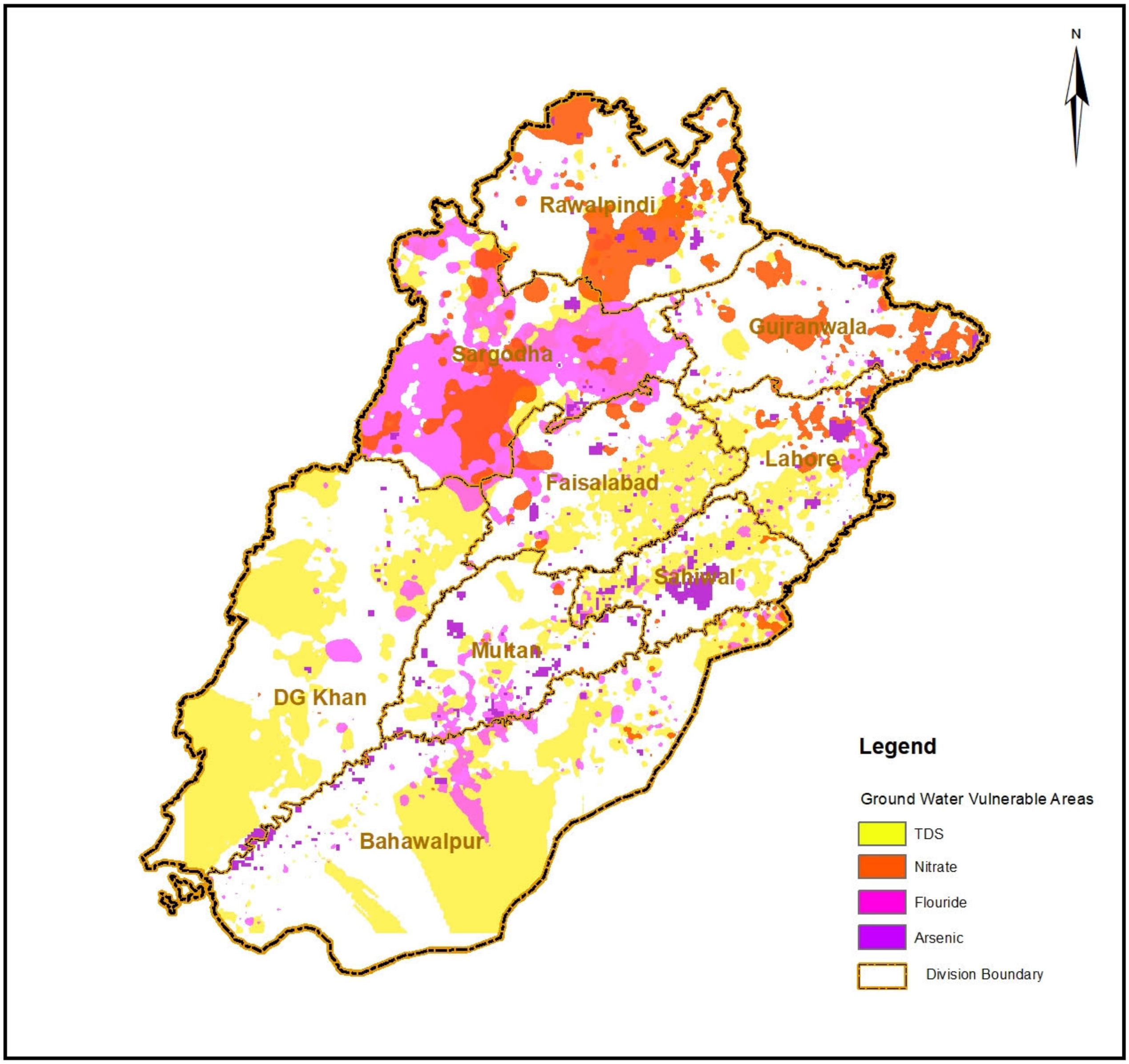
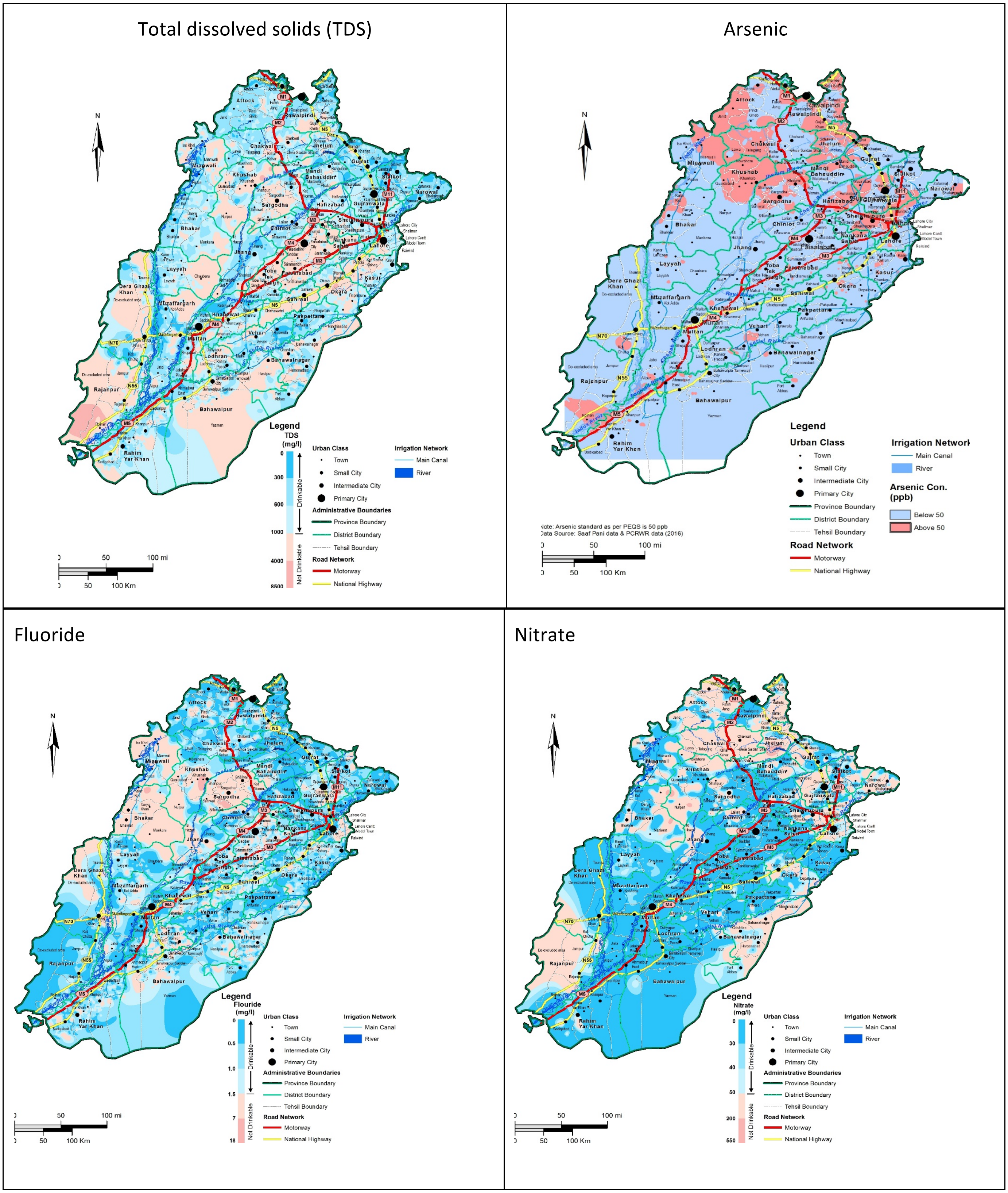


Figure 8.9: Distribution of different contaminants in ground water sources across Punjab



Source: UNICEF-PHED-2014

Safely managed water

Under Sustainable Development Goals, safely managed water services are defined as: Population using an improved drinking water source, which is: i) Located on premises; ii) Available when needed; iii) and free of faecal and priority chemical contamination. As per Joint Monitoring Program (JMP), of three indicators of the safely managed water, the lowest indicators will be baseline of the defined area. As per MICS 2018, 91.4% population has drinking water available in sufficient quantity when needed, 74.2% have water accessible on premises and 63.8% have without E-Coli contamination in drinking water. An overall, 43.7% of household members with an improved drinking water source located on premises, free of E.Coli and available when needed access to improved water.

Table 8.4: Safely managed drinking water

Punjab	Improved sources			Percentage of household members with an improved drinking water source located on premises, free of E. coli and available when needed
	Without E. coli in drinking water source	With drinking water available in sufficient quantities	Drinking water accessible on premises	
Overall	63.8	91.4	74.2	43.7
Rural	65.6	92.3	78.5	48.1
Urban	60.8	89.8	66.8	36.0

The PCRWR 2015 and PHED quality data indicated that around 35% population has access to safe drinking water, which is free from contamination. Based on this, the current baseline/ status of safely managed water in Punjab is 35%.

8.3 CHALLENGES RELATED TO WATER

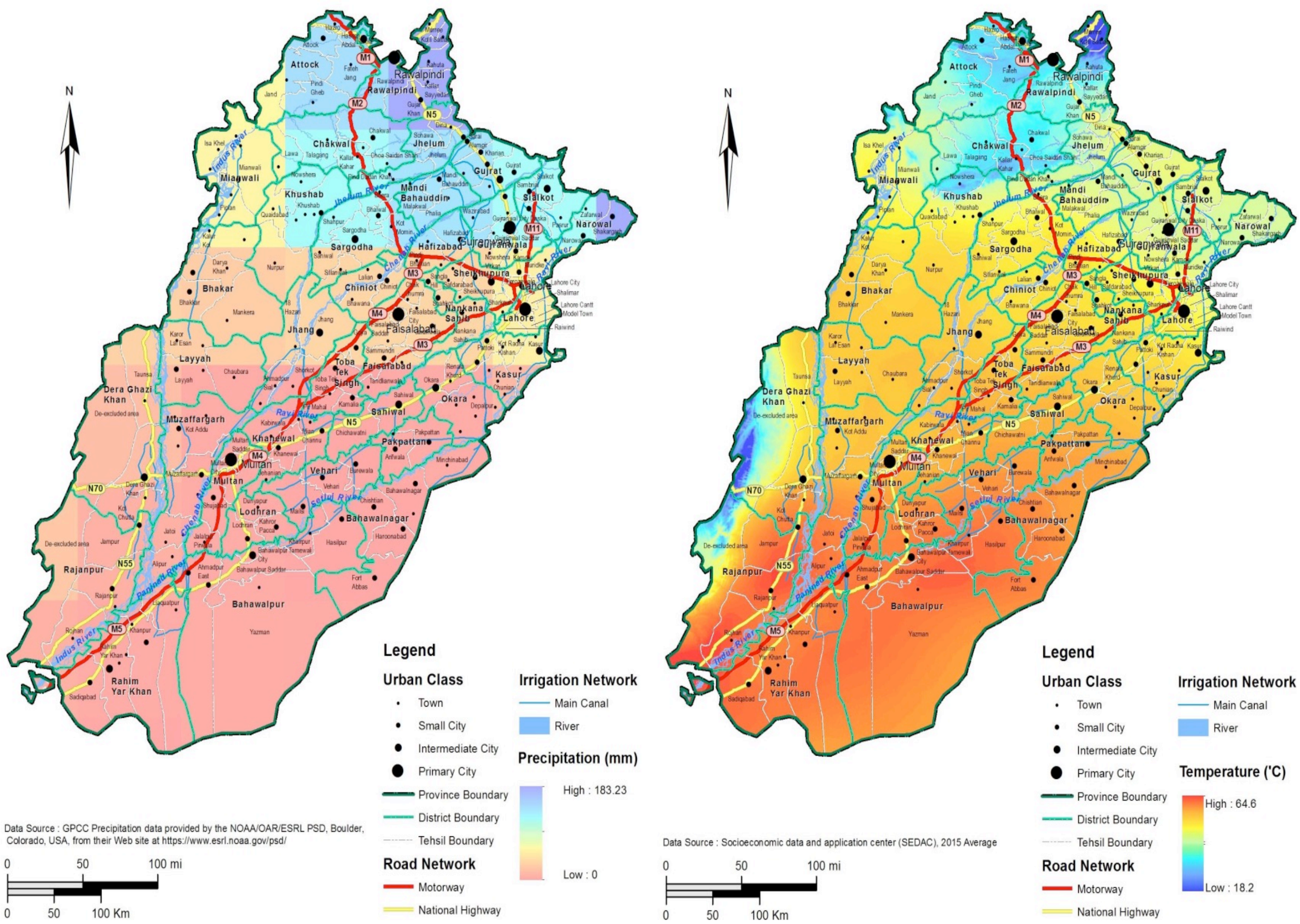
8.3.1 Climate change

Pakistan is among the top ten most affected countries on the Global Climate Risk Index (CRI, 2016)[10], and currently faces a number of climate-related challenges, including rising temperatures, unpredictable changes in precipitation patterns, increased frequency and intensity of extreme weather events, recurring droughts and floods, groundwater pollution, rising sea levels, potential for heightened conflicts over water rights between riparian regions, increased health risks due to changes in disease vectors, environmental degradation, especially of water-related ecosystems, declining agricultural productivity, and governance issues associated with these stresses[11].

[10] Kreft, S., Eckstein, D., Dorsch, L., & Fischer, L. (2015). *Global climate risk index 2016*: *who suffers most from extreme weather events? weather-related loss events in 2014 and 1995 to 2014*. Germanwatch Nord-Süd Initiative eV.

[11] U.S.-Pakistan Centers for Advanced Studies in Water (2017). International Conference U.S.-Pakistan Centers for Advanced Studies in Water on Climate Change and Water Security in Pakistan (Brochure).

Figure 8.10: Climate change (average annual temperature and rainfall) in Punjab (2007-17)



Source: Socioeconomic data and application center (SEDAC), 2015 and WWW. ESRI.NOAA.GOV/PSD/

The above maps shows average annual rainfall (precipitation) and temperature of Punjab.[12] Abbas (2013) reviewed the historical temperature record of the Punjab and found that the frequency of extremely cold days and nights decreased and the frequency of extremely hot days and nights increased during the analysis period. Increased temperature in urban areas causes a change in the energy balance of the urban areas, often leading to higher temperatures than surrounding rural areas under the phenomenon of urban heat island effect.[13]

8.3.2 Depleting water table and deteriorating water quality

The population of the Pakistan is increasing day by day by the rate of 3.2%. This increase is putting pressure on ground water aquifer Further studies revealed that the depletion of the underground water may result into the severe water crisis causing a drought like condition even in the big cities. For instance, in Lahore has seen reduction in water tables at 0.5 meters annually for past 30 years and 0.91 meter annually during 2011-13 (Table 8.4).

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[12] Detailed in Environment section of this document

[13] Abbas, F. (2013). Analysis of a historical (1981–2010) temperature record of the Punjab province of Pakistan. *Earth Interactions*, 17(15), 1-23.

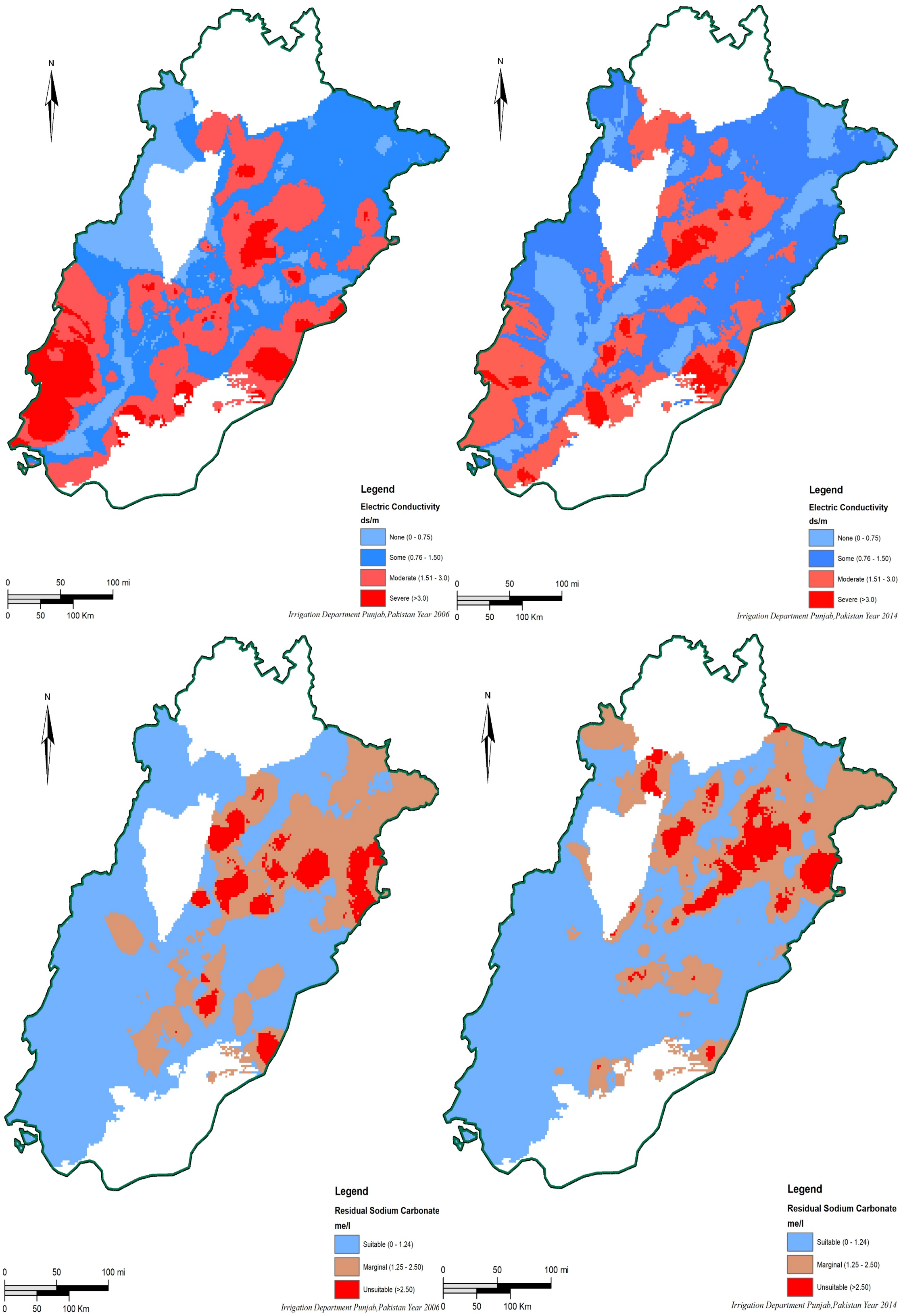
Table 8.5: Average annual rate of groundwater decline in Lahore

Period	Rate of Decline	
	Feet / Year	Feet / 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

Source: SBP Annual Report, Chapter 7, 2017

The underground water quality is also being contaminated at a very rapid rate with the heavy metals like Copper, Nickel and Cobalt etc. which are the cause of many diseases which can lead to the death. The data on water quality is shown by the following figures. The figures 8.11 show the deteriorating water quality in Punjab.

Figure 8.11: Water quality in Punjab (2014)



Source: Urban Unit Analysis based on Data of Irrigation Department of Punjab, 2014

8.3.3 Reduction in the capacity of existing reservoirs (dams)

But overall water storage capacity of Pakistan is depleting over time. As per World Bank analysis, "our storage capacity has gone down to 150 acre feet. India has improved its per capita storage up to 200 acre feet, which will improve further once under-construction dams start giving results[14].

The per capita storage capacity in the United States stands at 6,150 cubic meters, in Australia at 5,000 cubic meters and in Pakistan it is just 132 cubic meters that shows how vulnerable Pakistanis are in terms of access to water[15].

This situation urges the government to take steps for water conservation and its effective use, adding that it would reduce capital and operational costs.

8.3.4 Extremely low water tariffs and uncontrolled groundwater extraction

In Pakistan, there are very nominal water charges for household connection and no control on volume used. Similarly, 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. For instance, rice and cotton on average are charged at Rs. 85 per acre; even though rice consumes 60 percent more water than cotton. Furthermore, ***Abiana*** rates have no link with the amount of water being consumed. The prevailing pricing structure, which has no link with consumption, discourages water conservation.

Thus, in agriculture, 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).

8.3.5 Growing water demand

The Punjab's current population stands at approximately 110 million (as per 2017 Census) and growing at the rate of 2.1%. The growing population is also increasing demand of not only the drinking water but also for industry and agriculture. According to Ahmad (2016)[16], an increase of 14.2 percent in water availability is needed to meet the requirement of the population in 2025. This figure may further go up it has been estimated as the 1.5% population growth, where, as per Population Census 2017 the population average annual growth rate of population for Punjab is 2.1%.

8.4 SOLUTIONS AND POLICY OPTIONS

8.4.1 New small dams and reservoir

Currently, almost 30-35 MAF water goes to Arabian Sea (run-off below Kotri), whereas, the requirement is of 8.6 MAF annually.[17] This extra loss of water 20-25 MAF can be used to store by increasing the existing storage capacity through building news dams and reservoirs. In addition, there is water conveyance losses in Canals of Punjab is around 45%, a portion of it can also be saved by adopting water conservation strategies. Therefore, savings from this can also be stored in small dams and reservoirs.

8.4.2 Rainwater harvesting

For the countries like the Pakistan, which are already getting water scarce the rainwater harvesting is very important step. During the monsoon season when there is an adequate amount of the water available through the rainwater, almost all the water is wasted as we have no proper system for the rainwater harvesting. Instead of letting it simply to flow and enter into the municipal waste. This collection or storage can be done in the natural reservoirs or the artificial reservoirs. There are number of Rainwater harvesting techniques, for instance, barrel, dry system, wet system, green roof, earthworks, and mulch basins those can be adopted.

8.4.3 Water table replenishment

At present, the water tables are going down every year rapidly. For example, in Lahore, the water table in going below by 3 feet every year. Water storage and recharge are two major components of groundwater aquifer. There is need of geographically targeted policy to identify potential recharge zones (PRZs) in Punjab for water replenishment.

8.4.4 Sustainable extraction policy

Presently, there is no regulatory framework for ground water pumping. Groundwater pumping is an important source that contributes almost 40 percent to total supplies at farm gate is also facing sustainability concerns. Ground water extraction should be promoted where fields are waterlogged or salinized. It should be discouraged in certain areas where the over-exploitation has led to depletion of this valuable resource. Because, in a few areas, the excessive use has resulted in the intrusion of saline (brackish) groundwater into the fresh aquifers,

[14] "Water storage capacity of big dams goes down". *The Express Tribune*, Article March 21, 2017

[15] Bokhari, A. (2015). Underground water reserves under threat. *Dawn,* Article July 6, 2015.

[16] Ahmad S. (2016). Water Sector of Pakistan: A Situational Analysis. *Development Advocate Pakistan*, 3(4): 1-9A.

[17] 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". As cited in SBP Annual report 2017's Chapter 7

thereby making it then unusable. There should be a regulatory mechanism for

8.4.5 Volumetric water pricing (metering)

Water metering system should be adopted and 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.

8.4.6 Irrigation water conservation (drip irrigation etc., cropping-mix change)

Irrigation water management need to be improved. Currently, on farm (field application) water losses are almost 25% which can be managed through the adoption of on farm water conservation strategies such as laser land leveling, evapotranspiration based controllers, bed and furrow irrigation, micro-irrigation (drip irrigation, sprinkler irrigation) should be adopted. Rationalized water pricing can be used to make farmer adopt these strategies.

8.4.7 Improving water infrastructure (to reduce losses and improve efficiencies)

The gradual deterioration of water infrastructure resulting in extensive conveyance losses. According to estimates, 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[18]. Improving the water infrastructure can help saving water. Huge investment to upgrade the existing water infrastructure and recovering its maintenance cost from users can be one of the possible options. It may be noted that farmers already pay exorbitant amounts on diesel pump for tube-wells, as this ensures them reliable supplies of water and results in higher productivity.

Formulation of independent regulatory body

In order to ensure effective governance in water and sanitation sector and to improve the service delivery, an independent "Regulatory body" needs to be created at the provincial level. The watchdog body of regulation will require sustained policy and financial support. It will provide for a long-term sector perspective with regulatory functions to cover:

(i) Compliance with environmental regulations and monitoring of water quality;
(ii) Groundwater abstraction;
(iii) Tariff setting;
(iv) Providers' performance; and
(v) Protection of customer interests.

[18] SBP (2017). "Water Sustainability in Pakistan – Key Issues and Challenges". Chapter 7 in '*SBP Annual Report 2017*'. Karachi: State Bank of Pakistan

Establishment of Information Management System

There is need to establish reliable Monitoring and Evaluation System and provincial level Information Management Room i.e., for service delivery and operations (routine data collection and information on existing facilities and services, their status), planning and finances (quality and improvements required, financial performance and constraints/challenges), complaints, water quality, periodic publication of performance reports.

Integrated Development and Asset Management Plan (IDAMP)

Under the Punjab Cities Governance Improvement Program, the Urban Unit has brought some innovative reforms for asset management of water and sanitation agencies i.e., Energy audit, Asset Management Information System (AIMS) for geo tagging and computerization of all asset inventories and IDAMP -WASA has been compiled to prescribe detailed Standard Operating Procedures (SOPs) for municipal and city asset managers to prepare Integrated Development and Asset Management Plan (IDAMP). In particular, its application will assist in strengthening IDMAP processes and outcomes, the implementation of generally accepted asset management for improved service delivery and matters related to immovable assets, improve infrastructure investment planning efforts and management for improved governance and asset management in cities. Punjab Growth Strategy envision the institutionalization of these interventions as part of business processes and will be expand these processes in intermediate and small municipalities.

Improve Institutional Accountability

Improve institutional autonomy and accountability through Monitoring and Evaluation. Execution agencies be accountable for sound policy, planning and financing responsibilities, and their outcomes (i.e., percentage of population served) unlike the current practice where only input (ADP spending) is performance criteria. Performance criteria for service providers be developed to promote performance based service delivery approach.

Sustainable financial capacity

For better institutional performance and sustained service delivery in water and sanitation sector there is need to develop a mechanism to improve sustainable financial capacity of the institutes to reduce dependence on Government funding for routine operations. Capital investments be made by Provincial/Federal government and facilitate Public Private Partnership (PPP) for O&M. Devise mechanism for need based equitable distribution of water and sanitation resources at provincial, divisional, district, local levels. Develop efficient mechanism for revenue generation from service delivery to reduce dependence on government funding for Operation and Maintenance. Review tariff levels and Implement adequate and realistic water fee for the users, Introduce Water Metering System (Bulk & Consumer), Non-Revenue Water (NRW) management, carry out energy Audits, Develop and implement Demand Management System rather than Supply Management System

Capacity building and Mandatory Trainings

It is very important to review the service cadres engaged in sector service delivery (at all levels) with a view to developing a coherent service cadre for the sector and introduce mandatory trainings for promotions. This would require assessment of existing capacities and HR needs for: (i) strategic planning and management; (ii) engineering and technical; (iii) financial management; (iv) urban management; (v) social/community development/customer focus.

The Al-Jazari Academy has been established by Government of Punjab & JICA after consultation with Stakeholders in realization of Needs of WASA's PHED etc. through JICA grant in Aid Technical Support to Punjab Government in 2010. The overall goal is to build the capacity of the professionals in the water and sanitation sector with the objective to improve the delivery of service to the people. Until, now this academy has trained 300 plus WASA employees. This institution is capable of providing technical & managerial trainings to Staff at all levels. Use training institutes like Al-Jazari Academy, Lala Musa Training Academy and L-WASA Training Academy to develop & enhance technical capacities for: Planning, implementation, monitoring & evaluation of drinking water supply programs, Sanitation programs, Effective & efficient O&M of water supply and sanitation systems, Water quality monitoring, Community mobilization, Hygiene promotion, Training need assessment, Financial management, Audit & accounting, Contract & Asset management, Revenue collection.

8.5 WAY FORWARD

Following are the various targets for sustainable water management in Punjab.

Table 8.5: Indicative targets and strategic interventions

<table>
<tr><th>Focus Area</th><th>2017 (Baseline)</th><th>2027</th><th>2037</th><th>2047</th><th>Geographically Targeted Strategic Interventions</th></tr>
<tr><td>Field application losses</td><td>21 MAF*
(Irrigation Department, Punjab)</td><td>18 MAF</td><td>15 MAF</td><td>5 MAF</td><td rowspan="2">• Build institutional capacity for water accounting frameworks that lead to policies that enhance water efficiency
• Capacity building of public officials and awareness campaigns for water users i.e., farmers and general public
• Farmers to be incentivized to sow crops that require less water and produce higher yields per acre
• Water conservation techniques to be introduced through awareness campaigns for interventions at farm level
• Modern irrigation techniques, such as drip, spray and fine nozzle, to be introduced to farmers with cost-effective delivery mechanism to ensure take up
• Priority areas to be identified (like secondary, tributary or minor canals) where interventions can be targeted to limit leakage without affecting groundwater recharge</td></tr>
<tr><td>Canal Conveyance losses</td><td>23 MAF
(Irrigation Department, Punjab)</td><td>20 MAF</td><td>15 MAF</td><td>10 MAF</td></tr>
<tr><td>Ground water management, replenishment and sustainable extraction policy</td><td colspan="5">• Zoning of Punjab as per water table lowering & quality and restricting ground water extraction in areas where is water table is already below the sustainable limits
• Rainwater harvesting and replenishment of water tables (geographically targeted approach)
• Regulatory and monitoring mechanism for boreholes, tube-wells in urban areas and agricultural zones.</td></tr>
<tr><td>Rehabilitation and up-gradation of water infrastructure</td><td colspan="5">• Ensure early rehabilitation, remodeling and up-gradation of the existing irrigation infrastructure in each district to
• Ensure the rehabilitation and up-gradation of the existing urban drinking water infrastructure in each MC to make it resilient to climate change related extreme events</td></tr>
</table>