

ZIBELINE INTERNATIONAL
PUBLISHING

ISSN: 2716-5655 (Print)

CODEN: BDWRAP

Big Data In Water Resources Engineering (BDWRE)

DOI: <http://doi.org/10.26480/bdwre.01.2020.22.31>

REVIEW ARTICLE

AN OVERVIEW ON EMERGING WATER SCARCITY CHALLENGE IN PAKISTAN, ITS CONSUMPTION, CAUSES, IMPACTS AND REMEDIAL MEASURES

Saddam Hussain^{a*}, Saba Malik^{b*}, Muhammad Jehanzeb Masud Cheema^c, Muhammad Umair Ashraf^d, Muhammad Sohail Waqas^{e*}, Muhammad Mazhar Iqbal^f, Sikandar Ali^a, Lubna Anjum^a, Muhammad Aslam^a, Hassan Afzal^g

^aDepartment of Irrigation and Drainage, University of Agriculture Faisalabad, Pakistan

^bDepartment of Zoology, Wildlife and Fisheries, University of Agriculture Faisalabad, Pakistan

^cFaculty of Agricultural Engineering and Technology, University of PMAS-Arid Agriculture University, Rawalpindi, Pakistan

^dDepartment of Structures and Environmental Engineering, University of Agriculture Faisalabad, Pakistan

^eSoil Conservation Group, Punjab Agriculture Department (Field Wing), Rawalpindi, Pakistan

^fMilitary College of Engineering (MCE), National University of Sciences and Technology (NUST), Risalpur Campus, Islamabad, Pakistan

^gFaculty of Sustainable Design Engineering, University of Prince Edward Island, Charlottetown, PE C1A4P3, Canada

*Corresponding author's e-mail: saddamwahla2327@gmail.com; sabam3651@gmail.com; sohailwaqasrana@gmail.com

This is an open access article distributed under the Creative Commons Attribution License CC BY 4.0, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited

ARTICLE DETAILS

Article History:

Received 18 February 2020

Accepted 19 March 2020

Available online 27 March 2020

ABSTRACT

Around two-thirds of the earth's surface covered with water, it is obvious that water is among the most significant aspects that are essential for the life of human being. It is not only important to live, but also important to take a part in social and financial development. Water is God's personalized gift, as well as the necessity of life. Due to high level of gluttony, misused play of people with the environment and the global climate, shift results in progressive diminishing of natural resources. The problems of freshwater and food security at global level linked to the overwhelming population of the world. To overcome the food and water scarcity challenge, there is required to transfer the freshwater from agriculture sector to other straining purposes. Pakistan is facing the meager water scarcity crises in the last few years, as water is becoming scarce to any specified usage. The quickly growing population, expansion of drainage regions, increasing urbanization and industrialization put a lot of stress on available water supplies. At the moment, there is dire need to harvest rain water by constructing more dams and focus on effective management strategies for further use. Specifically, authors are recommended that, water should be provided demand base instead of supply base irrigation system. Moreover, in addition to land tax, tax on irrigation water quantity/usage should be rectified.

KEYWORDS

Water Shortage, Agriculture, Power Generation, Economy, Seepage, Indus River Basin.

1. INTRODUCTION

Water is one of the most important factors that play a vital role in life and basic need of the people for their activities (economic and cultural) mostly in the growing countries. It is a key progress pointer in almost every sector and used in household activities. One-quarter of the world's populace is now facing certain situation of water shortage and geographic or financial problems associated with water (Pretty, 2013).

Increasing demand for water across various sectors, particularly manufacturing, irrigation, power generation, household use, and climate, make it hard for people to obtain this finite resource for economic, consumer and public purposes. Unequaled distribution and unapproachability of water supplies in water scarce countries and regions; raising competition for scarce resources, which especially influences the poor and rural communities (Cosgrove and Loucks, 2015). Even though the growth of huge scale water supplies has already been take position in the world, there's not enough clean water for drinking as well as canal water for irrigation. Supply of water as per suggested by experts,

comprises of water being allocated for residential irrigation consumption (Kahr, 1983). Application of water in agricultural sector involves domestic irrigation, crop watering and other field usage, while considerable volume of water is needed for food production (Waqas et al., 2018). Currently, the process of water allocation to different sectors for consumption is disturbing and it makes sense that this happens due to inadequate water resources management. Which back-stream the citizens and not properly protected from flooding or disaster impacts (Adebayo, 2007).

Agriculture sector is the real powerhouse and plays a vital role in development of Pakistan, while around 90 percent of the country's total agricultural productivity depends entirely on irrigation (Cheema et al., 2014). Water supplies have played a very significant part in the production of the soil and composition of the water stock (Hamilton et al., 2014). More than fifty percent of the population in developed countries and sometimes even the lowest paid by these populations are highly dependent on the exploitation of public water supplies for their ways of life (Shah and Strong, 2000; Afzaal et al., 2020a).

Quick Response Code



Access this article online

Website:

www.bdwre.com.my

DOI:

10.26480/bdwre.01.2020.22.31

The lack of proper drinking water in Pakistan to satisfy drinking water requirement and proper sanitation requirements seems to be a restriction on public health and growth, moreover, on economic growth, but also on preserving a healthy environment and healthy ecosystems (Postel, 2003; Afzaal et al., 2020b). We all must be involved in the research and development for finding better ways to eliminate these limitations. Otherwise, we will face serious threats, especially given an evolving and unpredictable global climate change, as well as growing populace promoting accelerated economic and social growth, modernization and industrialization (Cosgrove and Loucks, 2015).

Keeping in view, the above discussed problems an effective research practices are needed in all water sectors and to improve the sustainable use of water resources. Furthermore, there is need to educate the people for more stable and prosperous future potential of water resources (Loucks et al., 2017). This paper outlines the effects and causes of water scarcity as well as explains the solutions for better water management strategies to cope with water scarce situation.

1.1 Pakistan is an Irrigated Agriculture Based Country

Pakistan is typically an irrigated agriculturally based country that is dependent on the surface as well as groundwater resources. In 1947, the irrigation system comprised of the old traditional canal system with all the irrigation systems reliant on runoff river flows of Indus and its tributaries (Holcomb, 2011; Cheema and Bastiaanssen, 2010). There are no irrigation facilities for future use and to store excess water sources. Today, as a one of the largest connecting irrigation system in the world, there are only three major reservoirs in the country i.e. Tarbela, Mangla and Chashma reservoir (Dam).



Figure 1: Tarbela, Mangla and Chashma are major reservoirs in Pakistan.

As shown in Figure 2, irrigation system of Pakistan has nineteen dams, twelve linking canals, forty-three canal commands and more than 0.1 million watercourses (Qureshi, 2005).

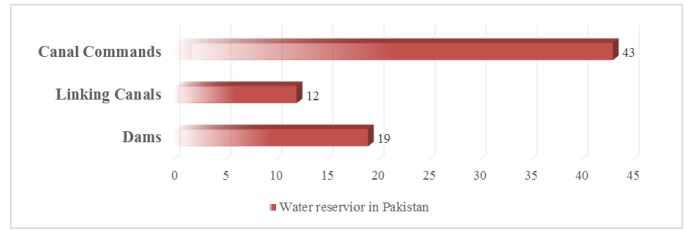


Figure 2: Showing Dams, Linking Canals and Canal commands in Pakistan.

Since independence, country’s agriculture had experienced various structural developments owing to large investments in water sector development, introduction of resource efficient technologies and governmental policies in providing credit or supporting prices on major crops. Not only self-sufficiency has been achieved in production of almost all major crops grown in country like wheat, cotton and rice along with poultry products but exports are also substantially increased (Reardon and Timmer, 2007; Iqbal et al., 2018a).

1.2 Water consumption in agriculture sector

Agriculture is an essential sector and plays a dynamic role in nation’s growth; take a broader view on agriculture’s contributions to net sales production, along with the related funding of serum vices. Agriculture is vitally important to Pakistan and at the time of freedom was predominantly a country based on agriculture (Secretariat, 2009).

However, thereafter Pakistan has become more varied because of industrialization. But industrialization has not removed the true essence of agriculture from Pakistan even though the value of farming had to increase meaningfully since birth. There is no denying the position of agriculture in Pakistan’s economic growth (Sarvesh,2013).

Agriculture sector of Pakistan made significant contributions to its Gross Domestic Product (GDP) while a nation’s GDP is directly linked with economic growth. This sector contributing 21 percent to GDP of Pakistan and much more than 45 percent to labor employment and far greater than half of the population living in rural areas (Usman, 2016). It is therefore, Pakistan’s primary source of financial exchange profits (Griffin and Khan, 1972). Export products based on grain, wool, corn, etc. brings about 65% of our total income.

1.2.1 Water Availability for Agriculture Sector is Doubled

The availability of canal water at farm gate has been doubled which has now arisen to around 106 MAF from 50 MAF since 1947, hence increased total water availability to the crops. This additional water supply came partly from the completion of two major reservoirs i.e. Mangla and Tarbela but mainly from private and public tube wells which has amplified from 40 thousand to over one million since independence (Briscoe et al., 2006).

Enhanced canal water supplies bring more area under crop production and remaining was used to increase the cropping intensity of present lands (Khan, 1972). Subsequently, the total cropped area has increased from 14.01 million hectares to 23.08 million hectares, presenting a dramatic 65 percent increase in last 70 years. Canal water diversions are reliable indicator to assess the contribution and effect of the storage/reservoir (Holcomb, 2011).

A considerable increase of about 7.3 MAF (9 BCM) had been witnessed during the post-Mangla dam. Accordingly, a further increase of around 9.7 MAF (12 BCM) had been observed during post-Tarbela dam (Archer et al., 2010). The scenario of canal water diversions during pre and post construction of Mangla and Tarbela dams is illustrated below in figure 4.

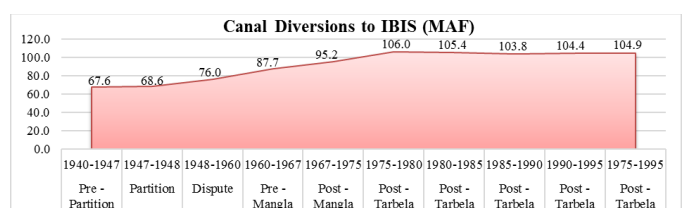


Figure 3: Showed canal water diversions to Indus Basin Irrigation System (IBIS)

Earlier, the consensus was made to develop/construct the dams/reservoirs after duration of every ten years. However, unfortunately, the consent was not accomplished and consequently, we face serious issues in the form of energy shortages and often the floods.

1.2.2 Per Capita Water Availability vs Major Crop Productions

Production of major crops is increasing despite of decreasing trend in per capita water availability (Figure 5). Declining per capita water availability in the country is not owing to diminishing total water availability in the country which stands almost stagnant at 144 MAF, but it is the increasing population which is ballooning at a terrifying rate of nearly 2.1 percent annually (Holdren and Ehrlich, 1974; Hussain et al., 2018). With the same amount of available water, the major agricultural commodities have shown an upward trend over the years.

This impression indicated enhanced production technologies and the efficient use of water resources resulted by wise use of water resources; moreover, adopting conservational practices like precise land leveling and improvement of watercourses etc. (Asif, 2009). The consequent increase in production of major agricultural commodities would indeed not have been possible without the enhanced water availability to the crops, thereby increased cropping intensity as well as total cropped area (Mirza, 2003).

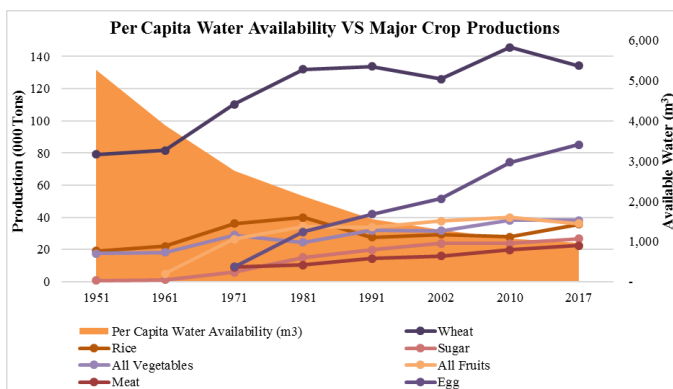


Figure 4: Showing per capita water availability vs production of major crops.

1.2.3 Per Capita Storage in Different Semi-arid Countries

Serious constraints in irrigation infrastructure for supporting horizontal expansion of agriculture and hence making the country one of the world’s most water stressed country because of insufficient and depleting water reservoirs (Hanjra et al., 2010). The designed live storage capacity existing in Pakistan is around 144 m³ per person which is relatively higher than Ethiopia that is considered as the arid regions of the world. On the other hand, USA has live storage of around 6,000 m³ per person followed by Australia and China having 5,000 and 2,300 m³ per person respectively (Hazell and Wood 2008; Rockstrom et al., 2009; Iqbal et al., 2018b).

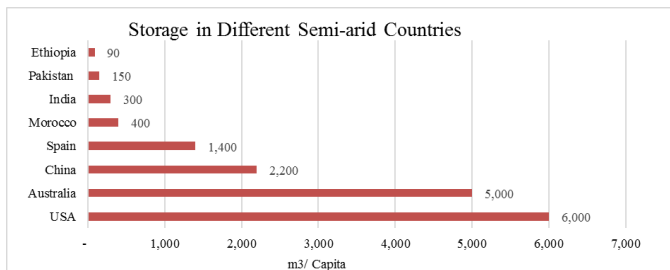


Figure 5: Showed per capita storage in different semi-arid countries

From the World Bank Development Report 63% of the total populace resided in rural communities (World Bank Development Report, 2010). In Pakistan, 70 percent of people is dependent on farming and seems to be their key subsistence asset as the nation’s essential need is nutrition and fiber.

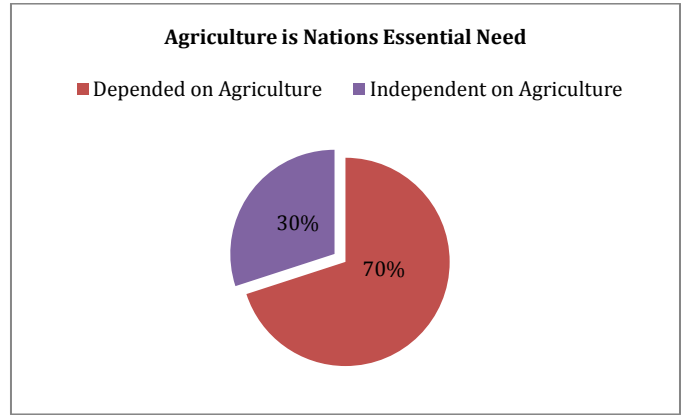


Figure 6: Showed nations dependency on agriculture

Advancement in crop yields is important for food safety, currently 29.6 Mha are appropriate for farmland from 80 Mha of geographic area, 29.6 Mha is ideal for irrigation, 13.3 Mha of which is irrigated drainage as well as 3.5 is rain-fed (Fentaye, 2017; Cheema et al., 2010). Agronomy works as an enterprise and has been increasing attention because of its significance in the fight against prevalent poverty and serves as a stabilization force within the economy. From the above evidence it is obvious that effective water management in agricultural production is essential (Hussain and Hanjra, 2003). Agriculture per day water consumptions is showing in table 1:

Description	Purpose	Quantity
Irrigation	Irrigation water transformed by biophysical cycle into water vapor	2000 to 5000 liters per capita per day

1.3 Water Consumption in Industry Sector

Industrial sector is a really significant field of the world and nations especially Pakistan, have not been successful on the strength of any field alone. Developing and supporting their industry is quite necessary for every country. As per study, Pakistan’s industry produces 8.5 percent of GDP and 52 percent of export. The industry uses up more water than requirement and drains undiagnosed polluted water in to public water bodies (Papanek, 2019).

Industrial sector rate of growth in Punjab throughout 2001-2011 has been 5 percent, as well as the Punjab business strategy proposed a rate of 8 percent in the next decade. Though, water predictions for 2020 and 2025 are predicated on a 5 percent / annum increased water supply, as these industries must be water efficient over the next decade (Munawar, 2014). The following table 2 is the industrial water usage per day values.

Description	Purpose	Quantity
Industrial use	One vehicle coming from assembly unit	is required 150,000 liters of water
	Every liter of gasoline which is refined	is required 300 liters of water
	Thermal processing of every kg-watt hour of generating energy	is required 225 liters of water

Industries as normal is no longer possible as we need to realize that perhaps the water problems we face nowadays are interconnected. We should be part of a solution rather than being part of the problem (Tietenberg and Lewis, 2016). For our current position of becoming designated a water stressed nation, our main focus will be on industry sector structural growth, in particular our main objective is to improve the efficiency of our industry sector for small water footprints but higher value added (Daniels et al., 2011).

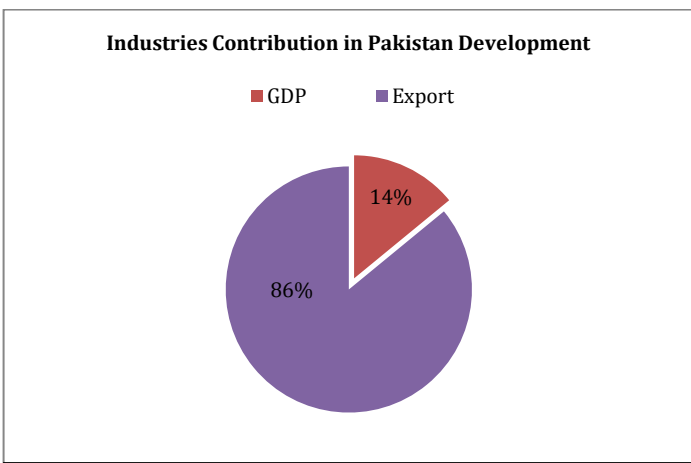


Figure 7: Showed industries contribution in Pakistan development

1.4 Water Consumption in Domestic Use

Total 69 percent of the water is used for the domestic purpose. If this water is not available, then it makes the life impossible. Human used the water as a drinking purpose and as well for the household purposes (McCaffrey, 1992). The following table 3 which shows the purpose of the water and daily water consumption by human.

Explanation	Purpose	Quantity
Human Need	Drinking	Three to five liter per unit per day
	Housekeeping	200 to 400 liter per unit per day

Pakistan’s agriculture sector is using far more water than the world’s average, which clearly indicated the injustice allocation of water to this sector (Asif, 2009; Iqbal et al., 2018a). With population increase, industrialization, urbanization and climate change, the agriculture sector will be confronting multifaceted challenges in the near future (Afzaal et al., 2020a; Hussain et al., 2019). In order to encounter these challenges water will need to be relocate from agriculture sector to other sectors. The scenario is illustrated below in the figure 9.

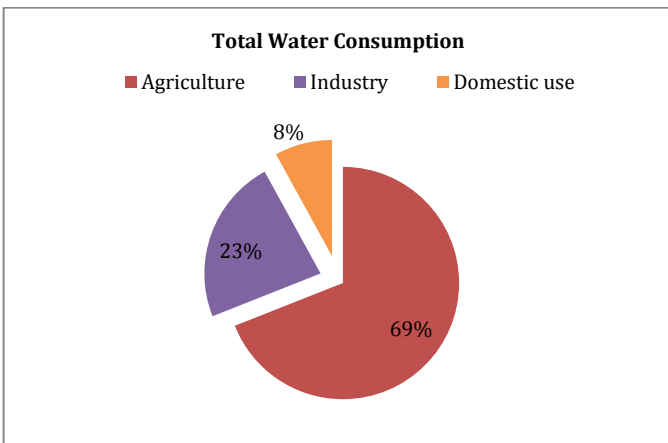


Figure 8: Total water use in Pakistan, by various sectors.

1.5 Water Scarcity

Availability of additional water can only be met by conserving the current water losses. As discussed earlier, the construction of large storage reservoirs would require a relatively longer duration (Gleick, 2000; Aslam et al., 2018). Therefore, management of water will be the only workable option for the next decade to feed the agriculture sector and will be the only source of allocating the water to other sectors by increasing its current efficiency levels. Figure 10 illustrate the usage of water in different sectors around the globe. South Asia ranked on the top in using 91 percent of total water usage in agriculture sector amongst other continents.

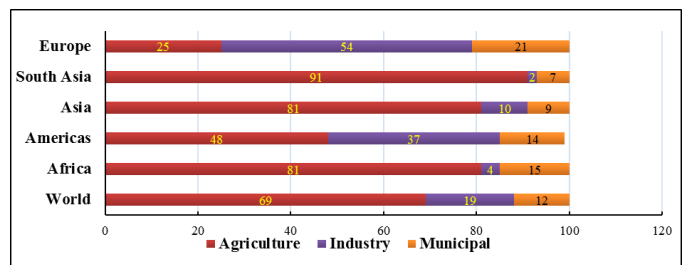


Figure 9: Showing sector wise global water use

2. WATER RESOURCES IN PAKISTAN

2.1 Rainfall

Eastern downturns (December-March), as well as Monsoons (July-September) are the main rainfall sources in Pakistan. The entire Indus plain experiences 212 mm and 53 mm of average rainfall, overall, during most of the Kharif and Rabi seasons (Enum, 2013; Khan et al., 2020). Depending on the 10-year median (1996-2006), the preceding chart shows the average rainfall data in some of large cities.

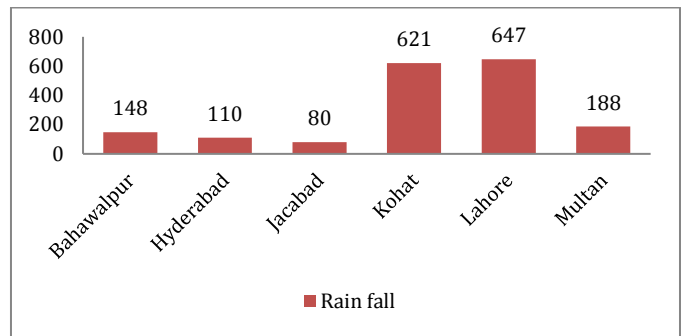


Figure 10: Ten years (1996-2006) average rainfall data of major cities

2.2 Glaciers

Virtually 13,680 Km² of Pakistan’s entire surface part is contained by ice caps, which helps to increase the river runoff in hot weather. As per researchers, glaciers throughout the Himalayas have decreased by almost one-fifth over just 30 years and this is assumed that glaciers in this area may have vanished by 2035, with a negative impact for the 1.3 billion people staying in river basins offshore offers diet as well as fuel (Enum, 2013; Cheema et al., 2014; Iqbal et al., 2020a).

2.3 Dams and Rivers

Pakistan has gifted Indus with numerous rivers which territories i.e. Jhelum, Chenab, Ravi, Beas and Sutlej are the five central rivers from the east side of Indus, along with Haro, Soan and Siran, are three small rivers (Swain, 2004).

2.4 The Indus River System

Created by either the Hindu Kush and Karakoram glaciers, Indus is Pakistan’s biggest river, as well as the main aquatic outlet. It enables meet family as well as commercial requirements and supports practically 90% of farming. Jhelum, Ravi, Chenab as well as Sutlej are also the eastern territories of an Indus (Clift et al., 2002; Wescoat et al., 2000). As per the Indus Water Treaty (1960), Bias, Ravi as well as Sutlej were controlled by India and Chenab, Jhelum and Indus were granted to Pakistan (Salam et al., 2020). Moreover, Pakistan have been numerous small rivers joining the west of the Indus, the largest of which would be Kabul. Certain rivers typically involve Swat, Tochi, Gomal and Kurram (Cheema et al., 2014; Iqbal et al., 2020b, Afzal et al., 2020a).

Sr. No.	River Name	Crops	
		Kharif	Rabi
1	Indus	50.066	9.975
2	Jhelum	16.437	6.777
3	Chenab	21.382	6.328
4	Ravi	1.164	0.352
5	Kabul	0.070	0.08
6	Sutlej	14.357	5.696
	Total	108.476	29.208

2.5 Hydro Power

Pakistan seems to have an approximate hydroelectric capacity of 40,000 MW in the higher Indus area. Pakistan currently does have a generation capacity of 22,797MW for electricity generation. Total production is 17,000 MW and the shortage varies from 4,000 to 5,000 MW. The main ones are Petroleum (35.2%), Hydel (29.9%), Gas (29%), plus nuclear and

exported (5.8%) (Afzal et al., 2017). Until the year 2025, WAPDA predicted an output voltage of 75149 MW that canister merely be accomplished by building larger storing reservoirs (dams). Table 5, demonstrates the energy generation as well as the thermal energy channels business in Pakistan (Clarke, 1993)

Table 5: List of operational thermal stations with their potential to generate energy

Sr. No.	Thermal Stations with Operational Fuel Type	Location	Potential Energy (MW)
1	Hub Power Company Plant (Thermal gas station fired with oil)	Hub Balochistan	1292
2	Hub Power Project Narowal (Furnace oil plant fired)	Narowal Punjab	225
3	Bin Qasim Power Plant (Plant fired with oil and natural gas)	Karachi, Sindh	1260
4	Jamshoro Power Station (Plant fired with oil and natural gas)	jamshoro, Sindh	1054
5	lalpir Limited (Thermal gas station fired with oil)	Muzaffargarh, Punjab	362
6	Altern Energy Limited (Diesel engine started with gas)	Fateh Jang, Punjab	29
7	Atlas Power Limited (Plant fired with oil furnace)	Sheikhupura, Punjab	225
8	Attock Gen Limited (Plant fired with oil furnace)	Rawalpindi, Punjab	165
9	Fauji Kabirwala Company (Paired cycled plant fired with gas)	Kabirwala, Punjab	157
10	Gul Ahmed Energy Limited (Plant fired with oil furnace)	Karachi, Sindh	136
11	Nishat Power Limited (Plant fired with oil furnace)	Lahore, Punjab	200
12	Nishat Chunian Limited (Plant fired with oil furnace)	Lahore, Punjab	200
13	Sapphire Electric Company (Plant fired with oil furnace)	Muridke, Punjab	225
14	Saba Farooq Company (Plant fired with oil furnace)	Farooqabad, Punjab	125
15	Southern Electric Power Company (Plant fired with oil furnace)	Raiwind, Lahore	135
16	Tapal Energy Limited (Plant fired with oil furnace)	Karachi, Sindh	126
17	Japan Power Generation Limited (Plant fired with oil furnace)	Raiwind, Lahore	135
18	Kohinoor Energy Limited (Plant fired with oil furnace)	Lahore, Punjab	131
19	Sitara Energy Limited (Plant fired with diesel and natural gas)	Faisalabad, Punjab	85
20	Saif Power Limited (Plant fired with diesel and natural gas)	Sahiwal, Punjab	225

3. WATER SCARCITY CAUSES

3.1 Less Rainstorm

The cycle of hydrology specifies the collection of mechanisms that carry water flow via system. The hydrological process is determined by evaporation, which is severely affected by the system due to the high pollution of wetlands, oceans as well as rivers (Nawaz et al., 2020; Daud et al., 2017). The rainfall ratio to agriculture is 5 to 10%. Cutting of wide Forest regions from seven to nine thousand hectares in Pakistan year⁻¹. It is reduced and is now only 5% rather than 25% of the entire land (Cleaver, 1999; Khan et al., 2020).

3.2 Reservoir Slurry

Water shortages and also the deteriorating load shedding has overwhelmed the country and pressured the nation to drop billions of dollars. But no one has been paying much attention to the reservoir topsoil erosion that threatens the dam's lifetime, the source of water that drastically alters agricultural production. Silting is as hazardous as water and energy shortages if not even more (Thomas, 1993). Tarbela and Mangla are Pakistan's largest reservoirs, face a lot of danger due to 36-year topsoil erosion of up to 6.6 million acre feet (MAF). That's rather alarming. The processing age generated under Indus Water Treaty has been adversely affected by increasing sand in reservoirs (Mahdi et al., 2005).

As result of the lost processing substitute due to topsoil erosion produced underneath the Indus Waters Treaty desperately needs replenishment, while part of the Treaty establishing Indus Waters. Topsoil erosion aquifers ruins storage space as well as negatively affects the manufacturing of agricultural products to which dams are constructed and water is deposited (Cech, 2009; Qureshi et al., 2008). Likewise, flood control gates such as silt control gate is also important to prevent trillions of dollars in loss of human life, assets and to conserve water for agriculture.

Table 6: List of Pakistan's major reservoirs and their storage capacity

Sr. No	Pakistan's Major Reservoir	Total Storage Capacity (MAF)
1	Tarbela Dam	10.20
2	Mangla Dam	05.60
3	Hub Dam	0.0924
4	Tanda Dam	0.0788
5	Khanpur Dam	0.059
6	Warsak Dam	0.0475
7	Rawal Dam	0.0475

The complete loss resulting from the topsoil erosion in reservoirs is around 13.20 MAF. Table 6, provides a list of Pakistan's primary reservoirs as well as their fuel storage capability. Seepage is defined as the process of transferring water from the surface, from the sides of the canals and watercourses into the ground. In Pakistan, the losses of leakage are generally high, but about 8 to 10 cusecs per million square foot of the wet area of the cross chapter; representing 35 to 40 percent distraction into the canal. In Pakistan the overall length of canals as well as waterways is 56073 km and 1.6 million km each.

Studies which show a total yearly loss of 18.3 MAF of useful rainwater to the field from undistinguished canals as well as waterways in Pakistan, via inlet on its own. If avoided, this massive loss of supplies can replant an extra 3.0 million acres per annum. The waterway of Indus is Pakistan's main source of irrigation (Reeves et al., 1991). If we minimize canal as well as navigable waterway losses, further region can be grown. Approximately 25 percent water (26 MAF) is calculated to be lost via canals, Major as well as minors distributaries. Moreover, around (45 MAF) water is lost via flow, evaporation, transpiration as well as flooding etc. from waterways.

3.3 Global Population Position Un-estimated

In 2006, the world population was 6.7 billion, growing at a level of 78 million year⁻¹ that has now exceeded 7.13 billion. The world has been projected to hit 10.9 billion by the year 2050. Growth rate exits as 90% in developing nations among this overall popularization. Nations like

Pakistan are now experiencing several foods, fiber, healthcare and education issues. Population growth would put huge strain about the use of water. Pakistan is the sixth most populous country with 19.6 million inhabitants increasing by 2014 at such a rate of 1.52%.

3.4 Indus Water Treaty

Shortly, since 1947, a conflict emerged among India and Pakistan over water management. In 1960, the agreement was signed via World Bank. This deal separated the two countries' use of rivers as well as canals. For the three western rivers, named Indus, Jehlum and Chenab, Pakistan received exclusive privileges as well as India maintained freedoms over the three eastern waterways, Ravi, Beas, and Sutluj in particular. The agreement still expected undisturbed water source for ten years. Pakistan would be to build large dams throughout this time, partially funded by lengthy term funds from the World Bank and Indian compensation capital (Rodrik, 2003; Wescoat et al., 2000).

Three mega purpose dams were constructed including Warsak, Mangla and Tarbela. Moreover, eight channel connection framework was also installed as well as the new tunnels were remodeled. This agreement also included the building of five dams and a gated siphon. However, 24 MAF selling complete water, irrigating about 8 million acres tract of land. The IWT occurred in 62 million pounds and the nation suffered a major loss, making the water scarcer (Khan et al., 2020).

4. WATER LOSSES

Complete available water resources of Pakistan's as well as the canals, waterways and land losses showed in figure 12.

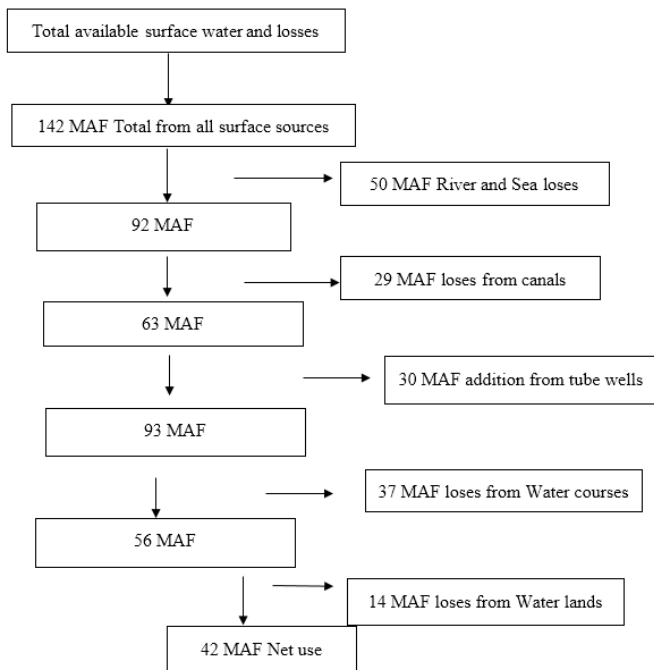


Figure 11: Shows total reversibility of water irrigation system in Pakistan

5. DISCUSSION

Any type of irrigation construction work could be carried off without sufficient knowledge of the supply of water. A good assessment of the sufficient irrigation water is indeed a pre-condition for progress. Therefore, quantity and quality of water must be measured prior to its use. The agritourist water system is obtained from froze ice, surface space age groups as well as ground trapping (Scott et al., 2003; Iqbal et al., 2020a). However, rainfall is really the true, and only refilling medium. Rainfall is usually insufficient to maintain over a lower level of crop manufacture, especially in semi-arid regions. This needs efficient watershed administrators to extract surface as well as sub-surface water flow, and water expenditure preparedness from all outlets (Wescoa et al., 2000). The water for irrigation is a growing supply in Pakistan, as well as the world at large. It really is evident from regional reality that, with careful management, planning and processing must be in the right areas for successful further growth of the agribusiness industry.

6. WATER SHORTAGE INFLUENCE

6.1 Impact on Agriculture

Due to water shortage, 29 Mha of land is cultivatable instead of 80 Mha, yet only 17 Mha is still barely fertilized by the canal, which puts additional stress on the financial system before importing meal grains. Pakistan is the main home to Basmati Rice, a fragrant lengthy grain cultivated in the lowlands of north Punjab. A few of Pakistan's best fruit varieties are risen. Pakistan also produces a wide range of vegetables. But in the present situation, the water scarcity will bring a considerable decline in the aforementioned outputs and have an effect on the country's development (Ali,1993).

6.2 Impact on Urbanization

The total population of Pakistan in 2014 is over 190 million, rendering it the 6th densely populated counter-try in the world. Because of the fast pace of population increase, urban development is rising, that will put enormous pressure on the country's economic demographic profile in which the urban areas are rising at such an alarming rate. Throughout this case the people require water, but in effect water shortages is seriously impacting water availability (Marella, 1998).

6.3 Impact on Ground Water

Surface water shortage has put huge stress on groundwater. Customers attempting to draw ground water to make-up for shortage. Recharging reduced in drag because of less percolation. It has led to increase in saline water lens increasing closer to the surface (Qureshi et al., 2010).

6.4 Impact in Nationwide Harmony

The most effect of water shortages being that it creates divisive dispute among regions that affects national cohesion and creates discord between regions.

6.5 Salt Water Interruption

The Indus water flows into the sea keeps the seawater at a range and does not allow it to mess too much with the surface and subsurface water re-inland reservoirs. With the existing water shortage, the situation is bringing to light. The invasion of the saltwater was located upstream, to 100 km north of the sea. The Sindh district of Laar is severely affected. The intrusion of saltwater ruins water sources and people are forced to drink brackish, and thus suffer from diseases of varying degrees (Mehta, 2000). Throat swelling due to the availability of saltwater is a common problem faced in the coastal regions of Sindh. Additionally, seawater makes productive land worthless, resulting in loss of employment and economic turmoil. Thousands of communities in the districts of Badin and Thatta were abandoned so people were forced to move to a few different places (Memon, 2002).

6.6 Coastal Land Lost

Because of the consistent rise of the Indus withdrawals in Punjab, the oversupply to shore has reduced to a lot. Subsequently, it destroyed the coastal environment. Natural resource deterioration has degraded habitats, persuasive many coastal people to move in quest of food and water to many other regions. Former Sindh Minister of Irrigation, Ali Mir Shah, received findings of a survey undertaken by Sindh's state that deteriorated or lost more than 1.2 million acres to the ocean inside Thatta and Badin regions. Moreover, identifying a quarter million inhabitants, and causing economic losses of more than Rs. 100 billion. At least one third of the land had been demolished by the Sea water. Furthermore, 12 Latest estimates put the average territory wasted to the sea at 1.4 million acres. Land losses due to degradation and sea water aren't out of the issue, as water scarcity continue indefinitely (Memon, 2002; Iqbal et al., 2020b).

6.7 Impact on Economy / Society

Agriculture is the nation's core as well as its bloodline is really the water running into the networks to the crop production. When water is scarce then the nation must be prepared to suffer financially as well as socially issues. The agricultural sector will suffer the loss of around Rs. 90 billion due to the drought as per federal guesstimates (Khoso et al., 2015). Given that agricultural has remains a significant source of shirking an already failing economy, and has a crucial part to play, especially in terms of food safety as well as the jobs of the nation's ever burning population. The negative effects of water scarcity on farming will have a soaring impact on the prevalent poverty threshold (Molden, 1997).

7. PREPARATIONS FOR WATER CRISIS

Pakistan is an agricultural country where freshwater is essential for survival, and water is losing mostly due to poor management. A huge investment in restoring established reservoirs and building new storage on a massive scale is an easy issue cure. Pakistan's government should equalize conflicting requirements in handling water supplies around public and private, rural and urban, the industry, as well as the climate. Nonetheless, since citizens have caused this problem, they have the power to avoid water shortage from crippling the community, farmland as well as infrastructure of Pakistan by modifying their behavior (Asif, 2012; Allan, 1999).

7.1 Kalabagh Dam is a Superlative Site

The Kalabagh dam is a superlative site both in terms of water storage as well as power generation along with flood control. This is the only site where province KP's 0.85 million acres fertile land of Bannu and D.I. Khan which are nearly 150 feet above the Indus water level can be brought under cultivation by establishing appropriate irrigation system. Apart from mentioned benefits, the site that can contribute to flood control because Kabul River joins just upstream Kalabagh dam (Ahmad, 2007). Additionally, this site is close to the load centers in terms of efficient electricity distribution. There are, however, a number of other dams also under the pipeline of country's future, for developing both water conservation and power generation. We have been delaying these dams to construct the best one first and hence making the classical example of "Don't let the perfect, be the enemy of good". Fortunately, now there is a good consensus to develop the Bhasha dam. Let's not waste this opportunity and develop the dam in minimum possible time and continue building other viable dams till another consensus been developed (Malkani and Mahmood, 2017).

7.2 Effective Management Strategies

Table 7: WAPDA's priority wise list for construction of major Dams in future				
Project (Dam)	Rivers	Capacity (MW)	Storage (MAF) Gross/ Live	Estimated Cost (\$ Million)
Diamer-Basha	Indus	4,500	8.1/6.4	11,178
Kurram Tangi	Kurran	84	1.2/0.9	700
Golen Gol	Chitral	106	RoR*	130
Tarbela 4th Ext.	Indus	1,350	-	826
Munda	Swat	740	1.3/0.7	1,401
Kohala	Jhelum	1,100	RoR*	2,400
Bunji	Indus	7,100	RoR*	6,838
Dasu	Indus	4,320	1.15/?	5,206
RoR* It means "Run of River"				

Time is required to manage the water supplies, as Pakistan is already experiencing water scarcity. This strategy could save about 1.3 MAF of water from current losses. The suggestions in this respect are as follows:

- Tremendous amount of water is lost due to flow, infiltration as well as spillage, etc. Leakage ultimately results in water dumping which makes the territory less fruitful. Such losses can be done away by clogging the waterways and channels (Ayub, 2020). Furthermore, people need to be educate as well as informed them, how to preserve and use water efficiently through cooperation (Adebayo, 2007).
- Like many Western states, the country should introduce water management regulations.
- The second biggest proportion to the current total water originates from groundwater outlets. Public and private tube well have exploited this supply, and have used it quite well. It would still supply more than 9 MAF of water. This supply could be utilized and is used for agricultural applications with due judgment. In some areas, however, due to tube wells and excessive extraction of water, groundwater is rapidly depleted. In these areas, government officials must gain control and save them from depletion and use outlets to recharge them.
- Steps should be taken to transform the drainage system premised on alignment into a demand oriented system.
- Water drainage must be used correctly and it can be regulated by the introduction of modern drainage methods, i.e. slowly creeping, sprinkling, etc., capable of proving the flow and the use of water.

- Waste water for irrigation purposes must be recycled.
- Adequate steps should be taken by the officials to counter unlawful water extraction and make sure its equitable distribution.
- Currently, the drainage agency has not stopped unlawful robbery and retrieval; therefore, the drainage distribution network requires to be nationalized via connections of water users.
- Furthermore, water has now been delivered to farm workers at a really low cost which is Why don't they just then view water as a valuable resource; furthermore, it is necessary to raise water price in order to create irrigators understand the importance of this resource Corcoran, 2010.
- Farmer's institutions, water users associations as well as the private industry are engaged in building, operating and maintaining the drainage system. All these connections are devised as a system for establishing a collaborative framework (Spulber and Sabbaghi, 2012).
- Pakistan can add much more value to agriculture from the existing flows by managing its present water resources which requires highly effective engineering, scientific as well as administrative capabilities. Although, nobody is starving as at-least flour and rice are available in plenty amongst other major food commodities. The climate of country is in favor of producing nearly every type of crop in almost all the regions, be it tropical, sub-tropical, arid, semi-arid, evergreen etc. Due to better availability of inputs like seed, fertilizer, insecticide/ pesticide etc. and induction of farm mechanization, agriculture sector of Pakistan has witnessed adequate growth and development. Growth was amply augmented by increasing per acre yields of major crops (Ensink et al., 2002; Khan et al., 2020).
- The country has attained food self-sufficiency despite exorbitant population growth. Pakistan's agriculture has performed exceptionally well since independence in almost all arenas. With the modest start in 1947, Pakistan has now ranked in top seven countries for production of chickpea, rice, mango, sugarcane, milk, date, palm, kinnow, apricot, wheat and onion (Kijne, 1996; Khan et al., 2020).

8. CONCLUSIONS

More than 70 percent of the people are living in rural regions of the world and their livelihood depends strongly on the improvement of local natural assets. Water, being the profitable resource on earth needs efficient management because this scarce resources is diminishing day by day. Awareness of the environmental calls for decreased complexity and better quality returns must be streams into all possible means. To attain sustainable economic growth in farming, a well-structured government policy is needed, that may help to examined the issue of water shortage and generate an efficient solution along with strict compliance. Increasing urban density and urbanization across the rivers on the one hand resulted in significant abstraction of freshwater as well as negatively effects the water resources. Consequently, water management, water quality and water accounting is required for reliable water management system across all potential sectors. Agriculture plays a vital role in the growth of Pakistan. The government must declare efficient policies that increase crop productivity (more crop per drop) in order to boost economic development. Governors should acquaint themselves with contemporary ways to produce production through the implementation of novel agricultural techniques. Furthermore, the government should research sound economic reforms, since the huge territories are much more efficient than the smaller ones, and should boost ownership of land to eliminate feudalisms. The growth of Pakistan's poor economy will certainly be enhanced by efficient and sustainable use of water resources that directly link with many sectors especially agriculture.

RECOMMENDATIONS

- Food as well as fiber are everybody's urgent needs, so suitable administrators of water supplies is needed.
- There is ample scope of increasing water productivity with the intention of eliminating the suspected water as well as energy crises in the country, the only option left is to conserve the water, subsequent efficient use, develop the new water resources and refining/renovating the existing ones.
- Several options are available in order to increase the water resources e.g. development of small dams, promotion of high efficiency irrigation systems, precise land leveling and integrated farm management strategies are one of the outstanding and viable routes to wrestle the challenges.
- As most of the country's water has already been allocated to different sectors like agriculture, domestic and industry, therefore, it is required to pose special focus on sustainability of infrastructures and improving water productivity.
- Annual water expenditure statistical data can assist to efficient water quality preparation.

- A one hundred year old drainage system still poses a significant water age concern via flow; it involves adequate incarceration at the required level.
- Consumers should be served well on the significance, quality and productive use of water by public agitation.
- Time requirement is administrative control, efficient water preparation and wise use.
- Efficiently apply furrow as irrigation system as well as drip as irrigation method.
- Water privileges, rules or even policies for controlling devilish issues such as module tampering, water extortion and pilfering etc.
- Legislation for groundwater abstraction is direly needed in order to ensure its judicious use and to meet the future domestic, industrial as well as agricultural requirements.
- Groundwater is being over exploited in many areas of the country and sewage along with other factors deteriorating its quality. Groundwater accounts for almost half of the total irrigation requirement of crops grown in the country.
- In addition to land tax, tax on water quantities/uses should be rectified.
- Currently, we are abstracting a large portion of around 60 MAF to irrigate the crops. Increasing number of tube wells, high abstraction rate as compared to low groundwater discharge is the main reason of its quality exploitation.
- Development of small dams/rainwater harvesting systems is a potential solution to conserve the rain water in rainfed areas. There is huge unharnessed potential for capturing surface runoff generated in Pothohar and locally use it for practicing high value agriculture. However, development of their respective command areas may led to increase GDP. It is, therefore, required to develop the command areas first and then develop the dam to get the real benefit from it. A number of small dams has been developed in the country but due to non-development of their command areas they are laying idle and water is evaporating in the atmosphere.

REFERENCES

- Adebayo, A., 2007. Adaptive Water Management System in Nigerian Peri-urban Center, paper presented at 4th Annual Association of Nigerian Geographers conference, held at University of Abuja, Nigeria.
- Afzaal, H., Farooque, A.A., Abbas, F., Acharya, B., Esau, T., 2020a. Groundwater Estimation from Major Physical Hydrology Components Using Artificial Neural Networks and Deep Learning. *Water*, 12, 5. <https://doi.org/10.3390/w12010005>
- Afzaal, H., Farooque, A.A., Abbas, F., Acharya, B., Esau, T., 2020b. Computation of Evapotranspiration with Artificial Intelligence for Precision Water Resource Management. *Appl. Sci.*, 10, 1621. <https://doi.org/10.3390/app10051621>.
- Afzal, A., Munir, A., Ghaffor, A., Alvarado, J.L., 2017. Development of a hybrid solar distillation system for essential oils extraction. *Renewable Energy (Elsevier)*, 13, 80-90
- Ahmad, S., 2007. Land and water resources of Pakistan. A critical assessment. *The Pakistan Development Review*, 911-937.
- Ali, I., 1993. *Irrigation and Hydraulic Structures Theory, design and practice*.
- Allan, J.A., 1999. Productive efficiency and allocate efficiency: why better water management may not solve the problem. *Agricultural Water Management*, 40, 71-75.
- Archer, D.R., Forsythe, N., Fowler, H.J., Shah, S.M., 2010. Sustainability of water resources management in the Indus Basin under changing climatic and socio-economic conditions. *Hydrology and Earth System Sciences*, 14, 1669-1680.
- Asif, M., 2009. Sustainable energy options for Pakistan. *Renewable and Sustainable Energy Reviews*, 13, 903-909.
- Asif, M., 2012. Energy crisis in Pakistan: Origins, challenges, and sustainable solutions. OUP Catalogue.
- Aslam, F., Nawaz, G., Hussain, S., Ahmed, S., 2018. Investigating MAD and Fertigation Effects on Tomato Under Drip Irrigation System in Greenhouse. In: M.J. Jaskani, R. Anwar, I. Ahmad and M. Azam (eds), *Proceedings of Pakistan Society for Horticultural Science*, 18-20, 264-270.
- Ayub, A., 2020. Gully Plugging Spillway Is an Effective Gully Rehabilitation Measure: A Case Study Of District Gujrat-Pakistan. *Big Data in Water Resources Engineering*, 1(1), 09-12.
- Briscoe, J., Qamar, U., Contijoch, M., Amir, P., Blackmore, D., 2006. *Pakistan's water economy: running dry*. Karachi: Oxford University Press.
- Burton, M., 1999. Note on proposed framework and activities, prepared for the IWMI.DSI.CEV- MBER Research Programmed on Institutional Support Systems for Sustainable Management of Irrigation in Water – Short Basins, Izmir.
- Cech, T.V., 2009. *Principles of water resources: history, development, management, and policy*. John Wiley & Sons.
- Cheema, M.J.M., Bastiaanssen, W.G.M., 2010. Land use and land cover classification in the irrigated Indus Basin using growth phenology information from satellite data to support water management analysis. *Agricultural Water Management*, 97(10), 1541-1552.
- Cheema, M.J.M., Immerzeel, W.W., Bastiaanssen, W.G.M., 2014. Spatial quantification of groundwater abstraction in the irrigated Indus Basin. *Groundwater*, 52 (1), 25-36.
- Clarke, R., 1993. *Water: The International Crisis* Earth scan, London.
- Cleaver, F., 1999. Paradoxes of participation: questioning participatory approaches to development. *Journal of International Development*, 11, 597 – 612.
- Clift, G., Edwards, L., Hildebrand, Amjad., White, S., 2002. The stratigraphic evolution of the Indus Fan and the history of sedimentation in the Arabian Sea. *Marine Geophysical Researches*, 23, 223-245.
- Corcoran, E., 2010. Sick water? the central role of wastewater management in sustainable development: a rapid response assessment. UNEP/Earthprint.
- Cosgrove, W.J., Loucks, D.P., 2015. Water management: Current and future challenges and research directions. *Water Resources Research*, 51, 4823-4839.
- Daniels, P.L., Lenzen, M., Kenway, S.J., 2011. The ins and outs of water use—a review of multi-region input–output analysis and water footprints for regional sustainability analysis and policy. *Economic Systems Research*, 23, 353-370.
- Daud, M.K., Muhammad, N., Shafaqat A., Muhammad R., Raees, A.B., Muhammad, B.S., Umair, A., 2017. Drinking water quality status and contamination in Pakistan. *BioMed research international*.
- Ensink, J.H., Van, D.H., Matsuno, W., Munir, Y., Aslam, S., 2002. Use of untreated wastewater in peri urban agriculture in Pakistan: Risks and opportunities IWMI. 64.
- Enum, N., 2013. *Pakistan's Water Crisis, Spread head Research Special Report*.
- Fentaye, B., 2017. Gis based land suitability assessment for surface irrigation: case study in kobo valley, eastern namhara.
- Gleick, P.H., 2000. A look at twenty-first century water resources development. *Water international*, 25, 127-138.
- Griffin, K., Khan, A.R., 1972. *Growth and inequality in Pakistan*. Springer.
- Hamilton, A.J., Burry, K., Mok, H.F., Barker, S.F., Grove, J.R., Williamson, V.G., 2014. Give peas a chance? Urban agriculture in developing countries. A review. *Agronomy for sustainable development*, 34, 45-73.
- Hanjra, M.A., Qureshi, M.E., 2010. Global water crisis and future food security in an era of climate change. *Food policy*, 35, 365-377.
- Hazell, P., Wood, S., 2008. Drivers of change in global agriculture. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 363, 495-515.

- Holcomb, M., 2011. Quantifying the water footprint: growing crops sustainably in northwest India (Doctoral dissertation, The Ohio State University).
- Holdren, J.P., Ehrlich, P.R., 1974. Human Population and the Global Environment: Population growth, rising per capita material consumption, and disruptive technologies have made civilization a global ecological force. *American scientist*, 62, 282-292.
- Hussain, I., Hanjra, M.A., 2003. Does irrigation water matter for rural poverty alleviation? Evidence from South and South-East Asia. *Water policy*, 5, 429-442.
- Hussain, S., Cheema, M.J.M., Waqas, M.S., Waqas, A., 2018. Effect of Potash Application on Growth and Yield of Onion Crop with Drip System. In: M.J. Jaskani, R. Anwar, I. Ahmad and M. Azam (eds), *Proceedings of Pakistan Society for Horticultural Science*, 18-20, 195-201.
- Hussain, S., Cheema, M.J.M., Arshad, M., Ahmad, A., Latif, M.A., Ashraf, S., Ahmad, S., 2019. Spray uniformity testing of unmanned aerial spraying system for precise agro-chemical applications. *Pak. J. Agri. Sci.*, 56(4), 897-903.
- Iqbal, M.M., Shoaib, M., Agwanda, P., Lee, J.L., 2018a. Modeling approach for water-quality management to control pollution concentration: A case study of Ravi River, Punjab, Pakistan. *Water* 10. <https://doi.org/10.3390/w10081068>.
- Iqbal, M.M., Shoaib, M., Farid, H.U., Lee, J.L., 2018b. Assessment of water quality profile using numerical modeling approach in major climate classes of Asia. *Int. J. Environ. Res. Public Health* 15. <https://doi.org/10.3390/ijerph15102258>.
- Kahrl, W. L., 1983. *Water and power: the conflict over Los Angeles water supply in the Owens Valley*. Univ of California Press.
- Khan, M. A., 1972. *The effective interface of irrigation water from the Tarbela Dam Project and the nature resources of the central Indus watershed* (Doctoral dissertation, Texas Tech University).
- Khan, M.M., Cheema, M.J.M., Mahmood, T., Hussain, S., Waqas, M.S., Numan, H.M., Nawaz, M., Saifullah, M., 2020. Crop area mapping by intelligent pixel information inferred using 250m MODIS vegetation timeseries in transboundary Indus Basin. *Big data in water resources engineering*, 1(1).
- Khoso, S., Wagan, H.F., Tunio, H.A., Ansari, A.A., 2015. An overview on emerging water scarcity in Pakistan, its causes, impacts and remedial measures. *Journal of Applied Engineering Science*, 13, 35-44.
- Kijne, J.W., 1996. *Water and salinity balances for irrigated agriculture in Pakistan*, IWMI. 6.
- Loucks, D.P., Van, B.E., 2017. *Water resource systems planning and management: An introduction to methods, models, and applications*. Springer.
- Mahdi, S.K., Chaudhry, M.M., Siddique, M., 2005. Characteristic of Reservoir Induced Seismicity at Tarbela and Mangla Dams. In 73rd ICOLD Meeting, Tehran, Iran.
- Malkani, M.S., Mahmood, Z., 2017. *Mineral Resources of Pakistan: provinces and basins wise*. Geological Survey of Pakistan, Memoir, 25, 1-179.
- Marella, L.R., 1998. *Water Use Trends and Demand Projections in the Northwest Florida Water Management District*, U.S. Geological Survey.
- McCaffrey, S. C., 1992. A human right to water: Domestic and international implications. *Geo. Int'l EIntl. L. Rev.* 5, 1.
- Mehta, I., 2000. *Water for the twenty-first century: challenges and misconception*, IDS Working Paper 111, IDS, Brighton.
- Memon, A., 2002. *An Overview of the History and Impacts of the Water Issue in Pakistan*, Proceedings of International Conference on "Sindh, the Water Issue and the Future of Pakistan," The World Sindhi Institute, November 9, Washington, DC.
- Mirza, M.M.Q. 2003. Climate change and extreme weather events: can developing countries adapt? *Climate policy*, 3, 233-248.
- Molden, D., 1997. *Accounting for water use and productivity*, SWIM Paper No.1, International Irrigation Management Institute, Colombo, Sri Lanka.
- Munawar, H., 2014. *Industrial, commercial water use to increase 63pc in Punjab*. The news.
- Nawaz, A., Hussain, S., Waqas, M.S., Rasheed, H., Ali, S., Iqbal, M.M., Yasmeeen, Z., Waqas, M.M., 2020. Health risk assessment of heavy metals due to untreated wastewater irrigated vegetables. *Big data in water resources engineering (BDWRE)*, 1(1), 01-03. DOI: <http://doi.org/10.26480/bdwre.01.2020.01.03>
- Papanek, G.F., 2019. *Pakistan's development: Social goals and private incentives*. Harvard University Press.
- Postel, S.L., 2003. *Securing water for people, crops, and ecosystems: new mindset and new priorities*. In *Natural Resources Forum*. Oxford, UK: Blackwell Publishing Ltd. 27: 89-98.
- Pretty, J., 2013. The consumption of a finite planet: well-being, convergence, divergence and the nascent green economy. *Environmental and Resource Economics*, 55, 475-499.
- Qureshi, A.S., 2005. *Climate change and water resources management in Pakistan*. Climate change and water resources in South Asia. AA Balkema Publishers, Leiden, 197-230.
- Qureshi, A.S., McCornick, P.G., Qadir, M., Aslam, Z., 2008. Managing salinity and waterlogging in the Indus Basin of Pakistan. *Agricultural Water Management*, 95, 1-10.
- Qureshi, A.S., McCornick, P.G., Sarwar, A., Sharma, B.R., 2010. Challenges and prospects of sustainable groundwater management in the Indus Basin, Pakistan. *Water Resources Management*, 24, 1551-1569.
- Reardon, T., Timmer, C.P., 2007. Transformation of markets for agricultural output in developing countries since 1950: How has thinking changed? *Handbook of agricultural economics*, 3, 2807-2855.
- Reeves, R.R., Chaudhry, A.A., Khalid, U., 1991. Competing for water on the Indus plain: Is there a future for Pakistan's river dolphins? *Environmental Conservation*, 18, 341-350.
- Rockstrom, J., Falkenmark, M., Karlberg, L., Hoff, H., Rost, S., Gerten, D., 2009. Future water availability for global food production: the potential of green water for increasing resilience to global change. *Water resources research*, 45, 7.
- Rodrik, D., 2003. *In search of prosperity: Analytic narratives on economic growth*. Princeton University Press.
- Salam, M., Cheema, M.J.M., Zhang, W., Hussain, S., Khan, A., Bilal, M., Arshad, A., Ali, S., Zaman, M.A., 2020. Groundwater storage change estimation using grace satellite data in Indus Basin. *Big data in water resources engineering (BDWRE)*, 1(1), 13-18. DOI: <http://doi.org/10.26480/bdwre.01.2020.13.18>
- Sarvesh, C., 2013. *The Role of Agriculture in Economic development of Pakistan*, <http://www.scribd.com/doc/47709856/Role-of-Agriculture-in-Economic-Development>. Retrieved on 28.01.2011.
- Scott, C.A., Naser, H., Hagan, R.E., Hijazi, A., 2003. Facing water scarcity in Jordan: reuse, demand reduction, energy, and transboundary approaches to assure future water supplies. *Water International*, 28, 209-216.
- Secretariat, C.G.I.A.R., 2009. *CGIAR Annual Report 2008: Global Recommitment to Agriculture*. CGIAR Fund Office.
- Shah, M., Strong, M., 2000. *Food in the 21st century: from science to sustainable agriculture*. The World Bank.

Spulber, N., Sabbaghi, A., 2012. Economics of water resources: from regulation to privatization. Springer Science & Business Media, 13.

Swain, A., 2004. Managing Water Conflict: Asia, Africa and the Middle East. Routledge. 1,800 miles long river after flowing out of Tibet through the Himalayas enters Kashmir and then moves into Pakistan, 46.

Thomas, R., 1993. Water Resources Policy and Planning: Towards Environmental Sustainability. ISPAN Technical Support Center.

Tietenberg, T.H., Lewis, L., 2016. Environmental and natural resource economics. Routledge.

Usman, M., 2016. Contribution of agriculture sector in the GDP growth rate of Pakistan. Journal of Global Economics.

Waqas, M.S., Cheema, M.J.M., Waqas, A., Hussain, S., 2018. Enhancing Water Productivity of Potato (*Solanum Tuberosum* L.) Through Drip Irrigation System. In: M.J. Jaskani, R. Anwar, I. Ahmad and M. Azam (eds), Proceedings of Pakistan Society for Horticultural Science, 18-20, 249-256.

Wescoat, J.L., Halvorson, S.J., Mustafa, D., 2000. Water management in the Indus Basin of Pakistan: A half-century perspective. International Journal of Water Resources Development, 16, 391-406.

