



# NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

## THESIS

**RUNNING DRY: WATER SCARCITY IN PAKISTAN**

by

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June 2019

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**RUNNING DRY: WATER SCARCITY IN PAKISTAN**

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Lieutenant Colonel, Pakistan Army  
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requirements for the degree of

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## **ABSTRACT**

With a water shortage reaching alarming proportions, Pakistan shows every sign that it is on its way to a serious water crisis. Such external factors as climate change and trans-boundary developments pose some problems for Pakistan's water supply; poor resource management at all levels of Pakistan's government and administration exacerbates the crisis. While most people attribute the crisis simply to the lack of adequate storage capacity, very few recognize that the heart of the problem lies in other water resource management issues: inefficient supply and delivery systems, irrational distribution and consumption patterns, low irrigation efficiency, incorrect selection of crops, overexploitation of groundwater, and other governance and administrative failures. The state's apparent apathy and indifference to this looming crisis represent an even greater crisis. This thesis asks: With no additional water to import, how can Pakistan cope successfully with its water scarcity? After taking stock of the water resources and identifying the causes adding to the crisis, this thesis offers a way forward on conservation and efficiency, storage, modernization of irrigated agriculture, crop selection, public awareness, regulatory framework, and other governance and administrative measures to enable Pakistan to cope with this resource crisis successfully.

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## **LIST OF ACRONYMS AND ABBREVIATIONS**

|      |                                       |
|------|---------------------------------------|
| AWD  | Alternate Wet and Dry                 |
| BCM  | Billion Cubic Meters                  |
| CR   | Critical Ration                       |
| DWMA | District Water Management Authority   |
| FAO  | Food and Agriculture Organization     |
| FoDP | Friends of Democratic Pakistan        |
| FWMA | Federal Water Management Authority    |
| GMC  | Genetically Modified Crops            |
| IBIS | Indus Basin Irrigation System         |
| IWT  | Indus Water Treaty                    |
| KPK  | Khyber Pakhtunkhwa                    |
| MAF  | Million Acre Feet                     |
| mha  | Million Hectares                      |
| mm   | Millimeters                           |
| PIS  | Pressurized Irrigation Systems        |
| PWMA | Provincial Water Management Authority |
| UBDC | Upper Bari Doab Canal                 |

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## I. INTRODUCTION

“When the well’s dry, we know the worth of water.”

—Benjamin Franklin, *The Way to Wealth* (1758)

Where once there was a water surplus, Pakistan now faces a serious water deficit. As the situation steadily worsens, “water crisis” has recently become a buzzword in the country. With less than 240 millimeters of rainfall in an average year, Pakistan is counted among the most arid countries in the world.<sup>1</sup> The water shortages, according to Anatol Lieven and John Hulsman, “present the greatest future threat to the viability of Pakistan.”<sup>2</sup> Similar claims have been made by many other scholars, hydrologists, and even Pakistani statesmen and heads of different institutions.<sup>3</sup>

Pakistan relies on the 2,900-kilometer-long Indus River and its tributaries for the state’s water needs.<sup>4</sup> All these rivers are fed by waters from the melting of the glaciers and rainfall in the mountain ranges.<sup>5</sup> Most of the rivers outside the Indus Basin only flow during the rainy season.<sup>6</sup> Among the larger nations of the world, Egypt and Pakistan are the only two countries solely dependent on a single basin—the Nile and the Indus, respectively.<sup>7</sup> From 1951 to 2016, per capita surface water availability has declined from 5,260 to 1,000 cubic meters per year in Pakistan and is likely to drop further to 860 cubic

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<sup>1</sup> John Briscoe and Usman Qamar, *Pakistan’s Water Economy: Running Dry* (The World Bank, 2005), xiii, <http://documents.worldbank.org/curated/en/989891468059352743/Pakistans-water-economy-running-dry>.

<sup>2</sup> Anatol Lieven and John Hulsman, “Developmental Realism,” *Harvard Law & Policy Review*, January 16, 2007, <http://harvardlpr.com/online-articles/developmental-realism/>.

<sup>3</sup> “Imran Warns of Drought Threat, Appeals for Dams’ Donation,” *Express Tribune*, September 7, 2018, <https://tribune.com.pk/story/1797733/1-pm-imran-give-important-message-nation-2nd-address/>.

<sup>4</sup> Asad Sarwar Qureshi, “Water Management in the Indus Basin in Pakistan: Challenges and Opportunities,” *Mountain Research and Development* 31, no. 3 (August 1, 2011): 253, <https://doi.org/10.1659/MRD-JOURNAL-D-11-00019.1>.

<sup>5</sup> Qureshi, 253.

<sup>6</sup> Qureshi, 253.

<sup>7</sup> Naser I. Faruqi, “Responding to the Water Crisis in Pakistan,” *International Journal of Water Resources Development* 20, no. 2 (June 1, 2004): 178, <https://doi.org/10.1080/0790062042000206138>.

meters by 2025, shifting the country from a status of “water stressed” to one of “water scarce.”<sup>8</sup> There is no additional water available to supplement the existing resources, and yet the population continues to grow, adding to the crisis. Moreover, growing urbanization and industrialization is escalating the demand even further.

The crisis precipitated by water shortage is having serious economic, social, and security impacts on Pakistan. Countries dependent on agricultural economies and hydropower energy resources are hugely affected by water insecurity.<sup>9</sup> Pakistan, with an agriculture-based economy and a dependence on hydropower for one-third of its energy needs, is extremely vulnerable to the effects of water scarcity. Additionally, while Pakistan, on one hand, has a long history of tensions with India over water issues, there are, on the other hand, qualms and reservations about water management within the country, too. The latter point is particularly urgent; Alex Evans note that while the cases of open conflict with other countries are rare, inequitable distribution of or access to water can lead to violent conflicts within a nation.<sup>10</sup>

A 2006 Human Development Report also finds that water scarcity is often manipulated to the disadvantage of the poor, and especially “when it comes to clean water, the pattern in many countries is that the poor get less, pay more, and bear the brunt of the human development costs associated with scarcity.”<sup>11</sup> Thus, as the resource diminishes, the less privileged may potentially resort to violence; at the very least, a discontented and divided society is always vulnerable to exploitation by enemies, sub-nationalist separatists, extremists, and terrorists seeking to capitalize on the divisions to advance their respective agendas and narratives.

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<sup>8</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018* (Islamabad, 2018), 1, <https://mowr.gov.pk/wp-content/uploads/2018/06/National-Water-policy-2018-2.pdf>.

<sup>9</sup> Peter H. Gleick, “Water and Conflict: Fresh Water Resources and International Security,” *International Security* 18, no. 1 (1993): 79–112, <https://doi.org/10.2307/2539033>.

<sup>10</sup> Alex Evans, *Resource Scarcity, Climate Change and the Risk of Violent Conflict*, World Development Report 2011 (New York: World Bank, 2010), 8, <http://documents.worldbank.org/curated/en/351651468337157443/pdf/620500WP0RESOU0BOX0361475B00PUBLIC0.pdf>.

<sup>11</sup> Kevin Watkins, *Human Development Report 2006—Beyond Scarcity: Power, Poverty and the Global Water Crisis* (Rochester, NY: Social Science Research Network, 2006), 3, <https://papers.ssrn.com/abstract=2294691>.

## **A. MAJOR RESEARCH QUESTION**

With no additional water available to inject into the Indus River System, this thesis asks: How can Pakistan cope successfully with its water scarcity?

## **B. SIGNIFICANCE OF THE RESEARCH QUESTION**

According to the national water policy of Pakistan, “irrigated agriculture is the backbone of the country’s economy, and consumes around 95 percent of the nation’s water resources, the balance is used for domestic and industrial requirements.”<sup>12</sup> The Indus River Basin provides water for 90 percent of the food production in Pakistan; as such, shortages in food and water are intimately linked.<sup>13</sup> Pakistan can store only 10 percent of its annual river flows whereas the storage capacity worldwide hovers at 40 percent.<sup>14</sup> According to some recent estimates, water storage capacity may decline by 30 percent by 2025 due to the effects of climate change and siltation of main reservoirs.<sup>15</sup> By 2025, the projected water requirement for irrigation in Pakistan and potential availability in the Indus basin are 250 billion cubic meters (BCM) and 185 BCM, respectively.<sup>16</sup> Even if all groundwater resources are fully exploited, there simply is not enough water to match the requirement.

Pakistan’s national water policy 2018 recognizes the looming crisis by acknowledging that the “water crisis is descending like a thunderbolt.”<sup>17</sup> There is, however, divergence among experts on how to approach and address the crisis. This thesis attempts to establish the urgency of the issue and to explore what Pakistan should do to cope successfully with the water scarcity, mitigating the potential negative impacts.

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<sup>12</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 1.

<sup>13</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 252.

<sup>14</sup> Staff Reporter, “Wapda Chief Highlights Water Crisis,” *Dawn*, November 17, 2018, <https://www.dawn.com/news/1446105>.

<sup>15</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 252.

<sup>16</sup> Qureshi, 254.

<sup>17</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 3.

## C. LITERATURE REVIEW

A great deal of literature exists on global water resources, water scarcity, climate change, irrigation, and a host of other related issues. Similarly, literature also exists on Pakistan's water woes and related subjects. The sources mostly disagree on the potential solutions to the problem—some posit dams as the silver bullet, while others totally oppose dam building for a variety of environmental and political reasons. While few deny that water is scarce, others think there is more—maybe even enough—of it available, but it is badly planned or exploited. The primary reason for the disagreement is the difference in understanding of the issue and interpretation of the term “scarcity.”

### 1. Water Scarcity: Indicators and Indices

To assess water resource vulnerability, such as stress or scarcity, many indices have been developed over the last three decades. The several equally important facets of water use, supply, and scarcity make the characterization of water stress difficult. According to Amber Brown, “selecting the criteria by which water is assessed can be as much a policy decision as a scientific decision.”<sup>18</sup> The following are some of the common indicators and indices in use for measuring water scarcity.

#### a. *Falkenmark Indicator or Water Stress Index*

The most common way of expressing water stress is the Falkenmark indicator or water stress index, which proposes 1,700 cubic meters per capita per year of renewable water resources as the threshold.<sup>19</sup> This quantity is based on water requirement estimates for domestic, agricultural, industrial, and all other environmental needs. Countries are considered water-stressed when their renewable water supplies are below this figure. Countries experience water scarcity and absolute water scarcity when their supplies fall

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<sup>18</sup> Amber Brown, *A Review of Water Scarcity Indices and Methodologies*, The Sustainability Consortium (Fayetteville: University of Arkansas, 2011), 1.

<sup>19</sup> Frank R. Rijsberman, “Water Scarcity: Fact or Fiction?,” *Agricultural Water Management*, Special Issue on Water Scarcity: Challenges and Opportunities for Crop Science, 80, no. 1 (February 24, 2006): 2, <https://doi.org/10.1016/j.agwat.2005.07.001>.

below 1,000 and 500 cubic meters, respectively.<sup>20</sup> According to Frank R. Rijsberman, this indicator is simple and relies on data that is available and easy to understand. However, it has certain limitations as well. The Falkenmark indicator only takes the national averages ignoring the scarcity effects at a smaller level; does not count the effects of infrastructure that changes the way water is made available to users; and does not account for lifestyle and other climatic effects that vary from country to country.<sup>21</sup> By modifying the Falkenmark indicator, Leif Ohlsson placed emphasis on a society's "adaptive capacity—meaning the capacity to adapt to stress through economic, technological, or other means." He called it a "social water stress index."<sup>22</sup>

### **b. Water Resource Vulnerability Index**

Igor A. Shiklomanov and a few others focused on other factors such as demand for water rather than fixed requirements or quantity of water per person. This method compares a nation's annual water availability with demand in different sectors such as domestic, industrial, and agriculture.<sup>23</sup> The 'water resource vulnerability index' of Paul Raskin et al. measures scarcity as total withdrawals during a year as a percentage of the total available water resources. According to them a country will be water scarce if its annual withdrawals are between 20 and 40 percent of its total annual supply and severely scarce if it is more than 40 percent.<sup>24</sup> Joseph Alcamo et al. use a similar indicator and call it the criticality ratio (CR), which is "the ratio of use to water availability in a watershed or country."<sup>25</sup>

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<sup>20</sup> M. Falkenmark, J. Lundqvist, and C. Widstrand, "Macro-Scale Water Scarcity Requires Micro-Scale Approaches. Aspects of Vulnerability in Semi-Arid Development," *Natural Resources Forum* 13, no. 4 (November 1989): 258–67.

<sup>21</sup> Rijsberman, "Water Scarcity," 2.

<sup>22</sup> Leif Ohlsson, *Environment, Scarcity, and Conflict: A Study of Malthusian Concerns* (Department of Peace and Development Research, Göteborg University, 1999), <https://books.google.com/books?id=3hOEAAAACAAJ>.

<sup>23</sup> Igor A Shiklomanov, *World Water Resources: A New Appraisal and Assessment for the 21st Century* (Paris, France: UNESCO International Hydrological Programme, UNESCO-IHP, 1998).

<sup>24</sup> Paul Raskin et al., *Water Futures: Assessment of Long-Range Patterns and Problems* (Stockholm Sweden: Stockholm Environment Institute, 1997).

<sup>25</sup> Joseph Alcamo et al., *Global Change and Global Scenarios of Water Use and Availability: An Application of WaterGAP1.0* (Kassel, Germany: University of Kassel, CESR, 1997), 3, <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.204.3561&rep=rep1&type=pdf>.

According to Rijsberman, the criticality ratio and similar indicators have certain limitations as well. The water resource availability in such indicators does not account for the quantity that can be made available for human use; does not show the amount used consumptively or through evapotranspiration and how much could be recycled through return flows; and also does not account for the adoptive capacities of specific societies to cope with the stress.<sup>26</sup>

**c.      *Physical and Economic Scarcity Indicators***

David Seckler et al. believe that those countries unable to meet their estimated water demands by 2025, despite their future adaptive capacity and conservation in irrigation through modern irrigation techniques, will be ‘physically water scarce.’ Further, those countries that have sufficient water resources but will require huge investment to make those accessible for different needs are ‘economically water scarce.’<sup>27</sup> According to Rijsberman, the limitation of this model is that it is less intuitive and requires an expert judgment due to non-availability of any data, like per capita indicators, to assess its components.<sup>28</sup>

**d.      *Water Poverty Index***

C. A. Sullivan et al. developed a water poverty index that attempts to gauge the security of individuals at the household and community level. They look at the physical availability of water, the degree to which it is serving the humans, and how much of it goes to the maintenance of ecological integrity. Components of this index include “access to water; water quantity, quality and variability; water uses for domestic, food and productive

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<sup>26</sup> Rijsberman, “Water Scarcity,” 3.

<sup>27</sup> David Seckler et al., *World Water Demand and Supply, 1990 to 2025 Scenarios and Issues*. (Colombo, Sri Lanka: IIMI, 1998).

<sup>28</sup> Rijsberman, “Water Scarcity,” 3.

purposes; capacity for water management; and environmental aspects.”<sup>29</sup> While this indicator is very comprehensive, it is not easy to understand intuitively.<sup>30</sup>

Gleick, however, points out that due to the dynamic and complex nature of water, neither the existing simple indicators can explain it well, nor can more sophisticated indicators be used due to non-availability of accurate water data. According to him, data reflect the picture at a national or larger scale while the water problems are often local.<sup>31</sup> Rijsberman reasons that despite having limitations, Falkenmark is still likely the most simple and widely used index and other indicators using different parameters may not be able to replace it.<sup>32</sup>

## **2. Multifarious Factors of Water Scarcity**

Just as it is difficult to measure water scarcity through a single index, it is also equally puzzling to ascertain factors that cause water scarcity; and the measures that can potentially address the problem. A similar set of factors and circumstances may have different effects on water availability in different parts of the world. Similarly, a certain solution effective in addressing water scarcity in one area may not be applicable in another. This section examines the complex nature of the scarcity of water.

### **a. Water Scarcity—Where and Why?**

Based on the Falkenmark index, it is evident that as the population grows, the availability of water per capita in a particular area will drop as the water resource stays more or less constant. According to Sandra Postel and J. A. Peterson, “population growth impacts the water resource pie in two ways: it forces the pie to be divided into smaller

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<sup>29</sup> C. A. Sullivan, J. R. Meigh, and A. M. Giacomello, “The Water Poverty Index: Development and Application at the Community Scale,” *Natural Resources Forum* 27, no. 3 (2003): 189, <https://doi.org/10.1111/1477-8947.00054>.

<sup>30</sup> Rijsberman, “Water Scarcity,” 3.

<sup>31</sup> Peter Gleick and R.W. Miller, *The World’s Water 2002-2003: The Biennial Report on Freshwater Resources* (Washington DC: Island Press, 2002).

<sup>32</sup> Rijsberman, “Water Scarcity,” 4.

slices and it reduces total size of the pie from overexploitation and misuse.”<sup>33</sup> Water will become increasingly scarce in areas with dense population densities and low rainfall.<sup>34</sup> Nevertheless, it is wrong to assume that water scarcity will always lead to inadequate water for domestic use.<sup>35</sup> According to Gleick the water requirements for basic human needs is 50 liters per person per day—5 liters for drinking; 20 liters for hygiene, sanitation, and disposal of human wastes; 15 liters for bathing; and 10 liters for food preparation.<sup>36</sup> Calculating the water requirement at 50 liters per person per day, the domestic requirement is less than 20 cubic meters per capita per year, which is much less than the scarcity levels of the Falkenmark index. In the domestic sector, people are basically affected by lack of access to water rather than by water scarcity as defined by the Falkenmark index.<sup>37</sup>

Moreover, the lifestyle of a people determines the amount of water they use. About 13.5 cubic meters of water is consumed in production of a kilogram of meat in California.<sup>38</sup> According to D. Renault and W. W. Wallender, a typical diet in the United States requires about 5,400 liters per day whereas a diet with same nutritional value can be produced by certain crops at less than one-fifth of that amount of water.<sup>39</sup> Similarly, the water requirement for a vegetarian diet with same nutritional value will be 2,600 liters per day.<sup>40</sup> The amount of water required to grow food for people is 70 times more than what they require for domestic purposes. Moreover, up to 90 percent of the water used in the domestic sector can be recycled using modern technologies while a huge amount of water, as much as 90 percent, used in agriculture is consumed (evapotranspired) and is not available for

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<sup>33</sup> S.L. Postel and J. A. Peterson, *Dividing the Waters: Food Security, Ecosystem Health, and the New Politics of Scarcity* (Washington, DC: Worldwatch Institute, 1996).

<sup>34</sup> Rijsberman, “Water Scarcity,” 4.

<sup>35</sup> Rijsberman, 4.

<sup>36</sup> Peter H. Gleick, “Basic Water Requirements for Human Activities: Meeting Basic Needs,” *Water International* 21, no. 2 (June 1996): 83–92, <https://doi.org/10.1080/02508069608686494>.

<sup>37</sup> Rijsberman, “Water Scarcity,” 4; Frank Rijsberman, “The Water Challenge,” 2004, <https://cgspace.cgiar.org/handle/10568/38646>.

<sup>38</sup> Rijsberman, “Water Scarcity,” 4.

<sup>39</sup> D Renault and W.W Wallender, “Nutritional Water Productivity and Diets,” *Agricultural Water Management* 45, no. 3 (2000): 275–96, <http://linkinghub.elsevier.com/retrieve/pii/S0378377499001079>.

<sup>40</sup> Rijsberman, “Water Scarcity,” 4.

reuse.<sup>41</sup> According to Rijsberman, “Falkenmark indicator thresholds do not indicate that water is becoming scarce for domestic purposes, but that water is becoming scarce for food production.”<sup>42</sup>

Population growth alone does not determine the demand for water. During the last century the world’s population tripled, but water use multiplied sixfold.<sup>43</sup> The increase in requirement of water per capita, according to most estimates, is due to rising incomes.<sup>44</sup> Rijsberman notes that with the rapid urbanization and industrialization of the world, “it is safe to assume that domestic and industrial demands will rise rapidly in developing countries, but it is much less evident how other demands for water will develop.”<sup>45</sup> The amount of water per person needed in future will depend on a range of policy and personal choices.<sup>46</sup> Gilberto Gallopin and Frank Rijsberman assert that the demand for water is intimately linked to the “values and lifestyles” of future generations.<sup>47</sup>

Rijsberman claims that without taking into account the environmental needs for water, “there is no water scarcity in the developed world.”<sup>48</sup> He adds that in countries in North Africa and Middle East “there is already absolute or physical water scarcity.”<sup>49</sup> He further cautions that the water scarcity will grow and the water will become an important factor, especially in the lives of people living in rural areas of Asia, Africa, and China.<sup>50</sup>

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<sup>41</sup> Rijsberman, 4.

<sup>42</sup> Rijsberman, 4.

<sup>43</sup> William Cosgrove and Frank Rijsberman, *World Water Vision: Making Water Everybody’s Business* (London: Earthscan Publications Ltd, 2000).

<sup>44</sup> Alcamo et al., *Global Change and Global Scenarios of Water Use and Availability: An Application of WaterGAP1.0*; Raskin et al., *Water Futures: Assessment of Long-Range Patterns and Problems*; Shiklomanov, *World Water Resources: A New Appraisal and Assessment for the 21st Century*.

<sup>45</sup> Rijsberman, “Water Scarcity,” 5.

<sup>46</sup> Rijsberman, 5.

<sup>47</sup> Gilberto Gallopin and Frank Rijsberman, “Three Global Water Scenarios,” *International Journal of Water* 1 (2000): 16–40, <https://doi.org/10.1504/IJW.2000.002055>.

<sup>48</sup> Rijsberman, “Water Scarcity,” 8.

<sup>49</sup> Rijsberman, 8.

<sup>50</sup> Rijsberman, 8.

**b. River Basin Level**

The analysis of water at global level has limited use to predict whether individuals or communities are truly water scarce or otherwise. Analysis of water at the river basin level is more suitable as human use of water directly affects the water availability in a basin and, in some instances, even leads to depletion, forcing basins to ‘close.’<sup>51</sup> Fred Pearce states that in closed basins, where river water does not reach sea, extensive water savings may have rebound effects as “one man’s waste of water is often another man’s source of water.”<sup>52</sup> According to Rijsberman and Mohamed, if the water availability in a basin drops rapidly, say by 500 cubic meters in a decade, the effects of scarcity in the situation will be more intense than if the water level in the basin declines slowly, even if the slow drop ultimately reaches absolute scarcity level; hence, the effects of scarcity are directly related to the rate of change of water scarcity in a basin.<sup>53</sup>

Recalling Franklin’s quotation at the outset of this chapter, we determine the value of a resource by its relative scarcity. According to Rijsberman, the increase in water scarcity leads to an increase in its value; the increase in value leads to competition among users and competition often leads to conflicts.<sup>54</sup> Typical examples of such conflicts arise between urban areas and agriculture sectors or between agriculture and environment as each wants greater water share in order to expand and flourish.<sup>55</sup> Conflicts also occur within components of the same user. Mostly, the upper and lower-riparian users distrust each other and want a maximum share for their use and development.<sup>56</sup> Gleick concurs and writes that “scarcity of water leads to conflict, especially in cases when there is a stress due

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<sup>51</sup> François Molle and International Water Management Institute, *Development Trajectories of River Basins: A Conceptual Framework* (Colombo, Sri Lanka: International Water Management Institute, 2003), 1.

<sup>52</sup> Fred Pearce, *When the Rivers Run Dry: Water, the Defining Crisis of the Twenty-First Century* (Beacon Press, 2006), 243.

<sup>53</sup> Rijsberman, “Water Scarcity,” 10.

<sup>54</sup> Rijsberman, 10.

<sup>55</sup> Rijsberman, 10.

<sup>56</sup> Iram Khalid and Ishrat Begum, “Hydro Politics in Pakistan: Perceptions and Misperceptions,” *South Asian Studies* 28, no. 1 (June 2013): 8, [https://www.academia.edu/35228570/Hydro\\_Politics\\_in\\_Pakistan\\_Perceptions\\_and\\_Misperceptions](https://www.academia.edu/35228570/Hydro_Politics_in_Pakistan_Perceptions_and_Misperceptions).

to growing population and where nations consider it as a matter of national security.”<sup>57</sup> When a community exhausts its water, it is very expensive to secure additional water.<sup>58</sup> Texas lost \$9 billion in a drought in 2011 while China loses \$15 billion and \$24 billion each year due to groundwater depletion and pollution, respectively.<sup>59</sup>

### **3. Addressing Water Scarcity**

According to Brian Richter, the water budget, like an economic budget, can be balanced in two ways—“increase the deposits or reduce expenditures.”<sup>60</sup> He believes that a country that runs short or out of water has to balance its water budget by exploring new sources, resorting to storage of existing water for dry days or reducing consumptive uses of the water. Richter outlines six options for a country facing water scarcity—“desalination, water reuse, water importation, water storage, watershed management and conservation.”<sup>61</sup>

Storing water is extremely useful, especially when the pattern of rainfall becomes erratic from one year to another or when flows in rivers vary significantly over different times of the year. Rijsberman believes that while infrastructure, especially dams, have been successful in increasing human control over water and by making it available for use when needed, the downside is also huge.<sup>62</sup> Pearce contends that dams affect the ecology immensely, and very often the dams designed to prevent floods, end up creating them.<sup>63</sup> He adds that benefits of the dams are usually short-term and these structures mostly benefit the elites in cities only, depriving the poor of their wetlands in the countryside.<sup>64</sup>

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<sup>57</sup> Gleick, “Water and Conflict,” 79.

<sup>58</sup> Brian Richter, *Chasing Water-A Guide for Moving from Scarcity to Sustainability* (Washington, D.C: Island press, 2014), 15.

<sup>59</sup> Richter, 14.

<sup>60</sup> Richter, 39.

<sup>61</sup> Richter, 39.

<sup>62</sup> Rijsberman, “Water Scarcity,” 11.

<sup>63</sup> Pearce, *When the Rivers Run Dry*, 135,152.

<sup>64</sup> Pearce, 138.

Scholars agree that the solution must also include the demand side of the water equation. For example, Postel believes that the current manner in which water is used in agriculture, especially flood irrigation, is not sustainable.<sup>65</sup> She adds that the underpricing of water leads to the illusion of plenty, which in turn leads to wasteful practices.<sup>66</sup> Water must be appropriately priced, reflecting its true value, so that consumers realize its worth and consume it accordingly.<sup>67</sup> The free ride in agriculture is a big impediment because it hinders innovation and leads farmers to choose ill-suited varieties.<sup>68</sup> Water use reduction by one-tenth could free up sufficient water to double the uses in the domestic sector worldwide.<sup>69</sup>

Pearce claims that the world grows twice as much food as a generation ago, but consumes three times more water to do it.<sup>70</sup> As the population grows and the use of surface and groundwater increases, the rainwater is becoming more and more important. Pearce and J. R. Julius suggest that rainwater is one of the least expensive water resources, and that catching the rainwater can solve the food problems of the world.<sup>71</sup> Pearce believes that “we must learn to ride the water cycle, rather than replace it.”<sup>72</sup> He adds that it is not the lack of fresh water that is creating problems for mankind; in fact, the lack of efficient regimes is making the matter worse.<sup>73</sup>

According to Rijsberman, there are increasing “calls for shifts from supply management to demand management.”<sup>74</sup> According to him, few good proposals in this

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<sup>65</sup> Sandra Postel, “Growing More Food with Less Water,” *Scientific American* 284, no. 2 (February 2001): 46–51, <https://doi.org/10.1038/scientificamerican0201-46>.

<sup>66</sup> Sandra Postel, *Last Oasis: Facing Water Scarcity* (New York, NY: W. W. Norton & Company, 1992), 166.

<sup>67</sup> Postel, 155.

<sup>68</sup> Postel, 168.

<sup>69</sup> Postel, 99.

<sup>70</sup> Pearce, *When the Rivers Run Dry*, 24.

<sup>71</sup> J. R. Julius, “Rainwater Harvesting (RWH)—A Review,” *Innovative Journal of Research and Development* 2, no. 5 (2013): 926.

<sup>72</sup> Pearce, *When the Rivers Run Dry*, 308.

<sup>73</sup> Pearce, 307.

<sup>74</sup> Rijsberman, “Water Scarcity,” 11.

regard include effective involvement of users in water management; making the water a tradable commodity by increasing its price; and establishing river basin authorities to integrate the efforts of the disjointed government agencies responsible for a hydrological defined area. When water becomes increasingly scarce, J. Keller et al. propose three stages for development of a basin—boosting supply through infrastructure; conservation and efficiency of use; and water re-allocation among users, ostensibly from low to high value use.<sup>75</sup>

#### **D. POTENTIAL EXPLANATIONS AND HYPOTHESES**

This thesis hypothesizes first that water scarcity in Pakistan is not a fiction, and second that it is the poor management, insufficient storage, irrational distribution, and wrong patterns of consumption that are making it into a crisis. There is every hope that Pakistan can successfully cope with water scarcity through better management, improved irrigation efficiency, sufficient storage, and conservation of the available water resources. This thesis aspires to contribute to the resolution of this pressing crisis in Pakistan.

#### **E. RESEARCH DESIGN**

This thesis attempts to answer the question by breaking the issue into different elements. The first element is to determine whether Pakistan is running out of water. This part takes stock of the total water and land resources of the country, discusses the Indus Basin and related water infrastructure, and offers a brief history of the Indus Water Treaty. The second element determines how efficiently Pakistan uses its water and the degree to which the avoidable losses of water contribute to its scarcity in the country. This is done by examining supply and delivery, storage capacity, consumption and exploitation patterns, water usage efficiency, governance and administration of the water sector, and other similar aspects. The third element determines what Pakistan can do to cope with the water scarcity by implementing and adopting certain conservation measures and techniques and by abandoning the wasteful and inefficient practices.

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<sup>75</sup> J. Keller et al., “River Basin Development Phases and Implications of Closure,” *Journal of Applied Irrigation Science* 33, no. No. 2 (1998): 145–63.

For the purpose of research, the thesis uses a variety of sources including scholarly journals, articles, policy papers available openly, books, reports, and openly available publications related to the issue.

## **F. THESIS OVERVIEW AND CHAPTER OUTLINE**

This thesis is divided into four chapters. Chapter II covers the land and water resources—precipitation, glaciers, surface and groundwater—and the Indus River System, including the mighty Indus and its tributaries, the Indus Water Treaty (IWT) 1960, Indus Basin Irrigation System (IBIS), water storage capacity, and other challenges of water management in the Indus basin. Chapter III discusses storage, supply, distribution, delivery, consumption patterns, administration/governance, and other aspects related to water to determine the gaps and inefficient practices that result in huge water losses. This chapter also explicates the nature of the problems with intrinsic indicators suggesting what is avoidable and curable and what is not. Chapter IV recommends measures that Pakistan must take to cope successfully with the water scarcity it currently faces.

## II. PAKISTAN'S WATER RESOURCES AND INFRASTRUCTURE—KEY FACTS

“Water is the basis of life, and our stewardship of it will determine not only the quality but the staying power of human societies.”

—Sandra Postel, *Last Oasis*

Like its diversity of landscape, Pakistan has diverse sources of water—precipitation, glaciers, surface water, and groundwater. Despite having sufficient resources, however, the country is challenged by water shortages—in terms of water availability per person—due to the huge growth in population, currently nearly 210 million, which is an almost seven-fold increase since its independence in 1947.<sup>76</sup> Moreover, there is a great seasonality and variability in precipitation from one area to the other area, from one year to another year, and even within the same calendar year. Climate change, likely to make floods and droughts more common, will add to this variability. Pakistan inherited a well-established irrigation system from the British, expanded it, resolved water issues with India soon after partition and, today, claims to have the largest contiguous irrigation system in the world. This chapter gives an overview of Pakistan's land and water resources and of the broad contours of the Indus Basin Irrigation System (IBIS) to ascertain the severity of water scarcity, in the physical sense, in the country.

### A. LAND RESOURCES OF PAKISTAN

Located south of the great mountain ranges of the Himalayas, Karakoram and Hindu Kush, Pakistan spans an area of 796,095 square kilometers.<sup>77</sup> Bordered by India to the east, China to the northeast, Afghanistan to the northwest, Iran to the west, and the Indian Ocean to the south, Pakistan has a unique blend of landscapes—plains, deserts, high mountains, and coastal areas—as shown in Figure 1.

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<sup>76</sup> Willian Young et al., *Pakistan: Getting More from Water* (Washington, DC: World Bank Group's Water Global Practice, 2019), ix, <http://documents.worldbank.org/curated/en/251191548275645649/Pakistan-Getting-More-from-Water>.

<sup>77</sup> Khalid and Begum, “Hydro Politics in Pakistan,” 8.

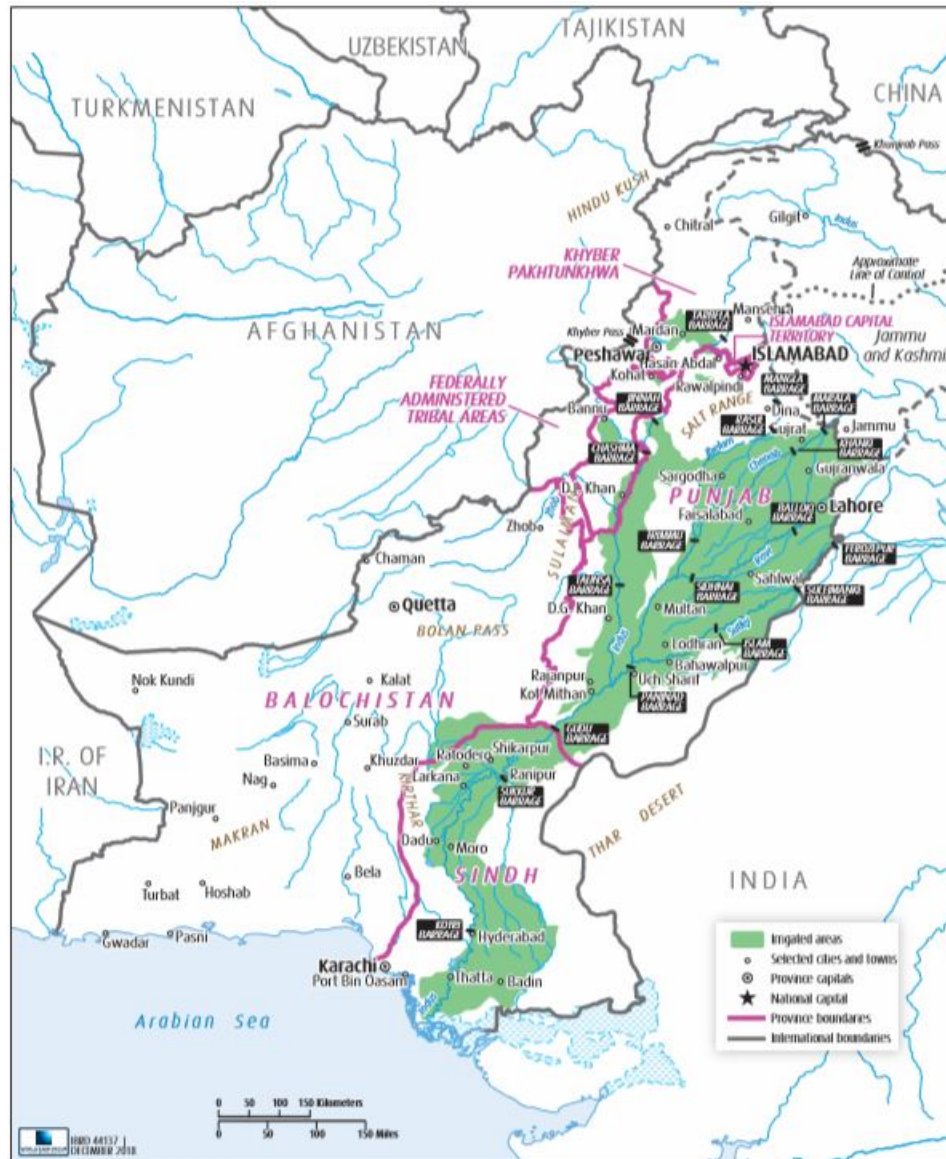


Figure 1. Map of Pakistan<sup>78</sup>

According to Shahid Ahmad, the geographical area of Pakistan, excluding the northern areas, is 79.61 million hectares (mha). Some 72 percent (57.07 mha) of this land has been surveyed while the remaining 28 percent has not been surveyed for land use classification. The surveyed area comprises 22.05 mha of cultivated area, 8.12 mha of culturable waste, 4.02 mha of forest area, and 22.88 mha that is not available for

<sup>78</sup> Source: Young et al., *Pakistan: Getting More from Water*, 4.

cultivation.<sup>79</sup> Table 1 shows the land resources of Pakistan and its classification based on usage.

Table 1. Land Resources Classification of Pakistan<sup>80</sup>

| Type of Land Use                   | Area  |        |
|------------------------------------|-------|--------|
|                                    | (mha) | (%)    |
| Geographical Area                  | 79.61 | 100.00 |
| Total Reported Area                | 57.07 | 71.7   |
| Area Cultivated for Agriculture    | 22.07 | 27.7   |
| Forest Area                        | 4.02  | 5.1    |
| Culturable Waste                   | 8.12  | 10.2   |
| Area Not Available for Cultivation | 22.88 | 28.7   |

## B. WATER RESOURCES OF PAKISTAN

According to estimates, only 16 countries have more water than Pakistan—but as the sixth-most populous country in the world, Pakistan’s per-person water availability is so low that only 10 percent of the world’s population lives with lower water availability per capita.<sup>81</sup> Pakistan comprises three hydrologic units: with 92 percent of the total water resources in the Indus Basin, the remaining 8 percent of the water resources are located in the other two units—the Kharan Desert system, and the Makran coastal drainage.<sup>82</sup> The geography of Pakistan allows very little inter-basin transfer of water for technical and

<sup>79</sup> Shahid Ahmad, “Land and Water Resources of Pakistan—A Critical Assessment,” *The Pakistan Development Review* 46, no. 4 (2007): 911, <http://www.jstor.org/stable/41261204>.

<sup>80</sup> Source: Ahmad, 911.

<sup>81</sup> Young et al., *Pakistan: Getting More from Water*, xv.

<sup>82</sup> Young et al., 3.

economic reasons.<sup>83</sup> Necessarily rough estimates put the total renewable water resources of the country at 229 BCM.<sup>84</sup> Table 2 shows annual renewable water resources of Pakistan.

Table 2. Pakistan's Annual Renewable Water Resources<sup>85</sup>

| <b>Basin</b>                                           | <b>BCM</b>   |
|--------------------------------------------------------|--------------|
| <b>Indus Basin</b>                                     |              |
| <b>External</b>                                        |              |
| Indus (including Kabul river), Jhelum, Chenab          | 170.5        |
| Ravi, Beas, Sutlej (eastern rivers allocated to India) | 3.3          |
| <b>Internal</b>                                        |              |
| Surface runoff                                         | 32.6         |
| Groundwater rainfall recharge                          | 12.7         |
| <b>Total</b>                                           | 219.1        |
| <b>Kharan Desert</b>                                   |              |
| Surface runoff                                         | 5.5          |
| Groundwater rainfall recharge                          | 0.7          |
| <b>Total</b>                                           | 6.2          |
| <b>Makran Coast</b>                                    |              |
| Surface runoff                                         | 2.9          |
| Groundwater rainfall recharge                          | 0.6          |
| <b>Total</b>                                           | 3.5          |
| <b>Grand Total</b>                                     | <b>228.8</b> |

These water totals include water in the Indus Basin that is generated both within and outside the country, the flows from the eastern rivers (Ravi, Sutlej, and Beas allocated to India according to Indus Water Treaty of 1960), and the water generated in Balochistan

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<sup>83</sup> Young et al., 3.

<sup>84</sup> Young et al., 3.

<sup>85</sup> Source: Young et al., 5.

(the Kharan system and Makran drainage).<sup>86</sup> The renewable water resources of Pakistan do not include glaciers and snow deposits, an important water resource asset that acts as reservoir and contributes enormously to the flow in the Indus river.

The World Bank Group’s Water Global Practice, in its paper titled “Pakistan: Getting More from Water,” claims that “Pakistan is commonly considered to be both water scarce (low water availability per capita) and water stressed (high water withdrawals relative to water availability).”<sup>87</sup> Nonetheless, the group claims such assumptions overlook two important aspects—first, the 24 percent of water resources generated internally are ignored; and second, the total withdrawals are exaggerated by essentially double-counting the groundwater<sup>88</sup> as “much of the groundwater is simply surface water withdrawals that seep from canals, distributaries, and fields into the aquifers.”<sup>89</sup> While different estimates put the withdrawal at 74 percent to 80 percent of the total available water, the group claims that “adjusting for the double counting inherent in the withdrawal total, however, indicates a less alarming stress level of 59 percent” and that “Pakistan is indeed ‘water stressed,’ but perhaps less so than typically assumed.”<sup>90</sup> Table 3 shows average annual water withdrawal in Pakistan.

Table 3. Average Annual Water Withdrawal<sup>91</sup>

|                 | <b>Water Withdrawal<br/>(BCM)</b> | <b>Remarks</b> |
|-----------------|-----------------------------------|----------------|
| Canals          | 122                               |                |
| Groundwater     | 62                                |                |
| Total           | 184 of 228.8                      | 80 Percent     |
| Double Counting | 48                                |                |
| Net Withdrawal  | 136 of 228.8                      | 59 Percent     |

<sup>86</sup> Young et al., 3,4.

<sup>87</sup> Young et al., 5.

<sup>88</sup> Young et al., 5,6.

<sup>89</sup> Young et al., xvii.

<sup>90</sup> Young et al., 6.

<sup>91</sup> Adapted from Young et al., 5.

The total water resources of a country can be broadly divided in four categories: precipitation, glaciers and snow deposits, surface water resources, and underground water resources.

## **1. Precipitation**

The amount of precipitation greatly varies in Pakistan from area to area and season to season. While some areas, such as parts of Balochistan and Sindh provinces, receive less than 100 mm a year, others, such as northern mountains, receive more than 1,500 mm during the same period.<sup>92</sup> According to the National Water Policy of Pakistan 2018, on a broader scale, “The mean annual precipitation ranges from less than 100 mm in parts of the Lower Indus Plain to over 750 mm near the foothills in the Upper Indus Plain.”<sup>93</sup> In the glaciated zone in the northern areas, the snow fall exceeds 5,000 mm, adding immensely to the country’s water resources.<sup>94</sup>

As mentioned previously, there is a great seasonality in the precipitation. The country receives most of its rains during the Western Disturbances (December–March) and Monsoon seasons (July–September).<sup>95</sup> The rainfall in Rabi (winter), the cropping season that generally lasts from October to March, varies from 50 millimeters in Sindh province to 500 millimeters in Khyber Pakhtunkhwa (KPK) province while rainfall in Kharif (summer), the cropping season that generally lasts from April to September, varies from 50 millimeters in Balochistan to 800 millimeters in the northern Punjab and KPK.<sup>96</sup>

The rainfall varies and gradually decreases as one moves from north and northeast to the south of the country.<sup>97</sup> The variability in seasonal rainfall impacts the river flows directly with more flows during Kharif than Rabi. Due to an irregular pattern and high

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<sup>92</sup> Ahmad, “Land and Water Resources of Pakistan—A Critical Assessment,” 911.

<sup>93</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 32.

<sup>94</sup> Ahmad, “Land and Water Resources of Pakistan—A Critical Assessment,” 911.

<sup>95</sup> Enum Naseer, *Pakistan’s Water Crisis Special Report* (Lahore: Spearhead Research, 2013), 8.

<sup>96</sup> Ahmad, “Land and Water Resources of Pakistan—A Critical Assessment,” 912.

<sup>97</sup> Ayaz Ahmed, Henna Iftikhar, and GM Chaudhry, “Water Resources and Conservation Strategy of Pakistan,” *The Pakistan Development Review* 46, no. 4: Part II (Winter 2007): 998.

intensity of downpour, especially during monsoons, most of the rainwater goes wasted without an economic benefit, causing destruction and miseries to the people living along rivers.<sup>98</sup> Rainwater contribution accounts for roughly 13 percent of mean annual canal diversions. Ninety-two percent of Pakistan's areas are classified as semi-arid to arid due to higher aridity and water shortage.<sup>99</sup>

According to the World Bank report in 2005, "there are strong indications that climate change is likely to affect Pakistan in a number of ways."<sup>100</sup> First, it is apt to affect western glaciers of the Himalayas, which act as reservoir for the Indus. A glacial retreat and torrential rainfall in the initial few decades may increase flows in the rivers and cause flooding, which will be followed by a substantial decrease of 30 percent to 40 percent in the rivers after the glacial reservoirs become empty during the next few decades.<sup>101</sup> Climate change also is likely to intensify the variability of the already variable patterns of rainfall in the region; the report claims that "while the exact shape of the future climate regime is uncertain, it is very likely that there will be greater variability—both of droughts and floods."<sup>102</sup> The monsoonal zone of Pakistan has shifted by almost 100 kilometers northwest, which may result in rains in northwestern parts of the country and may cause floods in the Indus and Kabul rivers.<sup>103</sup> The National Water Policy of Pakistan also acknowledges that Pakistan is located in the heat surplus zone and as such is extremely vulnerable to "increase in frequency and intensity of extreme weather events and erratic monsoon rains."<sup>104</sup>

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<sup>98</sup> M.A. Kahlowan and Abdul Majeed, *Water Resources Situation in Pakistan: Challenges and Future Strategies*, COMSATS' Series of Publications on Science and Technology 3 (Islamabad, 2003), 25.

<sup>99</sup> Ahmad, "Land and Water Resources of Pakistan—A Critical Assessment," 912.

<sup>100</sup> Briscoe and Qamar, *Pakistan's Water Economy*, 26.

<sup>101</sup> Briscoe and Qamar, 26–28.

<sup>102</sup> Briscoe and Qamar, 28.

<sup>103</sup> Water Sector Task Force, *A Productive and Water-Secure Pakistan: Infrastructure, Institutions, Strategy* (Islamabad: Friends of Democratic Pakistan, 2012), a4–2.

<sup>104</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 4.

## 2. Glaciers and Snow Deposits

The perennial glaciers of Pakistan's northern areas (NA) are huge with more than 100 glaciers over 10 kilometers long, many stretching beyond 50 kilometers.<sup>105</sup> The glaciers and seasonal snow are huge reservoirs for freshwater and contribute immensely to the flow of the Indus river.<sup>106</sup> Four of the fourteen 8,000-meter mountain peaks, including K-2, are situated in these areas of Pakistan. The ice reserves in the glaciated areas of the northern areas and KPK are the largest frozen resources in the country, estimated to be about 2,738 cubic kilometers (billion cubic meter), which is roughly 16 times the average flows in the rivers yearly.<sup>107</sup> According to Ayaz Ahmed et al., "There are more glaciers in Pakistan than any other land, except North and South Poles."<sup>108</sup> These glaciers are natural regulator of water supplies and serve as an important resource that feeds the rivers.

## 3. Surface Water Resources

According to Daanish Mustafa, "Just as Egypt has been described as a gift of the Nile, the bustling ancient cultures of northwestern South Asia and present-day Pakistan and northwestern India can be described as the gift of the Indus."<sup>109</sup> The Indus River and its tributaries constitute the surface-water resources of Pakistan. With 2,900 kilometers in length, the Indus River drains about 966,000 square kilometers area.<sup>110</sup> The Indus Water Treaty accorded the right of use of water of the three eastern rivers—Sutlej, Beas, and Ravi—to India and three western rivers—Chenab, Jhelum, and Indus—to Pakistan.<sup>111</sup> The Indus is also joined by three minor tributaries—Soan, Harro, and Siran—on the eastern

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<sup>105</sup> Ahmad, "Land and Water Resources of Pakistan—A Critical Assessment," 912.

<sup>106</sup> Ahmad, 912.

<sup>107</sup> Ahmad, 912.

<sup>108</sup> Ahmed, Iftikhar, and Chaudhry, "Water Resources and Conservation Strategy of Pakistan," 999.

<sup>109</sup> Daanish Mustafa, *Hydro-Politics in Pakistan's Indus Basin* (Washington, DC: United States Institute of Peace, 2010), 2, [https://www.usip.org/sites/default/files/SR261%20-%20Hydropolitics\\_in\\_Pakistan's%20\\_Indus\\_Basin.pdf](https://www.usip.org/sites/default/files/SR261%20-%20Hydropolitics_in_Pakistan's%20_Indus_Basin.pdf).

<sup>110</sup> Kahlow and Majeed, *Water Resources Situation in Pakistan: Challenges and Future Strategies*, 23.

<sup>111</sup> Kahlow and Majeed, 24.

side and by a number of minor tributaries on the western side, with the River Kabul as the biggest among them.<sup>112</sup>

The river flows are constituted of glacier and snow melt, rainfall, and runoff. While the flows differ from river to river, they all generally rise in spring and summers. The melting of snow and monsoon rains result in peak discharges into the rivers in July and August.<sup>113</sup> Similarly, in the winter months, especially November to February, the rivers flow at their minimum.<sup>114</sup> There are many seasonal streams with flows mainly dependent on rainfall. In the pre-storage period, 1937–1967, the average flow in the western rivers (Chenab, Jhelum, and Indus) was 173 BCM, with an additional contribution of 26 BCM by eastern rivers (Sutlej, Beas, and Ravi) annually.<sup>115</sup> In the post storage period—after 1967 until 2006–2007—the western rivers have provided 168 BCM of water annually—approximately 3 percent less than the pre-storage period.<sup>116</sup>

“Pre-storage” refers to the time when there was no storage capacity on the Indus River and its tributaries; the post-storage period arrived after Mangla and Tarbela reservoirs were built in the 1960s and 1970s as part of Indus Water Treaty replacement works. During this period, the contribution of the eastern rivers has only been 8.6 BCM of water annually, showing that the contribution reduced from 26 BCM to 8.6 BCM annually.<sup>117</sup> The contribution from eastern rivers has recently declined further to almost 3 BCM, as indicated in Table 2, due to developments on these rivers on the Indian side. Kaiser Bengali notes that there has been a declining water availability in the Indus and its tributaries. Bengali writes that while the average flows for 1978–2008 were 140 MAF (173 BCM), the average flow from 1998 to 2008 was 128.52 MAF (158.5 BCM).<sup>118</sup> As compared to the Rabi, flows in the rivers have been five times greater in Kharif due to

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<sup>112</sup> Kahlown and Majeed, 23.

<sup>113</sup> Kahlown and Majeed, 23.

<sup>114</sup> Kahlown and Majeed, 23.

<sup>115</sup> Ahmad, “Land and Water Resources of Pakistan—A Critical Assessment,” 912.

<sup>116</sup> Ahmad, 912.

<sup>117</sup> Ahmad, 912.

<sup>118</sup> Michael Kugelman, and Robert M. Hathaway, eds., *Running on Empty: Pakistan’s Water Crisis* (Washington, D.C: Woodrow Wilson International Center for Scholars, 2009), 48.

heavy rainfall in monsoons and more snowmelt due to high temperatures in the spring and summer.<sup>119</sup> It is important to note that the figures quoted by different writers slightly vary from the data in Table 2 and among themselves due to the lack of accurate and robust water accounting means. According to Ahmad, this “variability in river flows is a major limitation in the development of run-of-river type irrigated agriculture in the Indus Basin, especially to meet crop irrigation requirement during low-flow period of the Rabi and early and late Kharif seasons.”<sup>120</sup>

#### **4. Groundwater Resources**

The Indus groundwater aquifer is huge, covering about 16.7 mha of gross command area—the area that can be economically irrigated without limitations on the quantity of available water. The existing hydrological equilibrium in the Indus Basin was disturbed when the water level rose as a result of percolation to the aquifer after development of the canal irrigation system.<sup>121</sup> The groundwater reservoir of freshwater is approximately 2,000 BCM, “which is equal to 10 times the mean annual river flows.”<sup>122</sup> Currently about 67.8 BCM of water is pumped out by 1 million tube wells for irrigation purposes.<sup>123</sup> The National Water Policy of Pakistan, however, considers such huge extraction of water as over-mining and warns of negative impacts.<sup>124</sup> Ahmad, however, claims that an almost equal quantity, approximately 67.9 BCM of water is recharged to the groundwater in the basin annually. The underground aquifer, overused as a result of excessive pumping during dry years, is recharged during wet years.<sup>125</sup> According to most estimates, the problem of over-mining is more serious in Balochistan where use of groundwater exceeds recharge.<sup>126</sup> A 2012 report of the Friends of Democratic Pakistan (FoDP), however, suggests an almost

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<sup>119</sup> Ahmad, “Land and Water Resources of Pakistan—A Critical Assessment,” 912.

<sup>120</sup> Ahmad, 914.

<sup>121</sup> Ahmad, 917.

<sup>122</sup> Ahmad, 918.

<sup>123</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 29.

<sup>124</sup> Ministry of Water Resources Government of Pakistan, 32.

<sup>125</sup> Ahmad, “Land and Water Resources of Pakistan—A Critical Assessment,” 918.

<sup>126</sup> Young et al., *Pakistan: Getting More from Water*, 36.

balance of groundwater with 74.2 BCM recharge against 74.6 BCM discharge.<sup>127</sup> The groundwater is recharged by different sources under contemporary conditions: 21 percent by rainfall, 45 percent by canal and distributary leakage, 26 percent by irrigation returns, 6 percent by river recharge, and 2 percent by return flows.<sup>128</sup>

## C. INDUS BASIN

Home to the millennia-old Harappa civilization, the Indus Basin is witness to many irrigation developments and changes.<sup>129</sup> Two major developments in the recent past have significantly affected flows in the basin: the Indus Basin Irrigation System and the Indus Water Treaty of 1960.

### 1. Indus Basin Irrigation System

The roots of the ancient Indus civilization lie in the irrigated agriculture.<sup>130</sup> The Indus Basin Irrigation System, the lifeblood of the Pakistan's economy, is a tribute to the British irrigation experts who modeled its original system almost a century before the partition of the subcontinent and also to the Pakistani irrigation experts who added to the infrastructure that Pakistan inherited.<sup>131</sup> IBIS, according to Asad Sarwar Qureshi, is a “gravity run system with minimum management and operational requirements.”<sup>132</sup> Before the introduction of IBIS in the middle of 19th century, irrigation was through inundation canals, which were useful only during periods of high river flows.<sup>133</sup> While there was

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<sup>127</sup> Water Sector Task Force, *A Productive and Water-Secure Pakistan: Infrastructure, Institutions, Strategy*, a3-3.

<sup>128</sup> Young et al., *Pakistan: Getting More from Water*, 36.

<sup>129</sup> Winston Yang Yu Yi-Chen Savitsky, Andre Alford, Donald Brown, Casey Wescoat, James Debowicz, Dario Robinson, Sherman, *The Indus Basin of Pakistan, Directions in Development—Countries and Regions* (Washington, DC: The World Bank, 2013), 17, <https://doi.org/10.1596/978-0-8213-9874-6>.

<sup>130</sup> Karen Frenken, *Irrigation in Southern and Eastern Asia in Figures-AQUASTAT Survey—2011*, FAO Water Reports 37 (Rome: Food and Agriculture Organization of the United Nations, 2012), 383, <http://www.fao.org/docrep/016/i2809e/i2809e.pdf>.

<sup>131</sup> Shahid Amjad Chaudhry, “Pakistan: Indus Basin Water Strategy—Past, Present and Future,” *The Lahore Journal of Economics* 15 (2010): 187.

<sup>132</sup> Asad Sarwar Qureshi et al., “Challenges and Prospects of Sustainable Groundwater Management in the Indus Basin, Pakistan,” *Water Resources Management* 24, no. 8 (June 2010): 1552, <https://doi.org/10.1007/s11269-009-9513-3>.

<sup>133</sup> Frenken, *Irrigation in Southern and Eastern Asia in Figures-AQUASTAT Survey—2011*, 383.

sufficient water for the Kharif (summer) crop, the Rabi (winter) crop was mostly dependent on the residual moisture only.<sup>134</sup> The present day system of canal irrigation development began in the mid-19th century. Upper Bari Doab Canal (UBDC) from Madhopur headworks on the river Ravi was completed in 1859 and the Sirhind canal from Rupar headworks on Sutlej in 1872 (both now in India). These canals were followed by Sidhnai canal, Lower Chenab canal, and Lower Jhelum canal from the Ravi, Chenab, and Jhelum rivers in 1886, 1892, and 1901, respectively. Between 1885 to 1914, canals on the river Swat and the Paharpur canals in Khyber Pakhtunkhwa were also completed.

In the early 20th century, a mismatch was observed between the potential irrigable lands and water resources of individual rivers. Ravi was low in supply for the lands it irrigated while Jhelum and Chenab had surplus water. The surplus water of the Jhelum and Chenab rivers was transferred to the Ravi River through the Triple Canal Project during 1907 to 1915—an irrigation marvel and innovation that provided a model for the resolution of a water dispute between Pakistan and India in 1960.<sup>135</sup> By 1933, four barrages and two canals at Sutlej, Sukkar barrage and its system of seven canals, were completed.<sup>136</sup> Similarly, Haveli and Rangpur canals from Trimmu headworks and Thal canal from Kalabagh headworks on the Chenab and Indus Rivers, respectively, were completed in 1939 and 1947.<sup>137</sup> Barrages had very little storage capacity and were primarily meant to divert river water into canals.<sup>138</sup> On the eve of partition in 1947, work on different projects including barrages and canals was still in progress, in both present day Pakistan and India.

The boundary line, at the time of partition, between the two newly created states of Pakistan and India was drawn without any concern for the irrigation system, which resulted in serious disputes over water.<sup>139</sup> Pakistan continued work on its infrastructure, which was under progress at the time of independence, including the barrages at Kotri, Taunsa, and

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<sup>134</sup> Frenken, 383.

<sup>135</sup> Frenken, 385.

<sup>136</sup> Frenken, 385.

<sup>137</sup> Frenken, 385.

<sup>138</sup> Frenken, 385.

<sup>139</sup> Khalid and Begum, “Hydro Politics in Pakistan,” 8.

Guddu; by the 1950s an elaborate irrigation system was in place that consisted of ten barrages and 35,000 miles of canals.<sup>140</sup> The average inflow to the Indus Basin between 1921 and 1946 was 167 million acre feet (206 BCM), with Ravi and Sutlej/Beas (both join in India before entering Pakistan) contributing 32.7 million acre feet, 6.4 million acre feet, and 26.3 million acre feet, respectively.<sup>141</sup> India, in April 1948, stopped water in canals taking off from Ravi, Sutlej, and Beas as headworks of these canals were located in India, giving rise to an international water dispute.<sup>142</sup>

## **2. Indus Water Treaty of 1960**

The dispute between the two newly created independent states was finally resolved in 1960. Western powers, especially the United States, mediated and the World Bank extended financial support to help realize the Indus Water Treaty (IWT) between the two countries in 1960.<sup>143</sup> According to this treaty, the three eastern rivers (Beas, Sutlej, and Ravi) were allocated to India while the three western rivers (Chenab, Jhelum, and Indus) were given to Pakistan except for some specified and limited use by India. The treaty also provided for the exchange of data on project operation, establishment of a permanent Indus commission, provisions for the resolution of difference, and so on. Pakistan was also provided financial assistance and ten years to complete the replacement work, storage facilities and inter-river transfer links to meet the needs of water in canals originating from eastern rivers by diverting water from the western rivers.<sup>144</sup> According to Mustafa, the provisions of the treaty that allows India limited use of waters of western rivers has led to many tensions between the two countries as both countries interpret the same differently. Baglihar, Kishenganga, and Wuler are a few such projects by India on these rivers to which

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<sup>140</sup> Shahid Amjad Chaudhry, "Pakistan: Indus Basin Water Strategy-Past, Present and Future," *The Lahore Journal of Economics* 15 (September 2010): 188.

<sup>141</sup> Chaudhry, 188.

<sup>142</sup> Khalid and Begum, "Hydro Politics in Pakistan," 8.

<sup>143</sup> Mustafa, *Hydro-Politics in Pakistan's Indus Basin*, 4.

<sup>144</sup> Abdul Rauf Iqbal, "Water Shortage in Pakistan-A Crisis Around the Corner," *ISSRA Papers* 2, no. 2 (2010): 5,6, [https://ndu.edu.pk/issra/issra\\_pub/articles/issra-paper/ISSRA\\_Papers\\_Vol2\\_IssueII\\_2010/01-Water-Shortage-in-Pakistan-Abdul-Rauf-Iqbal.pdf](https://ndu.edu.pk/issra/issra_pub/articles/issra-paper/ISSRA_Papers_Vol2_IssueII_2010/01-Water-Shortage-in-Pakistan-Abdul-Rauf-Iqbal.pdf).

Pakistan has been objecting vigorously.<sup>145</sup> It is believed that India's enormous future water demands may compel it to proceed with the existing projects and may even undertake similar projects in violation of the treaty. Any reduction of water inflow to Pakistan will have serious economic and security effects on Pakistan as well as on the region.<sup>146</sup>

Following the treaty, massive replacement work was undertaken to transfer 20 million acre feet (MAF) of water from the western rivers to eastern irrigation command to substitute for approximately 30 MAF given to India.<sup>147</sup> The projects—including two major dams, Mangla at Jhelum (6 MAF) and Tarbela at Indus (9 MAF), five barrages, one syphon, and eight inter-river link canals—were completed between 1960 and 1971; the Tarbela Dam started operation in 1975–1976.<sup>148</sup> According to the Food and Agriculture Organization (FAO), “as a result of these extensive developments Pakistan now possesses the world's largest contiguous irrigation system.”<sup>149</sup> FAO elaborates that IBIS comprises “three large reservoirs at Tarbela, Mangla, and Chashma, 23 barrages/headworks/siphons, 12 inter-river link canals and 45 canals commands extending for 60,800 (kilometers) with communal watercourses, farm channels, and field ditches covering another 1.6 million (kilometers) to serve over 90,000 farmer-operated watercourses.”<sup>150</sup> Barrages and weirs divert water initially into main canals, and then branch canals, distributaries, and minors.<sup>151</sup> A detailed illustration of IBIS appears in Figures 2 and 3. Figure 2 shows IBIS as it exists today while Figure 3 shows a typical command canal in the Indus Irrigation System.

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<sup>145</sup> Mustafa, *Hydro-Politics in Pakistan's Indus Basin*, 5–7.

<sup>146</sup> Iqbal, “Water Shortage in Pakistan-A Crisis Around the Corner,” 8–11.

<sup>147</sup> Chaudhry, “Pakistan: Indus Basin Water Strategy-Past, Present and Future,” 189.

<sup>148</sup> Chaudhry, 189.

<sup>149</sup> Frenken, *Irrigation in Southern and Eastern Asia in Figures-AQUASTAT Survey—2011*, 386.

<sup>150</sup> Frenken, 386.

<sup>151</sup> Frenken, 386.

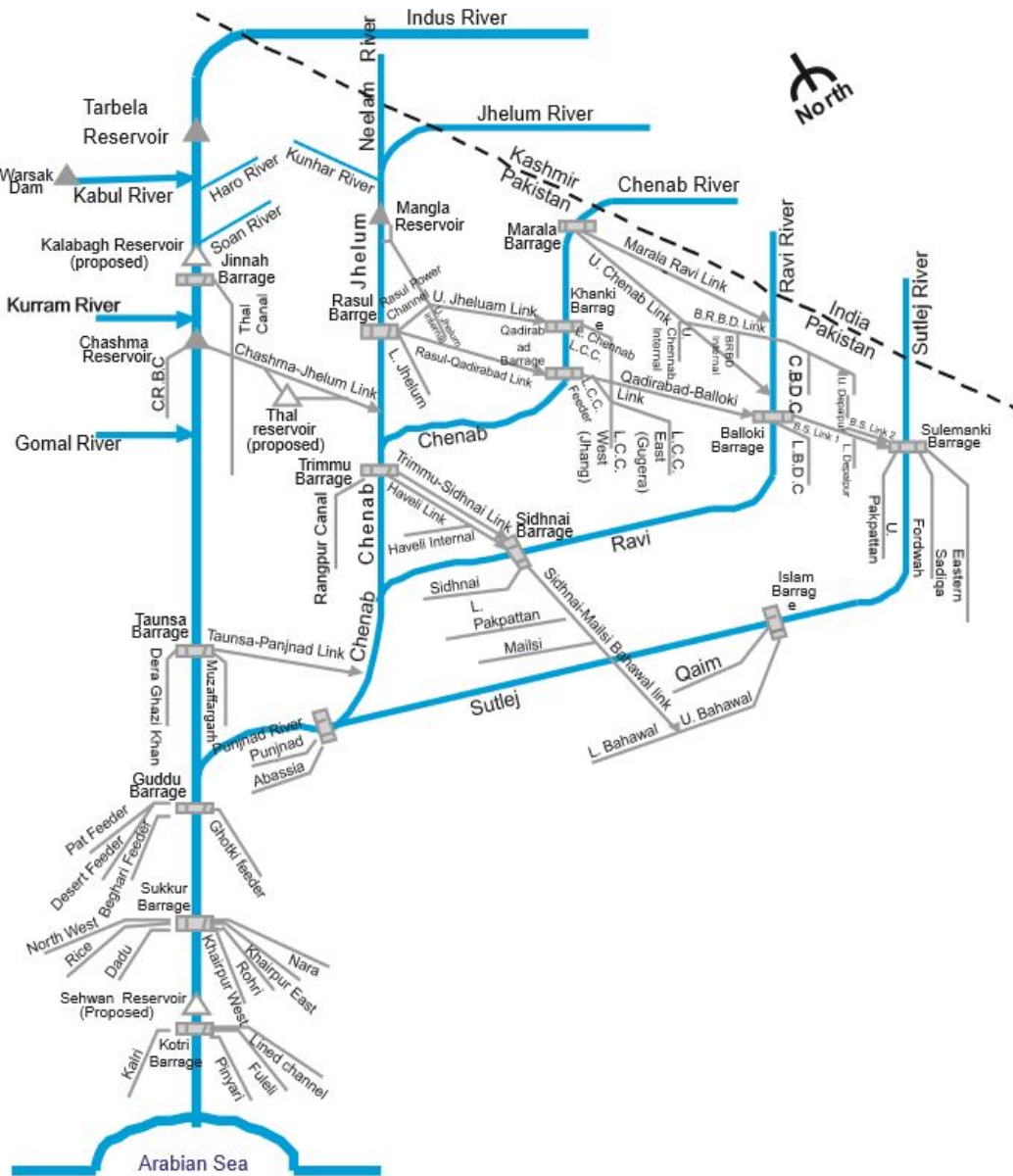


Figure 2. Indus Basin Irrigation System<sup>152</sup>

<sup>152</sup> Source: Briscoe and Qamar, *Pakistan's Water Economy*, 5.

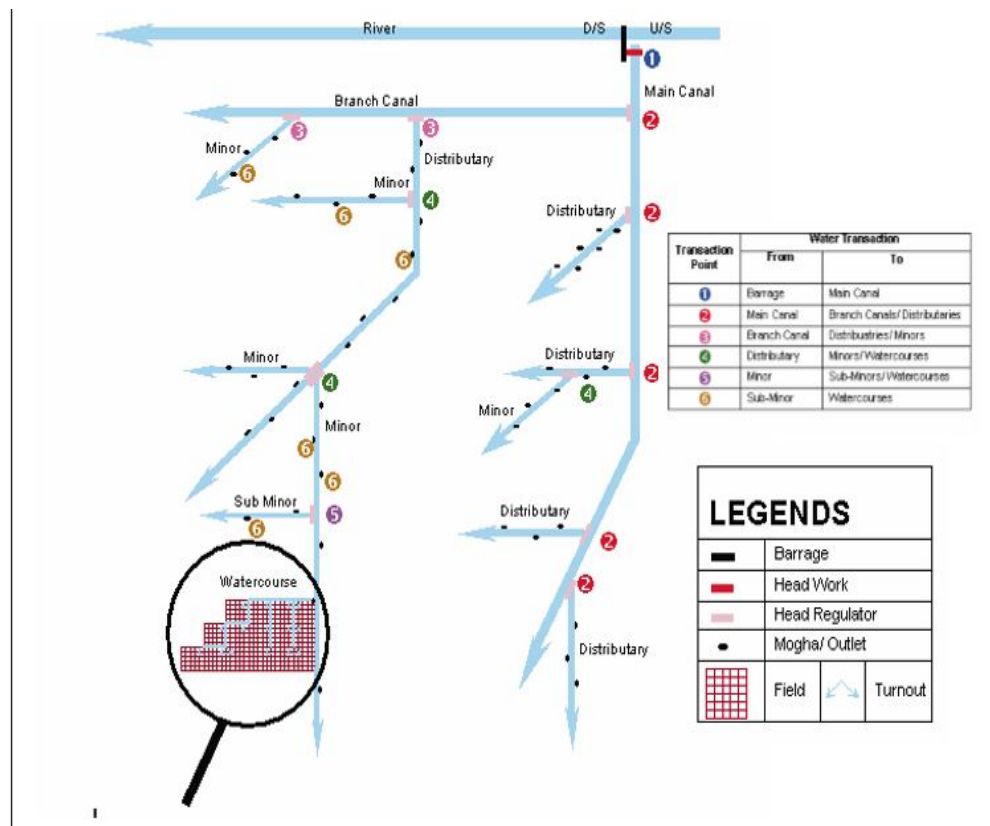


Figure 3. A Typical Command Canal in the Indus Basin Irrigation System<sup>153</sup>

According to John Briscoe and Usman Qamar, the “IWT was not a first best for either side.”<sup>154</sup> There was frustration in India about Pakistan getting 75 percent of the water and the act was considered as appeasement of Pakistan. In Pakistan, the feeling was that 75 percent allocation was unjust since 90 percent of the irrigated land was situated in Pakistan.<sup>155</sup> J. Peter Burgess et al. believe that while the IWT is a good case of peaceful international water sharing, the stress created by floods and droughts in both countries raises questions about its sustainability in future.<sup>156</sup>

<sup>153</sup> Source: Briscoe and Qamar, 6.

<sup>154</sup> Briscoe and Qamar, 9.

<sup>155</sup> Briscoe and Qamar, 38.

<sup>156</sup> J. Peter Burgess, Taylor Owen, and Uttam Kumar Sinha, “Human Securitization of Water? A Case Study of the Indus Waters Basin,” *Cambridge Review of International Affairs* 29, no. 2 (April 2, 2016): 392, <https://doi.org/10.1080/09557571.2013.799739>.

In sum, Pakistan is not water rich, but currently enough water exists to sustain the residents. This situation is apt to change drastically—and soon. The rising population is constantly adding to the water demands as availability of water per capita drops, thus adding to the scarcity—which explains why there is actually less water, even when apparently there is enough. With no additional water to inject into the system, water-intensive practices are making the effects of scarcity more pronounced, especially in combination with the growing population. So, while Pakistan is not acutely short of water in the physical sense, neither does it have an abundance of the resource to afford the luxury of mismanaging it—especially amid its escalating water demands.

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### III. PAKISTAN'S WATER RESOURCES MANAGEMENT— KEY PROBLEMS

“When the Rivers Run Dry ... the Wet Places Die.”

—Fred Pearce, *When the Rivers Run Dry*

In Pakistan, the development and management of water is a story of successes and failures—a glass that can be seen as half full as well as half empty.<sup>157</sup> While a country cannot do much about its geographical limitations and climatic changes, it cannot absolve itself of the negative effects of its own choices, actions, and inactions. Despite being blessed with a reasonable amount of water and a large contiguous irrigation system, Pakistan faces severe water shortages. The reasons are many and known—the state's apparent apathy make the matter worse.

Pakistan's water management is marred by irrational distribution and consumption patterns, system water losses, low irrigation efficiency, governance issues, poor policy choices, and so much more. Pakistan seriously lacks the storage capacity it needs, not only to store water for the dry periods, but also to mitigate the effects of the floods and droughts with which the country is well familiar. At the same time, Pakistan has a record, too, of some great achievements in dealing with its water issues. This chapter, however, discusses problems under three main areas—storage, supply, and production; exploitation and consumption; and administration/governance—that exacerbate the scarcity of water in Pakistan. Adding to the concern is the fact that most of these problems are knotted and intertwined—one having roots and links in the other—each in turn adding to the problems and augmenting the quandary. The nature of these concerns—natural as well as self-manufactured—demonstrate the gravity of the problems, the prospects for potential solutions, if any, and the contours of living and dealing with them.

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<sup>157</sup> Briscoe and Qamar, *Pakistan's Water Economy*, xiv.

## **A. PROBLEMS IN STORAGE, SUPPLY, AND PRODUCTION**

The importance of water as a resource is little realized in Pakistan, especially as reflected in the way it is stored, supplied, and blatantly misused. The fact that most of Pakistan's water is generated outside the geographical boundaries of the country leaves the state vulnerable. Moreover, the reality that India, having strained relations with Pakistan, enjoys some control over the flows as that country is upper riparian, puts Pakistan's water at additional risk of interference. Despite the variability in precipitation, seasonality in flows, and the twin facts that the existing flows are at risk of foreign interference and that no additional water can be injected into the Indus River system from other countries, the storage capacity is grossly insufficient. To make the matter worse, the existing storage is affected by sedimentation and siltation, and no worthwhile addition has been made to the existing storage capacity recently. The huge loss of water during supply/conveyance, from a barrage to the field, is another matter of serious concern. Some major issues in this regard are discussed in the following sections.

### **1. Insufficient Storage**

In comparison to most other countries of the world, Pakistan's storage capacity is insufficient for reliable irrigation. Pakistan's storage capacity of just 30 days is way too little—almost a drop in the bucket—when compared with 120–220 days of India, 500 days of South Africa, and 900 days of the United States.<sup>158</sup> Similarly, in terms of designed live storage capacity per person, availability in Pakistan is just 144 cubic meters as compared to 6,000, 5,000, and 2,200 cubic meters in the United States, Australia, and China, respectively.<sup>159</sup> According to Shahid Amjad Chaudhry, the seasonality of flows in Indus—with almost 80 percent of those flows occurring in Kharif season (summer) due to snow melt in the western Himalayas and precipitation patterns—and the Indus River having a “3 to 5 year flood and drought cycle” demands live storage for mitigation.<sup>160</sup> While the variation in summer and winter flows is about five to one, agricultural demands—more

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<sup>158</sup> Briscoe and Qamar, 63,64.

<sup>159</sup> Ahmad, “Land and Water Resources of Pakistan—A Critical Assessment,” 917.

<sup>160</sup> Chaudhry, “Pakistan: Indus Basin Water Strategy-Past, Present and Future,” 199.

than 90 percent of total available water—are two to one for the two seasons, respectively.<sup>161</sup> In light of the precipitation pattern and character of melt water flow in the basin, both of which greatly vary in summer and winter, storage of water from the glacial melt and rainwater is essential.<sup>162</sup> Qureshi mentions that Pakistan’s current storage capacity is about 15 percent of its annual river flows and concludes that with no addition to the storage capacity, Pakistan will face a significant shortfall in coming years as agriculture demands are likely to remain the same, if not to increase. Supporting Pakistan’s Water Sector Strategy estimates, Qureshi concurs that “Pakistan needs to raise its storage capacity by 22 BCM by 2025 to meet the projected requirements of 165 BCM.”<sup>163</sup>

Although dams better regulate seasonal flows and mitigate effects of floods, it is unfortunate that Pakistan has not constructed any new dams since the Tarbela Dam was built in 1976.<sup>164</sup> More worrisome is the fact that Pakistan’s dams have lost a considerable portion of their combined storage capacity to sedimentation and silting—especially Tarbela Dam, which has lost 33 percent of its gross storage in less than four decades.<sup>165</sup> D. R. Archer et al., also observe that the sedimentation is fast limiting the reservoir capacity in Pakistan; to cope with the growth in urban and industrial zones, Pakistan will have to increase its storage capacity to ensure it puts every last drop to its optimal use.<sup>166</sup> Additionally, in the Indus Basin, there is no option or source of water that can be mobilized to meet the requirements.<sup>167</sup> During a dry period, the only way to guarantee minimum flows

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<sup>161</sup> Kugelman, and Hathaway, *Running on Empty*, 68.

<sup>162</sup> A. N. Laghari, D. Vanham, and W. Rauch, “The Indus Basin in the Framework of Current and Future Water Resources Management,” *Hydrology and Earth System Sciences* 16, no. 4 (April 2, 2012): 1073, <https://doi.org/10.5194/hess-16-1063-2012>.

<sup>163</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 253–54.

<sup>164</sup> Water Sector Task Force, *A Productive and Water-Secure Pakistan: Infrastructure, Institutions, Strategy*, a6-1.

<sup>165</sup> Water Sector Task Force, a1-10.

<sup>166</sup> D. R. Archer et al., “Sustainability of Water Resources Management in the Indus Basin under Changing Climatic and Socio Economic Conditions,” *Hydrology and Earth System Sciences* 14, no. 8 (August 27, 2010): 1678, <https://doi.org/10.5194/hess-14-1669-2010>.

<sup>167</sup> Kugelman, and Hathaway, *Running on Empty*, 31.

is to have some regulatory mechanism of storage upstream.<sup>168</sup> The National Water Policy 2018, therefore, underlines the need for additional storage facilities, both large and small, and considers it essential to store surplus rainwater.<sup>169</sup>

Despite the clear benefit of dams, certain quarters including some experts, oppose construction of new dams. Michael Kugelman et al., for example, argue that dams are expensive, unproductive, and environmentally unfriendly and contend that Pakistan's problem lies in wasteful water practices.<sup>170</sup> They add that dams only store and do not produce water, and insist on water conservation and efficiency in water conveyance to places where it is most needed.<sup>171</sup> Similarly, Hassan Abbas alleges that Pakistan's problems lie in water consumption patterns; so, proper aquifer management rather than construction of huge reservoirs is the answer to the country's water woes.<sup>172</sup> The opposition to new dams also owes to inter-provincial rivalries, mistrust based on shares and delivery of water, and hydropower profits to the local people affected by such projects in the past.<sup>173</sup> Mustafa, believes that the reason for a lack of consensus on the issue of dam, especially Kalabagh Dam, are more political than technical.<sup>174</sup> In short, there are diametrically opposite views on construction of dams in Pakistan; one set of opinions favors while the other opposes it.<sup>175</sup> Nonetheless, statistics prove that Pakistan's storage capacity is grossly inadequate.

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<sup>168</sup> Simi Kamal, Pervaiz Amir, and Khalid Mohtadullah, *Development of Integrated River Basin Management (IRBM) for Indus Basin*, WWF Report Pakistan, 2012, 42, <http://waterinfo.net.pk/sites/default/files/knowledge/Development%20of%20Integrated%20River%20Basin%20Management%20%28IRBM%29%20for%20Indus%20Basin%20-%20Challenges%20and%20Opportunities%20-%20WWF%20-%202012.pdf>.

<sup>169</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 8,9.

<sup>170</sup> Kugelman, and Hathaway, *Running on Empty*, 20.

<sup>171</sup> Kugelman, and Hathaway, 61.

<sup>172</sup> Hassan Abbas, "Short of Water?," *Dawn*, June 28, 2018, <https://www.dawn.com/news/1416613>.

<sup>173</sup> Water Sector Task Force, *A Productive and Water-Secure Pakistan: Infrastructure, Institutions, Strategy*, a1-6.

<sup>174</sup> Mustafa, *Hydro-Politics in Pakistan's Indus Basin*, 9,10.

<sup>175</sup> Kugelman, and Hathaway, *Running on Empty*, 49.

## 2. Water Losses in the IBIS

There are tremendous water losses in the IBIS, which is basically a “gravity run system with minimum management and operational requirements.”<sup>176</sup> The operation of the IBIS is based on a constant supply of water rather than an actual requirement of water for a crop.<sup>177</sup> Pakistan’s extraordinarily dependence on the IBIS is no secret and the nation has invested in it immensely. Nevertheless, the system, owing to a combination of old age and ill-treatment over the years of “build/ neglect/rebuild” non-planning, is not in very good shape.<sup>178</sup> Qureshi holds that “due to deferred maintenance and lack of rehabilitation, the delivery capacity of canals is 30 percent lower than designed.”<sup>179</sup> Due to seepage and leakage, there are enormous water losses in the system and the ministry of water in Pakistan admits that “almost half of the water diverted from Indus system does make it to the farm.”<sup>180</sup> Most of the losses occur from April to July when the rivers generally rise.<sup>181</sup>

According to Ahmad, after the construction of Tarbela Dam, losses in the IBIS were around 64 percent, which accounted for 82.5 to 84 BCM; the lost water induced recharge to the underground water and resulted in installation of a huge number of tube wells for exploitation of this water.<sup>182</sup> Kugleman et al., make similar observations and add that “two-thirds is lost due to poor transmission and seepage in the canal system.”<sup>183</sup> Moreover, the irrigation users pay way too little and therefore the system does not generate the required funds for its repair and replacements.<sup>184</sup> It is not difficult to predict that in the absence of

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<sup>176</sup> Qureshi et al., “Challenges and Prospects of Sustainable Groundwater Management in the Indus Basin, Pakistan,” 1552.

<sup>177</sup> Qureshi et al., 1552.

<sup>178</sup> Briscoe and Qamar, *Pakistan’s Water Economy*, xviii.

<sup>179</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 257.

<sup>180</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 8.

<sup>181</sup> Ahmad, “Land and Water Resources of Pakistan—A Critical Assessment,” 923.

<sup>182</sup> Shahid Ahmad, *Country Report—Water Resources Development and Management in Pakistan*, n.d., 9, <https://waterinfo.net.pk/sites/default/files/knowledge/Water%20Resources%20Development%20and%20Management%20in%20Pakistan%20-%20A%20Country%20Report.pdf>.

<sup>183</sup> Kugelman, and Hathaway, *Running on Empty*, 33.

<sup>184</sup> Kugelman, and Hathaway, 31,32.

required repairs and replacement, the losses in the IBIS will increase as the time passes, thus adding to the scarcity at the consumer level.

### **3. Trans-boundary Developments**

The dispute over water between Pakistan and India was resolved as a result of IWT in 1960. According to this treaty, the three eastern rivers (Beas, Sutlej, and Ravi) were allocated to India while the three western rivers (Chenab, Jhelum, and Indus) were given to Pakistan except for some specified and limited use by India. Because each country interprets certain provisions of the treaty differently, many projects that India has undertaken, such as Baglihar, Kishenganga, and Wuler, have drawn strong objection from Pakistan, which considers the projects in violation of the treaty.<sup>185</sup> Currently, there are serious differences between the two countries over a number of such projects on the Indian side that have already affected the flows in the rivers; other planned and proposed projects are likely to further reduce the flows into Pakistan.<sup>186</sup>

Meanwhile, India is not the only neighbor whose projects have the potential to heighten Pakistan's water scarcity. The Kabul River contributes 25 BCM on average to the Indus, and construction of any storage facility by Afghanistan will certainly affect the water flows to Pakistan.<sup>187</sup> Thus, there is a constant and real danger of reduction in water flows into Pakistan from rivers entering into the country from both its neighbors unless the issues are resolved. The issues over water often leads to conflicts, especially in cases where countries face water stress and where water is considered as a matter of national security.<sup>188</sup> India, because of its enormous water demands, may undertake projects in violation of the treaty to satisfy its water needs, affecting the water flows into Pakistan and also bearing grave economic and security impacts.<sup>189</sup>

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<sup>185</sup> Mustafa, *Hydro-Politics in Pakistan's Indus Basin*, 5–7.

<sup>186</sup> Qureshi, "Water Management in the Indus Basin in Pakistan," 256,257.

<sup>187</sup> Qureshi, 256,257.

<sup>188</sup> Gleick, "Water and Conflict," 79.

<sup>189</sup> Iqbal, "Water Shortage in Pakistan-A Crisis Around the Corner," 8–11.

Climate change is another looming and real external threat to the water sector in Pakistan.<sup>190</sup> The ministry of water warns that “Pakistan is located in one of the three most vulnerable regions in the world in terms of climate change threats of increasing frequency and intensity of floods, prolonged droughts and the frightening possibility of the melting of the Himalayan Ice cap.”<sup>191</sup> Young et al. hold that as a result of climate change, floods as well as drought may become more severe as variability in inflows between and within years will increase.<sup>192</sup> Climate warming is likely to increase the water demand, in addition to demand from other factors, by 5 percent to 15 percent by the middle of the current century.<sup>193</sup>

The precipitation is likely to fall more in the form of rain than snow, and the chances of floods will increase.<sup>194</sup> The climate change will cause faster melting of the glaciers—the main reliable source of water in the Indus.<sup>195</sup> A. N. Laghari et al. contend that climate change, in the shorter term, may have positive effects by increasing the flows in rivers and negative effects in the longer term once the flows decrease considerably.<sup>196</sup> It is safe to assume that the monsoon season will become more unpredictable and floods in 2010 are a manifestation of the same.<sup>197</sup> Although climate change may not have significant effects in the near future, different studies suggest that it may exacerbate Pakistan’s problems and water security in the long term.

## **B. PROBLEMS IN EXPLOITATION AND CONSUMPTION**

Despite scarcity of water, Pakistan does not use this valuable resource judiciously. Distribution of water among user sectors is irrational and lacks correct priorities. While

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<sup>190</sup> Young et al., *Pakistan: Getting More from Water*, xvi.

<sup>191</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 3.

<sup>192</sup> Young et al., *Pakistan: Getting More from Water*, xvi.

<sup>193</sup> Young et al., xvi.

<sup>194</sup> Young et al., 103.

<sup>195</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 3.

<sup>196</sup> Laghari, Vanham, and Rauch, “The Indus Basin in the Framework of Current and Future Water Resources Management,” 1068.

<sup>197</sup> Water Sector Task Force, *A Productive and Water-Secure Pakistan: Infrastructure, Institutions, Strategy*, a6-1.

water productivity is important for all countries, it is even more important for water scarce countries. Generating a mere US\$ 1.38 per cubic meter of water withdrawn, “Pakistan ranks eighth lowest in the world.”<sup>198</sup> Pakistan’s irrigation practices are inefficient and wasteful. Under an illusion of plenty, the state as well as the people aggravate the situation and add to the crisis, the former by underpricing the resource and the latter by wasting it unknowingly as well knowingly, in some cases. Some of these issues are described in the following paragraphs.

### **1. Low Irrigation Efficiency and Incorrect Selection of Crops**

At a time when the rest of the world has embraced innovative and modern irrigation techniques and is benefitting from the marvels of the green revolution, Pakistan still uses the thousands-of-years-old flood irrigation system. For a country with a looming water crisis, this luxury is impulsive and ill-afforded. With little realization of the value of water, the country’s focus generally remains on the productivity per unit of land.<sup>199</sup> According to Muhammad Akram Kahlown et al., “in Pakistan, farmers generally apply water to unleveled bunded units, resulting in long irrigation events, poor water uniformity and over-irrigation.”<sup>200</sup> While irrigating the fields, 13–18 centimeters of water is applied in every such event which is significantly higher than the actual consumptive use.<sup>201</sup>

Most studies point toward lower crop productivity and irrigation efficiency. A World Bank report reveals that the wheat productivity in Pakistan relative to India and California is “about 5:8:10 per unit of water.”<sup>202</sup> Qureshi reports somewhat similar findings and adds that the water productivity in Pakistan is one of the lowest in the world; with wheat productivity at a mere 0.5 kilograms per cubic meter against 1.0 kilogram and 1.5

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<sup>198</sup> Young et al., *Pakistan: Getting More from Water*, xv.

<sup>199</sup> Briscoe and Qamar, *Pakistan’s Water Economy*, 30.

<sup>200</sup> Muhammad Akram Kahlown et al., “Water Use Efficiency and Economic Feasibility of Growing Rice and Wheat with Sprinkler Irrigation in the Indus Basin of Pakistan,” *Agricultural Water Management* 87, no. 3 (2007): 293.

<sup>201</sup> Kahlown et al., 293.

<sup>202</sup> Briscoe and Qamar, *Pakistan’s Water Economy*, 30.

kilograms for the same amount of water in India and California, respectively.<sup>203</sup> Similarly Muhammad Arif Watto and Amin William Mugeru find that the productivity of wheat and rice per unit of water, respectively, are 24 and 55 percent less than the global averages.<sup>204</sup> Productivity of other crops is even lower. The World Bank alleges huge losses in the flood irrigation system and finds that very little water is actually consumed as compared to the amount of water drawn for the purpose.<sup>205</sup>

The poor choice of crops contributes equally, if not more, to the low agriculture output. Kugelman et al., correctly highlight that most major crops of Pakistan are water intensive, especially rice and sugarcane.<sup>206</sup> Sugarcane requires as much as seven times more water than wheat.<sup>207</sup> Similarly, planting methods and irrigation practices, especially of rice, make conventional Pakistani agriculture even more water intensive.<sup>208</sup> Pakistan is one of the major exporters of rice in the world. Those who grow rice generally believe that to have a good yield, it requires standing water during the growing season.<sup>209</sup> Qureshi explains that transplanted rice, a practice common in Pakistan, consumes 23 percent more water than direct-seeded rice.<sup>210</sup> Similarly, Young et al., observe that “paddy rice in Pakistan uses 2.8 times the average irrigation water use across the major rice growing countries, and the evaporative water loss from rice in Pakistan is more than four times the average of the major rice growing countries.”<sup>211</sup> They note with concern that in Pakistan only 10 percent of the water is used for high value crops.<sup>212</sup>

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<sup>203</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 254.

<sup>204</sup> Muhammad Arif Watto and Amin William Mugeru, “Groundwater Depletion in the Indus Plains of Pakistan: Imperatives, Repercussions and Management Issues,” *International Journal of River Basin Management* 14, no. 4 (October 2016): 452, <https://doi.org/10.1080/15715124.2016.1204154>.

<sup>205</sup> Young et al., *Pakistan: Getting More from Water*, xv.

<sup>206</sup> Kugelman, and Hathaway, *Running on Empty*, 11.

<sup>207</sup> Kugelman, and Hathaway, 11.

<sup>208</sup> Kugelman, and Hathaway, 11.

<sup>209</sup> Kahlown et al., “Water Use Efficiency and Economic Feasibility of Growing Rice and Wheat with Sprinkler Irrigation in the Indus Basin of Pakistan,” 293.

<sup>210</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 258.

<sup>211</sup> Young et al., *Pakistan: Getting More from Water*, 92,93.

<sup>212</sup> Young et al., 94.

Water-intensive crops, especially rice and sugarcane have mainly benefited from improvements in the irrigation network and availability of water. These crops also put a strain on the groundwater resources as tube wells supply a significant amount of water, almost 70 percent, in the rice growing areas.<sup>213</sup> Pearce correctly points out that “if any country sums up the profits and perils of the overuse of water for irrigation, it is Pakistan.”<sup>214</sup>

## **2. Irrational Distribution and Consumption of Water**

The current consumption patterns of water are irrational, untenable, and adding to the water scarcity in multiple ways. Agriculture is consuming too much, well beyond its due share.<sup>215</sup> Even within the agriculture sector the sharing of water is not rational. The lion’s share of water—80 percent of the total 90 percent allocated to agriculture—is consumed by irrigated agriculture and much less by other agriculture sources such as livestock.<sup>216</sup> Yet, irrigated agriculture contributes very little to the economy—37 percent in contrast with 58 percent by livestock—to the total 20 percent share of agriculture in the economy.<sup>217</sup> Forestry, fisheries, and cotton ginning make up for the remaining value of the agricultural contribution.<sup>218</sup> The free ride in agriculture is a significant impediment, hinders innovations, and leads to choosing ill-suited varieties by farmers.<sup>219</sup> In Pakistan a lot of water is wasted in flood irrigation and there is hardly any concept of micro irrigation or any other better management techniques. As the population and economy grow, tensions will increase among different segments of agriculture as well as among different sectors,

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<sup>213</sup> Qureshi et al., “Challenges and Prospects of Sustainable Groundwater Management in the Indus Basin, Pakistan,” 1564.

<sup>214</sup> Pearce, *When the Rivers Run Dry*, 27.

<sup>215</sup> Kugelman, and Hathaway, *Running on Empty*, 89.

<sup>216</sup> Young et al., *Pakistan: Getting More from Water*, 14.

<sup>217</sup> Young et al., 14.

<sup>218</sup> Young et al., 14.

<sup>219</sup> Postel, *Last Oasis*, 168.

such as agriculture, industry, domestic and environment, as they seek their fair share of water.<sup>220</sup>

Despite obvious signs of shortages and scarcity, people waste water flagrantly, especially those who do not pay for it, by leaving taps running for various domestic chores such as laundry, car washing, dishwashing, and outdoor activities.<sup>221</sup> Water is highly underpriced in Pakistan, which not only leads to an illusion of plenty but also wasteful practices as people do not realize its true cost. The common man in Pakistan has very limited and for most part outdated information about water resources.<sup>222</sup> Because of this illusion of plenty, there is hardly any concept of re-use or recycling of wastewater in the country. Pakistan is a perfect example of what Postel said, “for many of us, water simply flows from a faucet, and we think little about it beyond this immediate point of contact.”<sup>223</sup>

### **3. Overexploitation of Groundwater**

Underground water is one of the most important components of the planet’s total water resources and should not be pumped out unless dire circumstances so warrant.<sup>224</sup> In Pakistan, however, underground water is considered as a gift of God with no restriction on its extraction.<sup>225</sup> Qureshi points out that anyone can install “a tube well anywhere in his land and extract any amount of water at any time without consideration of detrimental effects of his action on the resource and on others”<sup>226</sup> When the groundwater table rose as a result of a canal irrigation system, especially in areas of Punjab and Sindh, extraction of water through tube wells proved very useful and was encouraged to arrest the menaces of waterlogging and salinity. Unfortunately, the trend continued unchecked, and in less than

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<sup>220</sup> Young et al., *Pakistan: Getting More from Water*, 84.

<sup>221</sup> Sajjad Ashraf, *Pakistan’s Water Woes* (Singapore: National University of Singapore, n.d.), 3.

<sup>222</sup> Water Sector Task Force, *A Productive and Water-Secure Pakistan: Infrastructure, Institutions, Strategy*, a6-3.

<sup>223</sup> Postel, *Last Oasis*, 184.

<sup>224</sup> Pearce, *When the Rivers Run Dry*, 45.

<sup>225</sup> Asad Sarwar Qureshi, “Climate Change and Water Resources Management in Pakistan,” in *Climate Change and Water Resources in South Asia*, ed. M Monirul Qader Mirza and Q Ahmad (London: Taylor & Francis, 2005), 213.

<sup>226</sup> Sarwar Qureshi, 213.

five decades, the number of such tube wells rose from 10,000 in 1960 to over one million by 2007.<sup>227</sup> Statistics show that in three and half decades, from 1965 to 2000, groundwater extraction increased from 10 BCM to 69 BCM.<sup>228</sup> Currently the groundwater exploitation in Pakistan is rampant with 80 percent of it taking place in the private sector, significantly affecting the water table and accessibility to water.<sup>229</sup>

While there is little knowledge regarding techniques of recharging the aquifer, unregulated practice of water extraction has even adversely affected the groundwater quality in certain areas.<sup>230</sup> In Pakistan, according to a World Bank report, “groundwater now accounts for almost half of all irrigation requirements.”<sup>231</sup> Despite clear evidences of overexploitation of groundwater, installation of additional tube wells is a matter of concern as it is affecting the water quality by accumulating approximately 20 million tons of salt in the system each year.<sup>232</sup> If the groundwater level continues to drop at the current rate, Punjab aquifers may completely deplete in 50 to 100 years.<sup>233</sup> This is a dangerous prediction, even if only half true, as the state of groundwater and the water table in Punjab is better than in the rest of the country.

### **C. PROBLEMS IN ADMINISTRATION, GOVERNANCE, AND MANAGEMENT**

Pakistan does not use its water intelligently. The use of an inflexible old irrigation system marred by corrupt practices and inefficiencies are indicative of administrative impediments, governance failures, and incorrect priorities. Watto and Mugeru rightly claim that the water crisis in Pakistan has its “roots in unsustainable practices and institutional

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<sup>227</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 255.

<sup>228</sup> Sarwar Qureshi, “Climate Change and Water Resources Management in Pakistan,” 213.

<sup>229</sup> Sarwar Qureshi, 213.

<sup>230</sup> Water Sector Task Force, *A Productive and Water-Secure Pakistan: Infrastructure, Institutions, Strategy*, a6-1.

<sup>231</sup> Briscoe and Qamar, *Pakistan’s Water Economy*, xvi.

<sup>232</sup> Briscoe and Qamar, XVI, XVII.

<sup>233</sup> Chaudhry, “Pakistan: Indus Basin Water Strategy-Past, Present and Future,” 196.

failure.”<sup>234</sup> Some major issues concerning administration and governance are discussed in the following paragraphs.

### **1. Poor Resource Management and Delivery System**

Pakistan badly manages the water resources by following a rigid irrigation delivery system, commonly known as Warabandi—a system that emerged during British rule over the subcontinent and was “aimed to distribute the available water supplies equitably and proportional to the farm size as fixed weekly rotations.”<sup>235</sup> The water allocation in this system is based on the size of the farm, rather than the choice of the crop. The system was developed when agricultural intensity was low and water was abundant.<sup>236</sup> Now that the water is scarce and the agriculture intensity is high, continued adoption of the practice is a serious issue.

In Pakistan’s irrigation system, the water after it is released/diverted from a barrage, follows a main canal, branch canals, distributary, minor, sub-minor, and water course in the same sequence.<sup>237</sup> According to the Warabandi system, each individual farmer on his turn takes water on a specific day, regardless of requirement of quantity of water and timing of watering the crop.<sup>238</sup> Owing to flat-fee agricultural water pricing regardless of actual usage, according to Kugelman et al., “the common method is to flood the field and let the excess run off.”<sup>239</sup> Moreover, not only do the head users—those upstream—get more while the tail users—downstream—get less in this system but others, normally with more lands, can get more water by bribing the irrigation department officials.<sup>240</sup> This system, therefore, in certain cases benefits few users at the expense of others.

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<sup>234</sup> Watto and Muger, “Groundwater Depletion in the Indus Plains of Pakistan,” 451.

<sup>235</sup> Watto and Muger, 448.

<sup>236</sup> Watto and Muger, 449.

<sup>237</sup> Kugelman, and Hathaway, *Running on Empty*, 92.

<sup>238</sup> Kugelman, and Hathaway, 92.

<sup>239</sup> Kugelman, and Hathaway, 93.

<sup>240</sup> Kugelman, and Hathaway, 93.

Over the years, priority in Pakistan has been based on supply management rather than demand management. Being a highly subsidized commodity, the value of water is not realized by the users and, therefore, is a major impediment in shifting to demand management.<sup>241</sup> Almost every year, Kugelman et al., note that there is a crisis like situation as the “water demand exceeds supply,” often leading to excessive withdrawals from reservoirs, causing them to reach dead-level.<sup>242</sup> This poor management of the resource often leads to pumping of 55 MAF groundwater through the tube wells, which is more than the water available from canals, to meet the cropping requirements.<sup>243</sup> In the face of the forecasted population growth, it is estimated that the water supplies will have to grow by almost 10 percent every year to meet the food requirement.<sup>244</sup> The fact that there is no additional water available and that the food needs have to be satisfied, it is clear the poor demand management will make the situation even more precarious.

## **2. Poor Governance and Water Accounting System**

Different institutions dealing with water management at different levels are not only complicated but also lack coordination, consequently having numerous negative impacts.<sup>245</sup> According to the World Bank report, Pakistan’s water management is done in a non-transparent manner that is based on monopolies, individual discretions, and corrupt practices and often result in “inequitable distribution of water, poor technical performance, and a pervasive environment of mistrust and conflict from the provincial level to the water course.”<sup>246</sup> The report adds that the infrastructure is grossly inadequate for “collection, storage, sharing, and analysis of hydro-meteorological data and information.”<sup>247</sup> There are no robust water accounting means, resulting not only in incorrect and erroneous water data but also to faulty planning.

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<sup>241</sup> Chaudhry, “Integrated Water Resources Management in Pakistan,” 21.

<sup>242</sup> Kugelman, and Hathaway, *Running on Empty*, 47.

<sup>243</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 3.

<sup>244</sup> Watto and Muger, “Groundwater Depletion in the Indus Plains of Pakistan,” 450.

<sup>245</sup> Watto and Muger, 451.

<sup>246</sup> Briscoe and Qamar, *Pakistan’s Water Economy*, XIX.

<sup>247</sup> Briscoe and Qamar, xix.

The duplication of effort, as well as a lack of clear legal mandates and clarity about roles make these institutions ineffective.<sup>248</sup> Citizens have almost no role in the collection or analysis of water data—a practice that is otherwise encouraged world over and could be very useful in the case of Pakistan, especially for improved groundwater management.<sup>249</sup> Despite several public sector institutions, academic and research institutions, and national organizations, there is no single regulatory framework at the national level that deals with groundwater and its use.<sup>250</sup>

What is most alarming is the government's response to reforming this non-system.<sup>251</sup> Similarly, there is no regulatory framework to prevent water wastage and no proper check on the release of industrial and household pollutants and waste that contaminate the water sources.<sup>252</sup> The administrative vacuums, governance failures, and the perpetual attitude of shying away from these realities has worsened the water situation and will aggravate it further as the resource gets scarcer and users grow in number.

### **3. No Drought–Flood Management**

While not a stranger to floods or droughts, Pakistan does not have a well-defined mechanism in place for managing either. History proves that floods have been not only the most frequent but also the most damaging natural hazard in Pakistan. In its short history, Pakistan has seen over 30 floods affecting large populations—the flood in 2010 alone affected 20 million people.<sup>253</sup> Pakistan lacks robust flood forecasting measures that can timely and accurately predict floods<sup>254</sup> as well as mitigating measures, such as reservoirs<sup>255</sup> and the floods thus result in destruction of all the infrastructure that comes in the flood

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<sup>248</sup> Young et al., *Pakistan: Getting More from Water*, 59.

<sup>249</sup> Young et al., 60.

<sup>250</sup> Watto and Muger, "Groundwater Depletion in the Indus Plains of Pakistan," 451.

<sup>251</sup> Watto and Muger, 451.

<sup>252</sup> Ashraf, *Pakistan's Water Woes*, 3.

<sup>253</sup> Young et al., *Pakistan: Getting More from Water*, 20.

<sup>254</sup> Young et al., 19.

<sup>255</sup> Water Sector Task Force, *A Productive and Water-Secure Pakistan: Infrastructure, Institutions, Strategy*, a1-11.

waters' way to the sea. Damages to infrastructure result in water losses even when the floods are over.

To sum up, it can be said that despite inaction and apparent apathy about adding to the storage capacity, there is, at least, some realization in Pakistan about storage insufficiency. Many believe, and rightly so, that Pakistan needs to increase the storage capacity; however, what these supporters get wrong is the assumption that additional storage will solve all Pakistan's water security problems. What is more dangerous is the lack of realization that Pakistan badly manages its water. Few people know that the current crisis is due more to bad management and wasteful practices than to the lack of dams.

Pakistan does not handle water intelligently, and the years of neglect have put the system at risk. The issues discussed in this chapter are closely intertwined, one having roots in the other. The biggest issue is that everyone appears to have a role in this crisis: the state for its indifference and apathy, the individual for holding illusions of plenty and engaging in wasteful practices. But despite all this, there are signs of hope as well. The fact that so much water is wasted due to wrong choices, inaction, and government mismanagement demonstrate a hidden hope and silver lining as well. Humans can, after all, undo previous wrongs and make the right decisions.

## **IV. RECOMMENDATIONS AND CONCLUSION**

“Let it not be said that we did not prove equal to the task.”

—Muhammad Ali Jinnah, October 1947

Faced with numerous challenges of production, supply, storage, exploitation, consumption, governance; rampant growth in population; rising food demands; and the increasing trend of urbanization, Pakistan stands at the brink of a water crisis—and a bleak and insecure future. Serious and concerted efforts are required to avoid the threat of a famine and dependence on food imports in the future. A suggested approach to the multi-faceted challenges appears in this chapter. It is important to mention that in the web of problems in water management, response options, too, are interlinked, complementing each other, and the same measures may be relevant at more than one place.

### **A. STORAGE, SUPPLY, AND PRODUCTION: SOLUTIONS AND STRATEGIES**

While transboundary developments and climate change are external challenges to Pakistan’s water having less immediate impacts, the lack of requisite storage and dependence on an outdated supply system—IBIS—are immediate concerns and seriously threaten water security in Pakistan. To guarantee a sustained supply of water to the agriculture sector and to mitigate the effects of floods, Pakistan desperately needs additional water storage, rehabilitation of the centuries old irrigation system, an amicable resolution of the issues with its neighbors, and necessary adaptation measures against climate change. Thus, the following strategies are recommended.

#### **1. Augmenting the Storage**

In Pakistan, most of the water-related problems are commonly attributed to insufficient storage. While the evidence may not support the view completely, enhancing the storage capacity, in any form, is necessary for a sustained water supply for agriculture, industrial, and domestic requirements. Any proposed strategies must take into account the

intra-year variation in precipitation, the flood and drought cycle,<sup>256</sup> sedimentation affecting existing storage capacity, and other impediments—including the lack of consensus among provinces, grievances based on past experiences, lack of funds, and other social and environmental issues. With these considerations in mind, the following measures are recommended to augment the storage capacity in the country.

**a. Construction of New Reservoirs**

Based on low water productivity in Pakistan, large reservoirs for irrigation alone are economically not justified. Nonetheless, multipurpose large reservoirs with sufficient hydropower generating capacity and flood mitigation capability are necessary for system augmentation.<sup>257</sup> To surmount the domestic skepticism, such reservoirs should have a consensus of the federating units,<sup>258</sup> maximum safety, and minimum social and environmental degradation foot prints.<sup>259</sup> On the other hand, small and medium dams all over the country are likely a better choice as these are not only efficient for regional use but are also cost effective.<sup>260</sup>

**b. Intervention Strategy against Sediments and Silt**

A large portion of the existing storage has already been lost as a result of continuous silting in the dams, especially Tarbela. To stop further loss of storage capacity, the heavy loads of sediment accumulation into the reservoirs by the feeding streams must be checked.<sup>261</sup> Watershed management efforts in the catchment areas of rivers and streams feeding the reservoirs must be expedited to minimize the sedimentation process.<sup>262</sup> Pakistan must develop an intervention strategy and invest in sediment control, especially

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<sup>256</sup> Chaudhry, “Pakistan: Indus Basin Water Strategy-Past, Present and Future,” 209.

<sup>257</sup> Young et al., *Pakistan: Getting More from Water*, 134.

<sup>258</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 13.

<sup>259</sup> Briscoe and Qamar, *Pakistan’s Water Economy*, 65, 66.

<sup>260</sup> Bashir Ahmad, “Water Management: A Solution to Water Scarcity in Pakistan,” *Journal of Independent Studies and Research* 9, no. 2 (2011): 120.

<sup>261</sup> Kahlown and Majeed, *Water Resources Situation in Pakistan: Challenges and Future Strategies*, 37.

<sup>262</sup> Kahlown and Majeed, 37.

for the Upper Indus Basin.<sup>263</sup> Similarly, studies suggest that desilting the existing reservoirs, especially Tarbela, may offer same irrigation benefits at much lower cost than construction of new reservoirs and must therefore be seriously evaluated.<sup>264</sup> Diamer Bhasha—a large dual purpose reservoir—upstream of Tarbela, will considerably reduce sedimentation in Tarbela, as well as provide other benefits.<sup>265</sup>

**c. *Riverbed Transit Storage***

This type of storage can be conveniently created by raising the banks of rivers at appropriate sites and distances on different rivers in the county. Transit storage can be useful in multiple ways: one, offering constant availability of some water in the river for grazing animals and other uses; two, allowing water to be released to meet agricultural requirements downstream; three, providing the flexibility to regulate water in the storage to offset the effects of anticipated floods.<sup>266</sup>

**d. *Underground Dams and Aquifer Replenishment***

Subsurface and sand dams commonly called underground water dams—a method to create storage for water underground—are cost effective with minimal environmental and social degradation effects and water losses as a result of evaporation. Aquifer management is effectively used in many of the industrialized countries, including Germany, Switzerland, United States, Netherlands, and Sweden through artificial recharge of 15 percent to 25 percent.<sup>267</sup> Check and delay action dams—small temporary dams constructed to reduce flow velocities and erosion of the soil—can be very useful in recharging of the aquifer and must therefore be considered and built where feasible in the

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<sup>263</sup> Young et al., *Pakistan: Getting More from Water*, 137.

<sup>264</sup> Shafqat S. Shezad and Karin Astrid K. A. Siegmann, “Pakistan’s Water Challenges: A Human Development Perspective,” January 1, 2006, 32, <https://repub.eur.nl/pub/32696/>.

<sup>265</sup> Young et al., *Pakistan: Getting More from Water*, 134.

<sup>266</sup> Ahmad, “Water Management: A Solution to Water Scarcity in Pakistan,” 121.

<sup>267</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 258.

country.<sup>268</sup> Aquifer recharge can be specifically effective during periods of floods and surplus water flows during monsoons in Pakistan.

***e. Rainwater Harvesting***

The common practice in many parts of Asia and Africa is to store rainwater in small rock-and-soil dams and use the water by withdrawing it directly or allow it to percolate underground to shallow aquifers that can be easily accessed when required.<sup>269</sup> Collection of rainwater and storage can vary, such as collection and storage of the runoff away from the catchment area, collecting and storing the rainwater where it falls, and can even be done at the domestic level by collecting the rainwater from roofs and yards. The storage can be made at the surface as well as subsurface at many places in Pakistan and will be particularly effective in rural areas. In many areas of Pakistan where the water table has gone too low, subsurface storage can be very useful for groundwater recharge.<sup>270</sup>

**2. Minimizing Water Losses in IBIS**

With the exception of a few irrigation canals added after the Indus Water Treaty of 1960, very little has been added to the irrigation network originally developed by British before partition of the sub-continent. Some canals, particularly the ones built above the earth surface with raised banks experience maximum losses due to excessive seepage.<sup>271</sup> A number of factors contribute to the seepage in these canals. The conveyance efficiency of water in other water channels—distributaries, minors, and watercourses—is also very low and demands concrete measures for improvement.<sup>272</sup> While construction of any canals above the earth surface should likely be avoided in future, this research recommends the following measures to minimize water losses in existing water channels of IBIS.

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<sup>268</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 13,14.

<sup>269</sup> Richter, *Chasing Water-A Guide for Moving from Scarcity to Sustainability*, 47.

<sup>270</sup> Imran Ali Jamali, “Subsurface Dams in Water Resource Management: Methods for Assessment and Location” (Royal Institute of Technology (KTH), 2016), 2, <http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-181937>.

<sup>271</sup> Ahmad, “Water Management: A Solution to Water Scarcity in Pakistan,” 114.

<sup>272</sup> Kahlown and Majeed, *Water Resources Situation in Pakistan: Challenges and Future Strategies*, 34.

**a.      *Regular Maintenance and Cleaning***

Over time, the silt in canals has grown into small mounds that gather more silt and constantly grow in size and obstruct the flow of water. Because of the obstruction, sideways pressure is exerted, which in turn results in more and more seepage. Regular maintenance of the water channels would ensure smooth flow and reduce seepage and hence the wastage of water.<sup>273</sup>

**b.      *Roads and Tracks along Water Channels***

Solid, strong, and levelled embankments on the sides of the water channel can reduce seepage considerably. Construction of roads and tracks along either side of the channels would reduce seepage besides serving many other useful purposes.<sup>274</sup>

**c.      *Keeping the Grazing Animals at Bay***

The grazing of animals causes enormous damage to water channels. Buffalos, particularly when in large numbers, not only cause considerable damage to the banks of these channels but also obstruct flow when the entire herd sits inside the channel. The erosion of banks at specific locations and the obstruction of flow result in outflows, seepage, and wastage. A significant amount of wastage can be avoided by keeping these animals away from water channels through construction of ponds at appropriate places along the channel for grazing animals. Suitable arrangements for charging of the ponds, when required, can be ensured from the channels.<sup>275</sup>

**d.      *Brick Lining***

Brick lining should be effected to stop seepage, particularly in areas affected by water logging and salinity due to rising water levels. Brick lining is effective in reducing seepage and facilitating free flow in the water channels.<sup>276</sup> The brick lining, however, needs

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<sup>273</sup> Ahmad, "Water Management: A Solution to Water Scarcity in Pakistan," 115.

<sup>274</sup> Ahmad, 115.

<sup>275</sup> Ahmad, 115.

<sup>276</sup> Ahmad, 115.

to be done at selected places, especially water logged and salinity affected areas, as all water lost through seepage is not wasted and some of it actually goes to recharge the aquifer.

**e. Sufficient Maintenance Funds**

Typically, the government budgets too few funds for repair and maintenance of the IBIS, a mere 5 percent to 10 percent, of the required amount.<sup>277</sup> Similarly, the Abiana—the fees for water usage—are grossly insufficient to provide for the maintenance costs and must therefore be increased. Ideally, the users should pay for the system itself—including its operation, maintenance, and replacement costs—to continue benefitting from it. The government should increase the funds for necessary repairs if the charges collected from users are not enough for any reason.

**3. Trans-boundary Developments and Climate Change**

Pakistan must aggressively take up, in all relevant forums, the issues of recent developments on the western rivers on the Indian side in violation of the treaty. Pakistan must make sure that India does not exploit certain ambiguous and opaque provisions of the treaty related to limited use of water of western rivers by the latter and must seek active involvement of the World Bank and other international bodies that deal with the issue.

Pakistan should make efforts, as the 2018 National Water Policy of Pakistan very aptly stresses, to work out a mechanism with its neighbors, “for sharing of trans-boundary aquifers and joint watershed management including sharing of composite real-time flow information especially relating to hydro-meteorological disasters/disaster-like situations endangering Pakistan’s important infrastructure, communication network and economy.”<sup>278</sup> The policy further outlines the need for a mechanism to resolve the issues of Pakistan’s vulnerabilities to “hydro-meteorological disasters owing to trans-border water releases and stoppages at critical times.”<sup>279</sup> The IWT does not address many key issues like

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<sup>277</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 257.

<sup>278</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 15,16.

<sup>279</sup> Ministry of Water Resources Government of Pakistan, 15,16.

the effects of climate change, and Pakistan should therefore explore all strategic forums and policy options to find viable and practical solutions acceptable to both Pakistan and India.<sup>280</sup> There is also a need to make the role of Indus water commissioners more effective and relevant. While currently Pakistan does not have major water issues with Afghanistan, similar problems can simmer in future. To guard against any such possibility, Pakistan should explore the possibility of entering a similar treaty with Afghanistan on the River Kabul, which originates in Pakistan, enters Afghanistan, and re-enters Pakistan before it finally joins the River Indus.

Pakistan's capacity, both technical and financial, to adapt to the adverse impacts of climate change is very low despite its being one of the most vulnerable to such change.<sup>281</sup> While the effects of climate change are diverse and myriad, its effects on water—a resource inextricably linked to climate change—are immense and, thus, has serious implications for Pakistan. Pakistan's 2012 climate change policy very correctly identifies the following measures to lessen the impacts of climate change on water resources.

1. Development of sufficient storage facilities, harnessing the potential of hill torrents, and necessary rehabilitation of the existing irrigation infrastructure making it resilient to climate change.
2. Efficient water conservation strategies and reduction of water losses, especially irrigation losses.
3. Water allocations to various sectors in accordance with demands caused by climate change, artificial recharge of threatened aquifers, better regulation of groundwater pumping, re-use and recycling of water and other similar measures for better management of the resource.

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<sup>280</sup> Ministry of Water Resources Government of Pakistan, 15,16.

<sup>281</sup> Ministry of Climate Change Government of Pakistan, *National Climate Change Policy*, 2012, 3, [http://www.moccl.gov.pk/moccl/userfiles1/file/Moccl/Policy/National%20Climate%20Change%20Policy%20of%20Pakistan%20\(2\).pdf](http://www.moccl.gov.pk/moccl/userfiles1/file/Moccl/Policy/National%20Climate%20Change%20Policy%20of%20Pakistan%20(2).pdf).

4. Necessary legislation and other administrative measures to protect water resources from degradation as a result of waste management practices in industrial and domestic sectors.
5. Augmenting capacities in remote sensing and geographic information system techniques for constant monitoring of temporal changes in glaciers; enhancing capacity of accurate and timely hydro-meteorological forecasts, especially for monsoons; preparation of an all-inclusive inventory of water resources; better network and means of flood warning systems and river flows; and strengthening coordination among national and international water institutions.
6. Promoting awareness among the public regarding climate change, its impacts, and the measures that are required at the individual and community levels.<sup>282</sup>

## **B. EXPLOITATION AND CONSUMPTION: POTENTIAL SOLUTIONS AND REMEDIES**

Any increase in cultivated area necessary to meet the increasing food requirements in Pakistan is only possible with additional water resources. Hence, as the water resources are constant, the only way to meet the food requirement is to conserve water at every stage and place. It is imperative to have improved water productivity in order to grow more food with the same amount of water that is currently used. This research recommends the following in this regard.

### **1. Irrigation Efficiency**

Failure to adopt modern irrigation practices and techniques as well as the poor choice of crops are the major reasons for very low water productivity. Some measures for improvement include:

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<sup>282</sup> Ministry of Climate Change Government of Pakistan, 4–6.

**a. *Extending the Use of Laser Land Leveling***

Concerted efforts are required for laser land leveling in Pakistan as it considerably improves land productivity and efficiency of water use while it also reduces waterlogging and salinity. In the Indian state of Bihar, laser leveling trials revealed 40 percent reduction in water use, 50 percent increase in application efficiency, 50 percent reduction in the time for irrigation, 35 percent reduction in the labor requirement, and 20 to 25 percent increase in the yields.<sup>283</sup>

**b. *Implementing Furrow Irrigation and Raised Bed Planting***

This method has proved beneficial in increasing yield and water productivity. Even in saline and waterlogged soils in Pakistan, the World Bank study found that this method proved useful by reducing water use by 30 percent to 50 percent, increasing yields of wheat by 10 percent to 20 percent, and corn by 30 percent to 40 percent as compared to traditional basin irrigation.<sup>284</sup>

**c. *Encouraging the Use of Zero Tillage***

While zero tillage is already being practiced in some parts of Pakistan, there is a need to adopt the practice more widely. This method is particularly useful in growing wheat, where reported benefits include 60 percent to 90 percent reduction in tractor time, 36 liters of fuel savings per hectare, 20 percent to 35 percent water savings, and 5 percent to 10 percent yield increase.<sup>285</sup> Trials may be conducted for different crops commonly grown in Pakistan, and the government should encourage farmers to adopt this method.

**d. *Adopting Pressurized Irrigation Systems***

The government needs to encourage farmers to use pressurized irrigation systems (PIS) to reduce water demands for irrigation. Drip and sprinkler irrigation systems have a 100-percent conveyance and 70 percent to 90 percent application efficiency as against the

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<sup>283</sup> Ali Hasanain et al., “Irrigation and Water Use Efficiency in South Asia” (Global Development Network, June 2012), 37.

<sup>284</sup> Hasanain et al., 38,39.

<sup>285</sup> Hasanain et al., 40.

corresponding figures of 40 percent to 70 percent conveyance and 60 percent to 70 percent application efficiency for basin irrigation.<sup>286</sup> Using PISs, farmers can considerably reduce the time required for irrigation while significantly increasing their yields. In the same connection, the results of a survey conducted in Punjab and Sindh provinces showed a 200-percent increase in cropping intensity, water savings of 60 percent to 70 percent in drip, and 50 percent to 60 percent in sprinkler irrigation for PIS in comparison to the traditional surface irrigation. Similarly, the time needed for irrigation in comparison to the traditional method was also reduced by 60 percent to 70 percent for drip and 30 percent to 40 percent for sprinkler irrigation while the yield doubled for sugarcane, vegetables, and fruits.<sup>287</sup>

***e. Implementing Surge Irrigation***

Surge irrigation is another innovative method practiced in Texas and can significantly improve water productivity. The irrigation in this method alternates between two rows instead of continuous stream down the field. Percolation losses are reduced in this method as the soil seals as a result of the initial wetting, allowing subsequent application to advance quickly, thus reducing water use by 15 to 50 percent as compared to the traditional system of irrigation.<sup>288</sup>

***f. Adopting Alternate Wet and Dry Method and Direct Seeding***

Other innovative measures and practices can also prove beneficial in saving groundwater. Among them is the alternate wet and dry (AWD) method for rice in which fields are allowed to dry for few days, without stressing the plants, before re-irrigation. Similarly, the water requirement for rice is reduced by 23 percent when seeded directly as compared to the transplanted rice commonly practiced in Pakistan.<sup>289</sup>

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<sup>286</sup> Hasanain et al., 35–37.

<sup>287</sup> Hasanain et al., 35–37.

<sup>288</sup> Postel, *Last Oasis*, 99.

<sup>289</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 258.

**g.      *Transitioning to Demand Oriented System***

There is a need to shift from the existing rotation-based irrigation system—where water is available on turn at specific day/time and therefore used regardless of actual requirement—to a demand oriented system to increase water productivity.<sup>290</sup> Improvement of water courses and avoiding mid-day irrigation will reduce water losses through seepage and evaporation, respectively, and will add to water productivity.

**h.      *Promoting Wastewater Re-use***

Promoting the use of treated sewage and wastewater for non-edible crops will greatly reduce pressure on the freshwater resources, which can be used for other beneficial and potable purposes. The wastewater in certain cases is even better than the freshwater for irrigation purposes. Postel very aptly points out that “by using municipal water supplies twice—once for domestic use and again for irrigation—would-be pollutants become valuable fertilizers, rivers and lakes are protected from contamination, the irrigated land boosts crop production, and the reclaimed water becomes a reliable, local supply.”<sup>291</sup>

**i.      *Adopting Rain-fed Agriculture***

The government should encourage farmers to adopt rain-fed agriculture—already providing 60 percent of the world’s food—which has multiple benefits besides acting as a good source of recharging the groundwater.<sup>292</sup>

**j.      *Enhancing Knowledge Base of Farmers***

Most farmers in Pakistan are illiterate and have little knowledge of the modern and efficient irrigation practices.<sup>293</sup> Increasing literacy and awareness will lead to adoption of more efficient water practices.

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<sup>290</sup> Salim Khoso and Abdul Aziz Ansari, “An Overview on Emerging Water Scarcity in Pakistan, Its Causes, Impacts and Remedial Measures,” *Journal of Applied Engineering Science* Volume 13 (January 1, 2015): 42, <https://doi.org/10.5937/jaes13-6445>.

<sup>291</sup> Postel, *Last Oasis*, 127.

<sup>292</sup> FAO, “Crops and Drops,” 2000, <http://www.fao.org/3/Y3918E/y3918e00.htm>.

<sup>293</sup> Faruqi, “Responding to the Water Crisis in Pakistan,” 182.

### ***k. Facilitating the Transition***

The government must employ various methods, including tax subsidies, to encourage local industry to manufacture tools and components required for high irrigation systems and motivate farmers for their adoption by extending soft loans and other subsidies.<sup>294</sup> To be able to adopt modern irrigation and field leveling techniques, small farmers should be extended soft loans and subsidies that will greatly help in improving water productivity at the farm level.<sup>295</sup> Even provision of certain incentives may be considered to farmers and land owners for efficient and timely adoption of the modern irrigation techniques.

### ***l. Implementing Modern Irrigation Techniques***

The government must devise a plan at the national level for implementation of the previously mentioned modern irrigation techniques and carry out necessary legislation to ban flood irrigation in the country as early as possible.

## **2. Selecting the Right Crops**

Pakistan grows rice at a very high price—the enormous quantity of water needed to grow it—and exports a substantial part of it, especially Basmati rice. Nevertheless, there is a need to assess whether Pakistan should continue growing water intensive crops, especially rice and sugarcane, or develop a strategy to replace these with high market-value crops, such as pulses, sunflowers, vegetables, and other orchard produce that demand less water and generate substantially better incomes.<sup>296</sup> Appropriate changes in cropping pattern and varieties, such as a change from high to low delta crops and certain drought and salt resistant varieties of crops may also be considered.<sup>297</sup> Similarly, adoption of

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<sup>294</sup> Kahlown and Majeed, *Water Resources Situation in Pakistan: Challenges and Future Strategies*, 34.

<sup>295</sup> Qureshi et al., “Challenges and Prospects of Sustainable Groundwater Management in the Indus Basin, Pakistan,” 1563.

<sup>296</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 258.

<sup>297</sup> Kahlown and Majeed, *Water Resources Situation in Pakistan: Challenges and Future Strategies*, 34,35.

genetically modified crops (GMC), particularly in maize and cotton, can prove useful and more water productive.<sup>298</sup>

### **3. Allocating Water among Users Rationally**

In a country where 21 million people do not have access to safe drinking water,<sup>299</sup> it defies reason to spend 95 percent of the nation's water on agriculture alone. Recognizing water as a scarce and precious resource, Pakistan must treat it as a social and economic good. There is a need to reallocate some water from agriculture to industrial and domestic sectors where it, economically, weighs more.<sup>300</sup> Even within the agriculture sector, some reallocation from irrigation to other users, such as livestock, is necessary where the economic benefits per unit of water are much higher.

In agriculture, the water is used in extremely undesirable ways. Water is wasted, misused, and even abused. There is little distinction between water that is used for gardening, vegetation, and drinking as, in most cases, the same water supply system provides for all. With extremely low water tax, consumers basing on status/ approach to the relevant officials and department can enjoy unlimited water supply, leaving others in the same neighborhood, colony, or street without any water for drinking.<sup>301</sup> Even very modest savings of water in irrigation and reallocation to other sectors can have significant effects.

### **4. Encouraging Conservation and Optimum Utilization**

With a substantially lower availability of water than the potential future requirements, it is critical to adopt water conservation measures in all sectors. While the greatest savings of water through conservation can be made in irrigation, conservation in other sectors and, more importantly, public awareness can contribute significantly as it will

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<sup>298</sup> Chaudhry, "Pakistan: Indus Basin Water Strategy-Past, Present and Future," 208.

<sup>299</sup> Sana Jamal, "21 Million in Pakistan Don't Have Access to Clean Water: Report," *Gulf News*, March 22, 2018, <https://gulfnews.com/world/asia/pakistan/21-million-in-pakistan-dont-have-access-to-clean-water-report-1.2192988>.

<sup>300</sup> Faruqi, "Responding to the Water Crisis in Pakistan," 182.

<sup>301</sup> Ahmad, "Water Management: A Solution to Water Scarcity in Pakistan," 117,118.

effect positive changes everywhere, including in irrigation. Some important areas of focus are the following.

**a. Public Awareness**

People are the prime users of water, a basic and everyday commodity, and resultantly are major stakeholders in the water sector. No conservation efforts can succeed without an active involvement of the public. The following measures are recommended to improve public awareness.

1. There is a need for a more proactive role by agriculture universities in raising awareness among the public by producing and designing literature and information that is readily understandable to farmers, who are mostly less educated or totally illiterate. These universities also need to initiate and upgrade academic programs in conservation and management of water.
2. The role of women is extremely important in the management of water in mundane activities—drinking, hygiene, and even agriculture—and, therefore, are most important to be aware of why and how to conserve water in daily chores.<sup>302</sup>
3. The government should explore the effective use of social media to educate the public about the existing scarcity of water and need for conservation.
4. The government should design and distribute interesting posters and brochures depicting the bleak water situation in the country, make appeals for conservation, and emphasize the role everyone plays in conservation.

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<sup>302</sup> Sharad K. Jain and Vijay P. Singh, “Water Crisis,” *Journal of Comparative Social Welfare* 26, no. 2–3 (June 1, 2010): 235, <https://doi.org/10.1080/17486831003687618>.

5. The government should consider placing well designed and attractive advertisements in newspapers and daily publications promoting water conservation.
6. Along well traveled roads, public attention can be drawn to prominent billboards with eye catching phrases/pictures and appeals for water conservation.
7. Water saving slogans should be displayed on water bowsers and other vehicles, especially those belonging to various departments related to the water sector. Even private commercial vehicle owners could be encouraged to emulate the trend.
8. Islam lays a lot of emphasis on the conservation of water and strictly forbids against its wastage. Booklets with relevant references from the Holy Qur'an and hadiths could be printed and widely distributed/circulated.
9. Canopies with printed appeals/slogans for conservation could be distributed among traffic police and other guards at crowded places and main roads.
10. In order to involve children, the government should develop stickers, badges and posters with pictures of popular comic characters conveying water conservation messages and circulate/ distribute among students.
11. Special talk shows and documentaries on water issues and conservation measures should be broadcast on major television channels during prime time.
12. Awareness regarding water issues and conservation measures should be incorporated in the syllabi at primary, secondary, and tertiary levels of education.

13. Speeches and poster competitions on water issues and conservation themes should be organized in the schools.
14. Essay competitions on water conservation measures should be organized at the national level.
15. Frequent seminars and awareness vents should be held by hydrologists and water experts on the water situation in the country and the need for its conservation.

**b. *Re-using and Recycling Water***

Recycling and reuse of water is a rare phenomenon in Pakistan. Pakistan's 2018 National Water Policy correctly identifies the issue and stresses the need for the "adoption of technology for sustainable use of drainage water in agriculture, horticulture and forestry sub sectors."<sup>303</sup> The policy also encourages re-use and recycling of sewage after requisite treatment at the source.<sup>304</sup> If Frankfurt, Germany, can recycle every drop of water eight times,<sup>305</sup> efforts in Pakistan should be made to recycle some water, if not all, at least once—particularly water used in irrigation, industrial cooling, and fire-fighting—so as to conserve fresh water for potable use.

**c. *Making Rational Subsidies***

Water is a highly subsidized and underpriced commodity in Pakistan and can be rightly accredited as the main reason for its blatant misuse and wastage. There is a need to appropriately price the resource so that its worth is realized, and its wastage becomes expensive. Government officials should remove or minimize the subsidies on irrigation water in a manner that should have minimal effects on poor farmers. A tiered pricing system, like electricity and gas billing in Pakistan, can be introduced with specified brackets, where the charges per unit of water in the initial brackets are very low and

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<sup>303</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 14.

<sup>304</sup> Ministry of Water Resources Government of Pakistan, 14.

<sup>305</sup> Jain and Singh, "Water Crisis," 233.

increase substantially in the higher brackets. Everyone, including the government departments, should pay for the quantity they consume and the culture of free, often indefinite, supply must stop.<sup>306</sup>

## **5. Regulating the Overdraft of Groundwater**

Groundwater extraction in Pakistan is a complicated issue due to the reliance of irrigated agriculture on groundwater and the effects it may have on the livelihood of people, especially in rural areas. Any decision to reduce underground water overdraft will be politically unpopular and will also have economic impacts as it will reduce crop output. The introduction of any new measures or reforms will not succeed easily due to heavy population densities and a very large number of users; and therefore, a realistic and pragmatic strategy would be required to address the issue.<sup>307</sup> A proactive approach, however, is needed to better manage the extraction before the aquifers are completely pumped out and the problem becomes insolvable.<sup>308</sup> This research makes the following recommendations.

### ***a. Regulation and Licensing***

To reduce the overdraft of groundwater, the practice needs to be regulated and made licensed before a new tube well for irrigation can be installed.<sup>309</sup> The inventory of water resources and proper accounting must be done and constantly updated, especially in areas where the water table is already very deep, and restrictions must be imposed on the depth of tube wells to ensure the aquifers are not over-mined. Similarly, the water needs to be appropriately priced and subsidies reduced or withdrawn depending on the stress level of water in the area concerned.<sup>310</sup>

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<sup>306</sup> Ahmad, "Water Management: A Solution to Water Scarcity in Pakistan," 119.

<sup>307</sup> Qureshi et al., "Challenges and Prospects of Sustainable Groundwater Management in the Indus Basin, Pakistan," 1567.

<sup>308</sup> Qureshi et al., 1567.

<sup>309</sup> Ahmed, Iftikhar, and Chaudhry, "Water Resources and Conservation Strategy of Pakistan," 1007.

<sup>310</sup> Kahlown and Majeed, *Water Resources Situation in Pakistan: Challenges and Future Strategies*, 35.

**b. Community-based Extraction**

To stop the over-pumping of groundwater, pumping by individual consumers should be stopped or made conditional, and the activity should be organized on a community or area basis, preferably under some government mechanism.<sup>311</sup>

**c. Rejuvenation of the Depleted Aquifers**

Over a period of time, freshwater resources have been depleted to dangerous levels in different parts of the country, especially Balochistan and parts of Sindh and Punjab, and there is a need to rejuvenate them.<sup>312</sup> Artificial recharge measures, such as rainwater harvesting, need to be adopted to recharge the depleted aquifers and stringent measures need to be imposed on pumping of groundwater for irrigation purposes in these areas to ensure availability of water for the domestic purposes.

**C. IMPROVING GOVERNANCE, ADMINISTRATION, AND DELIVERY**

The emphasis on handling water in Pakistan, unfortunately, has traditionally been focused on the supply management. The national water policy recognizes that fact and stresses on according priority to demand management of water in its various uses.<sup>313</sup> Among other reasons, poor governance, administration, coordination, inflexible irrigation system, and inefficient and corrupt practices have contributed equally if not more to the current water crisis in the country. A few measures aimed at improving these issues and better management of drought and floods, common phenomena in Pakistan, are recommended in the following paragraphs.

**1. Institutional and Management Reforms**

Existing institutions dealing with water management are complicated, lack coordination, and are often ineffective due to duplication of effort. Moreover, there is little public participation in handling and managing the water issues. Ahmad offers a workable

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<sup>311</sup> Ahmad, "Water Management: A Solution to Water Scarcity in Pakistan," 119.

<sup>312</sup> Kahlowan and Majeed, *Water Resources Situation in Pakistan: Challenges and Future Strategies*, 37.

<sup>313</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 31.

solution by recommending water bodies, called water management authorities, at the federal, provincial, and district levels.<sup>314</sup> To inculcate a sense of ownership, he recommends inclusion of representatives from users in the water management authorities at all levels. While at the federal and provincial levels, selected politically elected members of assemblies can act as public representatives in the respective water management authorities, the district water management authority can have elected local bodies' members, or preferably farmers, as public representatives. The users, who currently use too much water and pay too little, will have greater trust in the system run by them; hence, they will use less and pay more voluntarily.<sup>315</sup> Responsibilities of proposed water management authorities are explained in the Table 1.

Table 4. Proposed Water Management Authorities<sup>316</sup>

| Level                                        | Responsibilities                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|----------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Federal Water Management Authority (FWMA)    | <ul style="list-style-type: none"> <li>- River water regulation and conservation.</li> <li>- Development of storage capacity in the country.</li> <li>- Management of barrages and canals and regulating water in link canals.</li> <li>- Ensuring equitable distribution of water among users.</li> <li>- Maintenance of riverbeds in view of necessary sustenance in case of unusual rains.</li> </ul>                                         |
| Provincial Water Management Authority (PWMA) | <ul style="list-style-type: none"> <li>- Management of water in irrigation canals within provincial jurisdiction.</li> <li>- Management of canals and water management in them to tail ends.</li> <li>- Building and maintenance of seasonal canals for drainage of excess water in unforeseen situations.</li> </ul>                                                                                                                            |
| District Water Management Authority (DWMA).  | <ul style="list-style-type: none"> <li>- Maintenance of water channels from field to the point where it connects with canal.</li> <li>- Decisions on usage/sharing of water in respective jurisdiction.</li> <li>- All finances for maintenance of the water courses/channels at district level to be met by the users and work to be executed through active participation of the users, such as village/town committees or farmers.</li> </ul> |

<sup>314</sup> Ahmad, "Water Management: A Solution to Water Scarcity in Pakistan," 116.

<sup>315</sup> Ahmad, 116.

<sup>316</sup> Source: Adapted from Ahmad, 116,117.

## **2. Water Accounting System and Equitable Delivery**

Accurate assessments and accounting of the water would help improve the understanding of its avoidable and unavoidable losses and corrective measures. The national water policy of Pakistan recognizes that “more than 50 per cent of canal water diverted from the Indus system does not reach the farm level.”<sup>317</sup> Lining of the water courses alone can result in a one-third reduction in the seepage losses.<sup>318</sup> Correct water data and information is not only important for better management but also for building trust among the stakeholders, including consumers, who would be willing to pay more for improved, efficient, and guaranteed water services.

Warabandi—a system that fixes irrigation turns for each farmer along a watercourse—has many issues. One of the fairness indicators in the distribution of water is that every farmer, including the one at the tail end, must get his due and proportional share of water. In Pakistan, on the average, a farmer at the head end gets 32 percent more water than the farmer at the tail end.<sup>319</sup> While canal lining considerably reduces water losses thorough seepage and improves equity conditions at the tail end,<sup>320</sup> there is a need for better regulation of the water from canals for irrigation purposes. Young et al. rightly suggest to “replace warabandi with new water sharing rules based on economic efficiency and farmer equity.”<sup>321</sup> Similarly, abiana—charges for irrigation water—are far too low, and there is a need to increase those fees to meet the operation and maintenance costs.<sup>322</sup>

## **3. Effectively Managing Drought and Floods**

Droughts and floods, common phenomena in Pakistan, significantly affect the national water situation and its management. While storage reservoirs can play a significant

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<sup>317</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 8.

<sup>318</sup> Ministry of Water Resources Government of Pakistan, 8.

<sup>319</sup> Qureshi, “Water Management in the Indus Basin in Pakistan,” 259.

<sup>320</sup> Shezad and Siegmann, “Pakistan’s Water Challenges,” 31.

<sup>321</sup> Young et al., *Pakistan: Getting More from Water*, 135.

<sup>322</sup> Young et al., 135.

role in mitigating the effects of droughts and floods, the following measures could be adopted.

**a. *Mitigating the Effects of Floods***

1. Dams can play a major role in mitigating the effects of floods. The National Water Policy 2018 of Pakistan stresses the following measures to mitigate the effects of floods in the country.
2. Ensuring capacity building and strengthening of all barrages and bridges to withstand and let safely pass floods of 100-year return periods.
3. Updating flood protection plans based on past experiences.
4. Ensuring avoidance of developments in flood hazard zones/areas that can exacerbate the effects.
5. Restricting permanent settlements in selected zones along flood prone rivers.
6. Reviewing and optimizing reservoir operational rules to regulate floods efficiently without compromising reservoir safety.
7. Providing better flood forecasting and early warning systems and using them more effectively.
8. Constructing additional and improving/strengthening existing flood protection infrastructure, with emphasis on strengthening of flood protection embankments.<sup>323</sup>

**b. *Reducing the Effects of Droughts***

A timely prediction of an approaching drought and requisite measures can lessen the severity and negative impacts of the calamity. Similarly, during floods or monsoons

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<sup>323</sup> Ministry of Water Resources Government of Pakistan, *The National Water Policy 2018*, 23,24.

when there is a water surplus, safety valve canals, as Ahmad proposes, can be used to “lead water to the dry river beds like Sutlej and Ravi which remain dry most of the times even when there is high flood situation in other three rivers.”<sup>324</sup> This arrangement thus mitigates the effects of flood and drought at the same time.

#### **D. CONCLUSION**

Although not poor in water resources, Pakistan has a comparatively low availability of water per capita and the level of availability is getting lower constantly due to rising population and additional water demands. While climate change and transboundary developments pose some threat to the country’s water, the biggest challenges and hence the opportunities are internal. The silver lining is that the resource is not physically scarce; it can sustain the country’s population, and the problem—bad management and flagrant wastages—is fixable with inherent solutions.

Like the myriad challenges, the impacts of this manufactured water crisis are many and varied—economic, social, and security-related—and the country cannot afford to ignore the water sector with a business as usual approach. Pakistan’s current economic and security situation, and its genuine desire based on its geographic location to aspire for a major role in the region, make it imperative for the nation to overcome the looming water crisis. Pakistan may declare a water emergency in the country and should also explore prospects of including some water sector related projects in the China Pakistan Economic Corridor. Alternatively, Pakistan might persuade other foreign investors to invest in the water sector in Pakistan. This thesis has determined that while the water crisis in the country is real, it is largely manufactured and worsened by our actions, inactions, and constant apathy. Consequently, this study has also proposed some practical remedies. With a pragmatic approach, vision, and will, there is no reason that the country cannot cope successfully with the scarcity it is currently facing.

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<sup>324</sup> Ahmad, “Water Management: A Solution to Water Scarcity in Pakistan,” 121.

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