Pakistan's Water Security Crisis: Challenges and the Case for Integrated Water Resource Management

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Abstract
Water security has emerged as the greatest security concern for Pakistan. Despite being endowed with abundant water resources, the country is steadily heading towards a severe water crisis due to excessive exploitation and widespread mismanagement. In the past, issues pertaining to water security were largely neglected, paving the way for its transformation into an existential threat with alarming consequences for Pakistan. The combination of inadequate water availability, deteriorating water quality, rising demand, and the compounded pressures of climate change and population growth underscores the severity of this crisis. This research examines Pakistan's critical water security challenges and explores potential future risks. The study is grounded in the theoretical framework of 'water security,' and the methodology used is the STEEPLE Analysis to foreground multifarious key factors behind burgeoning water insecurity in Pakistan. It argues that Pakistan's water crisis stems from a complex interplay of interconnected social, political, and economic factors, each with far-reaching implications. To address this crisis, the research advocates for the urgent and effective implementation of an Integrated Water Resources Management (IWRM) approach.

Keywords
Pakistan, Indus Basin, Water security, STEEPLE Analysis, water availability

Introduction
Water is the most cardinal resource for existence, livelihood, and development. Consequently, water security continues to pose a significant challenge for states across the globe. In Pakistan, this challenge is particularly critical due to the country's heavy reliance on its agrarian economy and the Indus River Basin (IRB), which supplies the majority of its water needs (Janjua et al., 2021). However, the country is predicted to reach absolute water scarcity by 2025 and become the 23rd most water-stressed state

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globally by 2040, as asserted by national and international reports, respectively (Ahmad et al., 2022). Given the severity of this issue, it has not received the attention it warrants. Even when recognized, practical measures to address the crisis have been minimal, further exacerbating an already dire situation.

The declining water resources, driven by complex factors, are propelling Pakistan toward a severe water crisis, embittering water insecurity with grave social, economic, and political implications. The water resources of the country have come under great stress from population explosion, urbanization, industrial development, and environmental pollution (Rashid et al., 2018). The poor water management and ever-enhancing climate variability have made Pakistan extremely vulnerable to natural disasters, droughts, and floods (Habib-ur-Rahman et al., 2022). The rampant corruption and prevalent water theft have further fueled the issue (Ullah et al., 2025). Moreover, Pakistan's fraught history of water disputes—both with India and among its provincial units—has politicized the water issue, raising serious security concerns about restricted water flow and the potential for water-related conflicts (Michel, 2020).

In this context, this paper examines the following key research questions: How do social, technological, economic, environmental, political, legal, and ethical factors individually contribute to the challenges of water security in Pakistan? Furthermore, how does water insecurity influence social cohesion, political stability, and economic development in Pakistan, and what strategies can be developed to mitigate these impacts?

Conceptual Foundations of Water Security

The concept of 'water security' can be traced back to post-war diplomacy in the 1940s, during the remapping of former colonial empires (Sun et al., 2024). It was formally articulated as a policy challenge in the 'Hague Ministerial Declaration on Water Security' released at the 2002 World Water Forum. This declaration defined water security as the protection and improvement of coastal, freshwater, and other ecosystems; ensuring access to sufficient, safe, and affordable water for a productive and healthy lifestyle; promoting environmental stability and political security; and safeguarding against water-related hazards (World Water Council, 2022). Subsequently, the Ministerial Declaration at the 2006 World Water Forum emphasized the urgency of making sanitation and water a national priority. It reaffirmed the commitment to achieving the goals of Integrated Water Resources Management (Jun 2010; Ministry of Foreign Affairs of Japan, 2022).

The United Nations-Water, created for harmonizing efforts for water-related matters, equates water security with the masses' ability to ensure uninterrupted access to sufficient quantities of passable quality water, adequate quantity for the wellbeing of humans, maintaining livelihoods, economic and social development, cinching safeguard against water-related calamities together with water-borne pollution. Moreover, water security emphasizes ecosystem preservation in a climate of political stability and peace (UN-Water, 2013). This definition categorically endorses the exigency to manage uncertainty and risk among water security's key elements. According to the Global Water Partnership, the key elements of water security include:

- *Water Safety:* Ensuring acceptable water quality in terms of odor, taste, and appearance that does not threaten human health.
- *Water Access:* Guaranteeing unrestricted access to water for all individuals, encompassing public spaces, healthcare facilities, schools, and households.
- *Water Affordability:* Providing sufficient and safe water at a reasonable cost.

Beyond these elements, water security encompasses multiple dimensions that collectively contribute to achieving national water security (Siwar & Ahmed, 2014).

- *Economic Water Security:* Supporting sustainable economic development through water resource management.
- *Household Water Security:* Ensuring adequate water supply for domestic needs.
- *Climate Water Security:* Addressing the impact of climate change on water resources.
- *Resilience to Water Calamities:* Strengthening the ability to withstand water-related disasters.
- *Urban Water Security:* Managing water supply and sanitation in urban areas.

Pakistan's limited and erratic water supply highlights the growing challenge of water insecurity in the country. Water availability in the country faces multiple risks, notably from climate change and pollution (Ahmed et al., 2020). Moreover, the water demand is rapidly increasing due to urbanization and the ballooning population. Consequently, the supply and demand imbalance drives Pakistan towards water insecurity. The strain on water resources is further exacerbated by inefficient water management practices, declining availability, and deteriorating water quality, collectively undermining the country's overall water security (Khan et al., 2024). These interconnected issues threaten all three pillars of water security—safety, access, and affordability—raising profound concerns about the nation's survival, livelihoods, and sustainable development.

Pakistan's Water Security: Current Status and Future Outlook

The River Indus and its six tributaries (Chenab, Ravi, Beas, Sutlej, Jhelum, and Indus) are the primary sources of water supply in Pakistan. According to the World Bank (2019), Pakistan's renewable water resources amount to approximately 228.9 billion cubic meters (BCM) annually, with the Indus Basin contributing the largest share, 96.3%, followed by the Kharan Desert at 1.3%, and the Makran coastal drainage accounting for 2.4%.

Surface water supplies in Pakistan are derived from three primary sources: 75% from the three western rivers, 1.5% from eastern rivers, and the remainder from rainfall and runoff within the country. The western rivers heavily depend on Himalayan glaciers, which provide about 50% of the downstream surface water, making Pakistan highly reliant on glacial flows (World Bank, 2019).

Renewable groundwater resources in Pakistan are estimated at approximately 74.2 BCM, recharged by river flows, rainfall, irrigation return flows, and canal seepage. Sector-wise, national water consumption is distributed as follows: 94% for agriculture, 3% for domestic use, and 3% for industrial purposes (Watto et al., 2021).

Water stress, water scarcity, and absolute water scarcity are key thresholds for assessing the availability of water resources relative to a country's population. According to the Falkenmark Indicator, a nation is water-stressed if its per capita water availability falls below 1,700 cubic meters per year. When renewable water resources drop below 1,000 cubic meters per person annually, the nation is categorized as water-scarce, and levels below 500 cubic meters signify absolute water scarcity (White, 2012).

Pakistan is on a trajectory toward acute water shortages, dramatically declining per capita water availability from 5,260 cubic meters per year in 1951 to approximately 1,000 cubic meters in 2016. By 2025, this figure is projected to decrease

to 860 cubic meters, shifting Pakistan's status from water-stressed to water-scarce (Ministry of Water Affairs, Pakistan, 2022). Additionally, the water shortfall, which stood at 11% in 2004, is expected to surge to approximately 31% by 2025, underscoring the need for 22-25 BCM storage capacity to address the widening gap between water demand and supply (PIPS, 2022).

Studies published by the Research in Water Resources (PCRWR) have warned that if poor water management and inadequate conservation practices persist, Pakistan could face absolute water scarcity by 2025 (Ashraf, 2018). Furthermore, the 'World Resources Institute' ranked Pakistan as the 23rd most water-stressed country, with a water score of 4.48. This score reflects the ratio of water withdrawals to the total renewable water resources available, highlighting the critical challenges the country faces (Luo et al., 2015).

STEEPLE Analysis of Pakistan's Water Security

The methodology used in this research is STEEPLE Analysis, which examines Social, Technological, Economic, Environmental, Political, Legal, and Ethical factors and their implications for a given sector or domain (Baruah, 2020). In Pakistan, these elements collectively reinforce one another, intensifying the ongoing water crisis.

Social Aspects

Social factors include population explosion and urbanization, having a colossal impact on the water resources of Pakistan. According to the United Nations, Pakistan ranks as the world's fifth-most densely populous state, with 220.9 million people (United Nations Pakistan, 2021). Its population is estimated to become 242.2 million by 2025, putting an unprecedented strain on the receding water resources (Yaqoob, 2021). Population explosion will compound the ever-enhancing water demand-supply gap due to the incessant rise of water demand. As per the International Monetary Fund Report, by 2025, the water demand of Pakistan will increase to 274 million acre-feet (MAF), but the water supply will remain constant at 191 MAF, causing a gap of 83 MAF between water demand and supply (IMF, 2015). The water demand in Pakistan is rising at a 10% rate, and the key reason behind that is the burgeoning population. The current water withdrawals from surface and groundwater resources that have surged to 175 km^3 further exacerbate the situation. The extraction rate is also extremely high, particularly for groundwater resources. For example, 83% of total groundwater while 74% of total surface water is extracted in Pakistan (Janjua et al., 2021).

The ratio of water withdrawal from renewable water resources, including groundwater and surface water, has increased significantly, from 62% in 1977 to 82% in 2017. With population growth, this ratio is expected to increase further, depleting already limited water resources. Urbanization is also accelerating, with the urban population projected to rise from 37.2% in 2020 to an alarming 52.2% by 2050 (Maqbool, 2022). At an annual urban population growth rate of 3%, nearly half of Pakistan's population will reside in urban areas by 2025.

This rapid urban expansion presents significant challenges for metropolitan areas, especially those lacking the infrastructure to provide basic services such as water and sanitation. Unplanned and unchecked urbanization will exacerbate pressures on provincial governments to ensure adequate service delivery, further straining limited resources (Khalid & Khan, 2020).

A striking example is Karachi, Pakistan's largest metropolitan city, with a population of approximately 18 million. As a water-stressed city, Karachi faces a water demand ranging from 720 to 972 million gallons per day (MGD), while its current

supply is only 670 MGD. Population growth and the rising rate of urbanization are the primary drivers of this water shortage. Furthermore, high levels of internal and international migration to Karachi are expected to increase water demand, intensifying the city's water crisis in the future (Khan et al., 2019).

Technical aspects

Another key factor behind water insecurity in Pakistan is inadequate water storage. Pakistan suffered a loss of 120 BCM (Billion Cubic Meters) of water during the 2010, 2012, and 2014 floods alongside the substantial impact on people, crops, and infrastructure, primarily because of limited storage. Three major reservoirs (Tarbela Dam, Mangla Dam, and Chashma Barrage) of the country have a water storage capacity of 9% of annual river water flows, which is far less than the world's average storage capacity of 40% (Ashraf, 2018). According to Indus River System Authority spokesman Muhammad Khalid Rana, Pakistan gets 145 MAF (Million Acre Feet) of water per annum but, due to limited storage capacity, saves merely 13.7 MAF (Akbar et al., 2021).

The existing capacity of reservoirs is decreasing rapidly because of sedimentation with an annual loss rate of 0.2 MAF. Sedimentation diminishes the water flow regulation, reduces storage volume, and obstructs the dams to achieve various objectives such as hydropower generation, flood mitigation, and irrigation. Deposition of sediment has decreased the storage capacity of Tarbela Dam by 40.58%. Ergo, the water carryover capacity of these reservoirs is 30 days, which is constantly declining. (Ateeq-Ur-Rehman et al., 2018). The storage capacity of Chashma Barrage has decreased to 60% of the total storage capacity as per the 2011-2012 hydrographic survey (Ali & Shakir, 2018)

Augmenting water insecurity in Pakistan is also linked to another technical problem: the system's efficiency. The irrigation system is poorly managed, plunging the overall efficiency to below 40% (Latif et al., 2016). Canal seepage brings about salinity, water logging, pollution, and freshwater depletion. Moreover, it increases the level of the groundwater table, causing irrigation inefficiency, waste of productive land, and a hike in operational costs (Shah et al., 2020). Pakistan faces the loss of 26 MAF through distributaries, canals, and minors, whereas the losses from water courses through evaporation, overtopping, transpiration, and seepage are 45 MAF (Khoso et al., 2015). Moreover, the loss of irrigation water during transportation in channel and field application stands at 60% (Shams, 2022).

Economic Aspects

Pakistan's water crisis is deeply intertwined with the structure of its economy. It is classified as the most water-intensive economy in the world, consuming the highest volume of water (in cubic meters) per unit of Gross Domestic Product (GDP) compared to any other country. As an agrarian economy, the agriculture sector forms a cornerstone of Pakistan's economy, contributing 19% to GDP and accounting for 80% of the country's total export earnings. Additionally, the sector employs over 42.3% of the national workforce (Agriculture Department Government of Punjab Pakistan, 2022). However, agriculture is also the primary driver of water scarcity, utilizing 93% of Pakistan's freshwater resources for agricultural production (Mumtaz & de Oliveira, 2019).

Out of Pakistan's total 22 million hectares of arable land, only 6 million hectares rely on rain, while the remaining 16 million hectares are irrigated. These irrigated lands contribute nearly 90% of the country's agricultural and livestock

production. The irrigation network spans the IRB, supporting Kharif (summer crops) from May to October and Rabi (winter crops) from November to April. Key crops such as rice, wheat, sugarcane, cotton, pulses, fruits, and vegetables are cultivated on this land. For these water-intensive crops, 27% of irrigated land depends on surface water supplies, while the remaining 73% relies solely on groundwater, making Pakistan the world's third-largest consumer of groundwater (Qureshi, 2020).

Pakistan is also the fourth-largest country globally in groundwater withdrawal, with the Indus Basin Aquifer—the country's primary groundwater source—recognized as the most overstressed aquifer in the world (Razzaq, 2022).

The cultivation of cash crops, particularly rice, has been a major factor in depleting water resources. Experts estimate that 4,000 liters of water are required to produce 1 kg of rice, resulting in water costs of approximately Rs. 10 billion to earn just 2 billion (Pakistan Rupees) through rice exports ("Fighting Water Scarcity," 2017). This unsustainable water usage for low-value agricultural production has exacerbated the water crisis, highlighting the need for strategic reforms in Pakistan's agricultural practices to mitigate the depletion of vital water resources.

Environmental Aspects

Climate change presents an unrelenting and long-term external threat to Pakistan's water security, significantly impacting average water availability and inflow variability. Over the coming decades, climate change is expected to intensify the frequency and severity of both droughts and floods. Rising temperatures are projected to increase water demand by 5% to 15% (a threefold rise) by 2047, in addition to the rising demand caused by economic growth and population expansion. Coastal storms and rising sea levels will further exacerbate seawater intrusion into the Indus Delta and coastal groundwater in the Lower Indus Basin (LIB). Meanwhile, rapid glacier melting in the Upper Indus Basin (UIB) will increase the risk of glacial lake outburst floods (GLOFs) (Nie et al., 2021; Young et al., 2019).

Pakistan's geographical location amplifies its vulnerability to the adverse effects of climate change. Situated at 69.34° N longitude and 30.37° E latitude, it lies in the Northern and Eastern Hemispheres, north of the equator. This positioning makes Pakistan heavily reliant on snow and ice melt for its water supply. However, glaciers and snow in the country's mountainous regions are melting alarmingly, diminishing freshwater availability. Compounding this issue is the vulnerability of the Hindu Kush-Karakoram-Himalaya (HKH) range, which feeds the Indus Basin—the lifeline of Pakistan's water resources. Climate change is the driving force behind glacial fluctuations observed in the 21st century (Malik et al., 2012; Khan et al., 2024; Ashraf, 2025).

In 1991, the *Working Group on Himalayan Glaciology* predicted that Pakistan could lose its glaciers by 2035 if deglaciation continues unabated. Similarly, a World Bank report in 2005 warned that glaciers could retreat significantly within five decades, leading to water scarcity and desertification (Shahzad et al., 2020). With over 7,000 glaciers and 3,000 glacial lakes, Pakistan faces a grave risk, with 36 glacial lakes identified as highly dangerous, exposing nearly 7 million people to potential flash floods during warm months like July and August (Akbar, 2020).

The concept of 'Peak Water' offers insight into the long-term effects of glacial decline on water security. As glaciers shrink, runoff during the melt season initially increases, reaching a peak phase followed by a terminal phase and an irreversible decline phase (Geopolitical Monitor, 2019). In Pakistan, the rapid recession of glaciers

is expected to initially cause flooding due to the lack of adequate storage capacity. However, reduced glacier mass in subsequent decades will lead to diminished water availability, further aggravating the country's water crisis.

Political Aspects

The political factors contributing to Pakistan's water insecurity can be categorized into three primary dimensions, as outlined below.

Hydro-Politics Between India and Pakistan

Water has been a highly politicized resource between India and Pakistan since independence in 1947. The partition of the subcontinent along religious lines overlooked the hydrological dynamics of the Indus River Basin (IRB). This oversight, coupled with the disputed territory of Kashmir—home to the headwaters of the Indus River System—has exacerbated tensions. Early attempts to resolve water disputes, as envisioned by the British, failed due to the nascent governments' inability to reach an agreement.

Partition rendered Pakistan the lower riparian state, while India gained control over the canal headworks of the IRB. This sense of insecurity heightened in 1948 when India blocked the flow of the Sutlej River into Pakistan. Pakistan relies heavily on the IRB to meet its industrial, agricultural, and domestic water demands. However, India's increasing number of projects on the western rivers allocated to Pakistan under the 1960 Indus Water Treaty (IWT) has heightened Pakistan's vulnerability.

India has constructed or planned multiple dams on the Jhelum, Chenab, and Neelum Rivers, including contentious projects like the Kishenganga, Sawalkot, Ratle Dams, and the Wullar Barrage. Pakistan asserts that these projects will substantially reduce water flows, posing a significant threat to its irrigation systems and domestic water supply (Salik, 2015; Qureshi, 2017).

Another rising concern is Afghanistan's potential damming of the Kabul River Basin, which could reduce water inflow into Pakistan. Despite its critical contribution to the Indus flow, no formal water-sharing agreement exists between Pakistan and Afghanistan, adding another layer of insecurity.

Inter-provincial Water Disputes

Domestically, water distribution among Pakistan's provinces has become increasingly contentious, exacerbated by shrinking groundwater resources and political interests obstructing conflict resolution. The Sindh province, as the lower riparian unit, accuses the upper riparian provinces Punjab and Khyber Pakhtunkhwa (KPK) of appropriating its water share from the IRB via canals like the Taunsa-Panjnad and Chashma-Jhelum. Sindh alleges that Punjab uses water excessively and violates international water-sharing agreements and regulations.

The Kalabagh Dam project is a significant point of contention, with Sindh opposing it over concerns that it would create water shortages, reduce the water-storing capacities of Haleji Lake and Manchar Lake, and disproportionately benefit Punjab (Imran, 2021).

Issues of Water Governance

Weak governance exacerbates Pakistan's water challenges. Fragmented management, outdated infrastructure, lack of water-sharing agreements, and political interference prevent effective utilization and equitable distribution of water resources. Addressing these governance challenges is essential to resolving inter-provincial and external hydro-political conflicts, critical to improving Pakistan's water security. Poor water

governance has severely undermined water management in Pakistan. According to the Organisation for Economic Cooperation and Development (OECD), water governance encompasses the institutional, political, and administrative rules, processes, and practices essential for decision-making and implementation in water management. It also involves articulating stakeholders' interests and holding decision-makers accountable for their actions (OECD, 2018).

Despite receiving significant grants and loans from USAID, the World Bank, and the Asian Development Bank to improve water governance, Pakistan's water resources remain poorly managed. Key issues include inequitable and inefficient allocation of water resources, inadequate sanitation infrastructure, unregulated groundwater extraction, and significant water wastage due to a deteriorating irrigation system (Ali, 2021).

The National Water Policy 2018 marked a positive step towards addressing Pakistan's growing water security challenges (Ministry of Water Resources, Pakistan, 2022). However, the policy falls short of comprehensively outlining fundamental priorities or providing an effective mechanism for achieving its stated objectives (Abubakr, 2018). These shortcomings reflect the broader systemic issues that impede effective water governance in the country.

Legal Aspects

Legal frameworks play a critical role in managing water resources; however, both inter-state and intra-state arrangements in Pakistan exhibit significant limitations, contributing to the country's water insecurity.

At the inter-state level, the 1960 Indus Water Treaty (IWT), backed by the World Bank, documented the Indus River's water distribution between India and Pakistan. The treaty also delimited the obligation and rights of both states for water usage (Vater, 2021). The four components of IWT are as follows:

1. The treaty allocated Beas, Satluj, and Ravi (regarded as eastern rivers) to India, while Pakistan was given Chenab, Indus, and Jhelum (the western rivers)
2. To assist Pakistan, a financing plan was proposed for the construction of Tarbela Dam, Mangla Dam, and seven link canals in Pakistan
3. IWT allowed India to use the western river's hydroelectric potential with restrictions imposed on the storage capacity of dams to avoid their adverse impact on Pakistan
4. Another key aspect is related to the dispute resolution mechanism, and in case of failure, the treaty enshrines the role of an impartial arbiter, either ICA-International Court of Arbitration or the World Bank (Riffat & Iftikhar, 2015)

IWT proves to be a landmark treaty for resolving the transboundary water issue, but since the 1990s, the increasing water stress has placed a substantial strain on the treaty. Moreover, there are two crucial issues which the treaty does not address. The first issue is the division of shortages between Pakistan and India during the dry season, when water flow reduces to half compared to the wet season. The second issue is the impact of storage on Chenab River flows in Pakistan (Hassan, 2017). Additionally, the IWT's clause permitting India to utilize the western rivers for hydropower generation under specific restrictions has created multiple challenges for Pakistan. India's aggressive development of water infrastructure in Jammu and Kashmir, such as the Uri Hydroelectric Project, Dumkhar Project, Nimoo Bazgo Project, Chutak Barrage, Pakal Dul Dam, and Burar Dam, threatens to reduce water further flows into Pakistan. These

projects risk rendering Pakistan's canal system ineffective, severely impacting its agricultural sector (Shahzad et al., 2020).

Furthermore, the Kishenganga Project on the Neelum River and the Wular Barrage on the Jhelum River present similar challenges. Both projects prioritize water storage during winter when water flow is naturally low, exacerbating Pakistan's water scarcity. These developments underscore the urgent need for revisions and updates to the treaty to address contemporary challenges effectively.

At the state level, the *Water Apportionment Accord 1991* is the most significant legislation for resolving inter-provincial water disputes in Pakistan (Anwar & Bhatti, 2018). The accord allocated water from the Indus Basin as follows: 47% to Punjab, 42% to Sindh, 8% to KPK, and 3% to Balochistan. While it was an important step towards equitable distribution, the accord has failed to address key grievances, particularly those of Sindh.

One major shortcoming is the absence of provisions to ensure a minimum environmental flow (E-flow) through Sindh and into the Arabian Sea, which is critical for maintaining the ecological health of the Indus Delta. Additionally, Sindh accuses upstream provinces, particularly Punjab, of excessive water extraction for irrigation and dam construction, which reduces downstream water flows ("Pakistan's Provincial Water Disputes," 2016).

Another critical issue is the Accord's inflexibility. The water allocation formula is based on the average water flows from 1977 to 1982, making it outdated and unable to adapt to current challenges such as climate change and population growth. Furthermore, the accord lacks clearly defined operating rules and control mechanisms for managing water distribution infrastructure.

The most significant omission, however, is the failure to address the sharing of water shortages during periods of scarcity. This neglect has fueled conflicts between lower riparian provinces like Sindh and upper riparian provinces like Punjab and KPK, exacerbating inter-provincial tensions (Naushad, 2021). Addressing these gaps is essential for achieving more effective and equitable water governance within Pakistan.

Ethical Aspects

Ethical issues, such as water theft and corruption, significantly exacerbate Pakistan's water crisis, depriving millions of people of access to clean and sufficient water.

Water theft is a pervasive issue, particularly in Karachi, Pakistan's largest city, where inadequate water supply has become the norm. The city requires 1.1 billion gallons of water per day (BGD), but its supply capacity is only 550 million gallons daily. The primary water source, Keenjhar Lake, is located 150 km from Karachi, and water reaches the city through canals to main pumping stations before being distributed via pipelines or water tankers. However, this system is plagued by theft. According to the Karachi Water and Sewerage Board (KWSB), an estimated 42% of the water is either stolen or lost before it reaches end users (Riiter, 2018).

Initially introduced as a short-term solution to Karachi's water supply challenges, the water tanker system has evolved into a significant part of the distribution network. While KWSB legally operates 10 hydrants, the city is burdened by nearly 100 illegal hydrants controlled by the 'water tanker mafia.' This group draws water illicitly and sells it at exorbitant prices, making clean water unaffordable for many poor residents. The illegal water industry in Karachi is estimated to exceed $0.5 billion in value, turning water theft into a lucrative business at the expense of public welfare (Hashim, 2022).

Corruption in Pakistan's water sector is another critical ethical challenge. According to surveys conducted by Transparency International (TI) in 2003 and 2006, the Water and Power Development Authority (WAPDA) ranked as the second most corrupt institution in the country. The 'Global Corruption Report' by Transparency International (2008) further highlighted the impact of widespread corruption on various aspects of the water sector, including irrigation, drinking water services, hydropower, and water resources management.

Corruption in these areas exacerbates issues such as poor access to potable water, inefficient irrigation systems, and hindered economic development. Funds intended for water infrastructure and services are often misallocated or embezzled, leaving critical projects underfunded and perpetuating water scarcity for millions of people (Transparency International, 2008).

Implications of Water Insecurity for Pakistan

Water insecurity in Pakistan has multifaceted ramifications, impacting its social, economic, and political fabric. Socially, inadequate or lack of access to water not only jeopardizes the health and well-being of individuals but also exacerbates existing inequalities, disproportionately affecting vulnerable segments of society. Economically, water insecurity deepens economic disparities due to its adverse effects on the agricultural sector, a fundamental source of livelihood in the country. Politically, challenges associated with water security have the potential to amplify governance issues and fuel conflicts over scarce water resources, thereby threatening national stability.

Water scarcity significantly worsens Pakistan's already dire food security situation. According to the 2021 Global Food Security Index, Pakistan ranked 75th out of 113 states (Economist Impact, n.d.). Rapid depletion of glacial reservoirs in the country is projected to cause a 40% reduction in the flow of the Indus Basin Rivers, which sustain the agricultural sector, thus posing a significant threat to food security. Since 2018, a 45% decline in average rainfall has severely impacted Kharif crops, including rice, millet, maize, and sugarcane. This escalating food stress has led to widespread undernourishment, particularly undermining women's health (Mansoor & Mukhtar, 2021).

The scarcity of healthy and safe drinking water has forced most of Pakistan's population to rely on unsafe water sources. Approximately 80% of the population consumes polluted water, while only 20% have access to clean drinking water (Nabi et al., 2019). The primary source of water contamination is fecal matter and sewage, while secondary sources include chemicals from fertilizers, pesticides, and industrial effluents discharged into water bodies. Waterborne diseases caused by human activities account for 80% of all diseases and 33% of total deaths in the country (Daud et al., 2017). Pakistan ranks 80th out of 122 states regarding drinking water quality, primarily due to poor management and insufficient monitoring of water safety standards, which poses significant public health risks. The consumption of polluted ground and surface water leads to numerous diseases, including typhoid, hepatitis, diarrhea, and intestinal worms, resulting in an estimated GDP loss of 0.6-1.44% or 25-28 billion (Pakistan Rupees) in annual income losses (Bashir et al., 2021).

The economic impact of water scarcity extends beyond GDP and income losses. The unavailability of water for agricultural production threatens Pakistan's agrarian economy, which depends on irrigation.

Migration is another consequence of the water crisis in Pakistan, which has a severe impact on livelihoods. According to the Pakistan Meteorological Department, as mentioned in the report by Islamic Relief on Climate-Induced Migration in Pakistan: Global Discourse, Local Realities and Governance, nearly 33% of the population from districts such as Washuk, Kharan, Noshki, and Chagai have migrated due to water scarcity (Islamic Relief Worldwide, 2021). Similarly, residents of the Chitral District have been forced to relocate because of land infertility and water shortages, creating an economic crisis for those left without income sources or access to education. Additionally, flash floods and torrential rainfall have compelled communities in Gilgit-Baltistan to migrate to safer areas. Future predictions are even more alarming. For example, if sea levels continue to rise at the current rate, Karachi is projected to be submerged by 2060, with Badin and Thatta potentially underwater by 2050 (Durrani, 2020).

Water insecurity also has the potential to trigger conflicts within Pakistan and between Pakistan and India. Both nuclear-armed neighbors have a long-standing rivalry over the Indus Basin water resources. Climate change, a significant driver of declining water availability, exacerbates this transboundary water dispute, which could escalate into a broader conflict (Shams, 2022). South Asia's central water reserves originate in the disputed Kashmir region, increasing the risk of regional instability. The Indus Waters Treaty (IWT) has historically helped manage this conflict. However, climate-induced water scarcity could undermine the treaty's effectiveness, resulting in severe and potentially irreversible repercussions for both Pakistan and India (Taimur, 2022).

Domestically, water scarcity has the potential to spark intra-state conflicts, posing threats to Pakistan's national security. Karachi serves as a test case, where rampant water theft and shortages have already strained governance. The government's inability to manage the water crisis could lead to widespread urban violence (Ahmar, 2021). Additionally, the economic ramifications of water conflicts are breeding divisions among communities, exacerbating inter-provincial rivalries over water resources, and further threatening national unity (Shams, 2022).

Way Forward

The Integrated Water Resources Management approach is the panacea for Pakistan's water crisis. IWRM signifies a process that encourages the harmonized management-cum-development of land, water, and associated resources for the maximization of equitable social and economic welfare while keeping eco-system sustainability in consideration. Being the cross-sectoral policy approach, IWRM promotes integrating environmental, industrial, and agricultural water demands into water catchment management, emphasizes inclusive participation of all water users, and encourages equilibrium in ecosystem sustainability, economic efficiency, and social equity. Additionally, it emboldens women's role in water management (United Nations Environment Program, 2020). Regarding Pakistan, IWRM shall include the following key priorities.

Water Tax

Water rates in Pakistan are currently insufficient, with inadequate collection mechanisms failing to cover even the essential Operation and Maintenance (O&M) costs. Over time, this deficiency has been exacerbated, resulting in a substantial gap in the water sector's financial sustainability. To address this, enhancing farmers' paying capacity for appropriate water rates is imperative to ensure O&M requirements are met effectively.

The exceedingly low Abiana (water charges imposed by the Provincial Governments of Pakistan for irrigation) not only encourages consumers to use water wastefully but also limits the availability of funds necessary for proper O&M. Increasing water taxes is essential to ensure fair coverage of O&M costs, promote responsible water consumption, and support the long-term development of water sector infrastructure. This adjustment will help create a sustainable framework for managing water resources more effectively in the future. Furthermore, water 'metering' is indispensable for measuring the amount of utilization in the agricultural, industrial, and domestic sectors to ensure pragmatic management of water resources.

Irrigation System and Changing Cropping Patterns

The conveyance efficiency shall be improved in Pakistan, and for that purpose, concrete control- structures must be installed to improve the watercourses, minors, and distributaries. Moreover, it is crucial to ameliorate surface irrigation techniques and methods to enhance water application efficiency. Bed and furrow irrigation techniques can be compulsory for growing grain and row crops such as maize, wheat, and cotton in plain areas. Additionally, drip irrigation remains the most modern and efficient technology for saving water and increasing yield, particularly for rice crops. Other techniques like zero tillage and precision land leveling can improve water productivity.

Variability in cropping patterns should be considered for water conservation and bridging the demand-supply gap. Shifting from water-intensive food crops (rice, maize, and wheat) to less water-intensive cash crops is essential for conserving water and boosting the economy.

Effective Groundwater Regulation and Building Water Reservoirs

Excessive groundwater abstraction must be regulated through a stringent legal framework entailing proper pricing and monitoring for tube well installation. Controlled groundwater extraction is essential for recharge and ensuring a sustainable water supply.

The construction of multipurpose water reservoirs should be a top priority for the government. These dams can fulfill various purposes such as water storage, water supply for various sectors, water regulation and flood control, and hydropower generation. This would resolve the issue of water scarcity, curb the hazardous impact of climate change, and, most importantly, reduce the burden on the economy linked with fuel imports for electricity generation. The sites for these dams can be Tarbela's downstream and northern areas.

Conflict Management of Inter-Provincial Water Disputes

The conflict among the provinces over water distribution can be tackled by applying mathematical models proposed by various authors (Janjua & Hassan, 2020). For instance, the bankruptcy game technique can be employed as a water allocation mechanism given the competing water demands amidst critical scarce conditions.

Hydro-diplomacy and Water Governance

In addition, hydro diplomacy and negotiations are key to developing a consensus among provinces. The Pakistan-Afghanistan agreement over water sharing is necessary to avoid transforming differences into water disputes. Furthermore, diplomatic efforts to exchange water data with India shall not cease.

Effective coordination and collaboration among the various actors are indispensable for the sustainable management of water resources. Existing regulations should be improved, and significant policy and legal framework lacunas must be filled.

Additionally, government departments' institutional and human capacity shall be enhanced, coupled with water users' structured participation.

Awareness Campaigns & Public-Private Partnership

Campaigns to generate awareness and convey the water insecurity issue shall target different sectors. This approach can sensitize the issue and encourage contribution towards the dual cause of water conservation and management. Moreover, the government should encourage the PPP Public-Private partnership, particularly for water recycling and optimal water pricing, to overcome financial constraints and ensure sustainable resource management.

Conclusion

Pakistan's water security predicament underscores the gravity of the challenges confronting the nation. The widening gap between water demand and supply, exacerbated by persistent shortages, propels the country toward acute water insecurity. This situation is expected to deteriorate further due to social, technical, economic, environmental, political, legal, and ethical factors. Among these, population explosion and the changing hydrology of the Indus Basin are the most critical, acting as catalysts that amplify the adverse effects of other contributing factors. With declining per capita water availability driven by a growing population and the impacts of climate change, the demand for water in industrial, domestic, and—most critically—agricultural sectors is surging. This escalating demand puts enormous strain on the government's ability to effectively manage water resources, with potentially dire social, political, and economic consequences. Urgent and drastic policy interventions are needed to address these challenges; otherwise, the country risks severe upheaval, jeopardizing both human and national security.

A comprehensive and integrated approach to water conservation and management is essential to meet the diverse demands of various sectors. Addressing all the aforementioned factors is imperative for devising a holistic strategy. Altering and regulating water-use behavior through innovative water policies and appropriate institutional reforms can significantly mitigate water insecurity. Such measures would stabilize the situation and pave the way for sustainable development and accelerated economic growth. Although achieving this vision appears complex and incremental, it is feasible through implementing an IWRM policy swiftly and effectively. This approach would foster efficient use of water resources, ensuring their sustainability for future generations while addressing the multifaceted challenges of water security.

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