

The Future of Water Security in Pakistan: Challenges and Opportunities

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Abstract

This study examines that Pakistan's water security faces significant obstacles in the future, but there are also chances for sustainable development. Population growth, climate change, poor management, and geopolitical tensions are all contributing to Pakistan's rapidly worsening water crisis, which has resulted in a sharp drop in per capita water availability of more than 70% over the past 70 years and growing water scarcity that is expected to get worse by 2040. The research employs qualitative design, descriptive, and historical methods to assess the challenges and opportunities of water security in future. The study also examines the water issues like rising population, climate change, and ineffective water management techniques pose serious threats to Pakistan's water security and widen the gap between supply and demand. The study concludes with recommendations to improve Pakistan's water security issues. A balanced strategy that prioritizes both boosting water availability and lowering demand is required to safeguard Pakistan's future water supply.

Keywords: Water Security, Climate Change, Water Resources, Indus Basin, Pakistan.

Introduction

Water security is linked to human rights, with access to clean water considered a fundamental right for all citizens. Growing population, careless water consumption, and changing weather patterns due to global warming are affecting countries worldwide. Both the wealthy and the poor will experience increased water scarcity in the twenty-first century. Pakistan's long-term economic success is seriously threatened by water scarcity. Out of 17 countries with "very high-water risk," which includes both hot and dry regions, the nation is ranked 14th. 4. The country's water crisis affects almost 80% of its people. At least one month of the year is characterized by scarcity. Pakistan's final resort for water supply, groundwater, is severely depleted, primarily for irrigation. If nothing changes, there could be a severe water shortage throughout the country by 2025. Pakistan, India's lower riparian nation, receives 78% of India's water supplies, making the issue much more complex. Because 95.8% of Pakistan's renewable water resources come from the Indus River system, the country's reliance on the Indus River system is quite dangerous. Because

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over three-quarters (78 percent) of Pakistan's water supplies are imported, the country is at risk (Mukhtar, 2021).

Pakistan is one of the 10 nations most at risk from climate change worldwide. The country's water supply is already under jeopardy due to rising temperatures, melting glaciers, changed rainfall patterns, and a rise in floods and droughts. Pakistan has recently experienced numerous floods as well as protracted droughts. Future collective water flows may decrease as a result of climate change. With an estimated population of over 220 million, the nation can continue to use 191 million acre-feet of water annually, but its water demand may rise to 274 million acre-feet and climb. It is projected that by 2050, Pakistan's population will have grown by over fifty-three percent to 338 million. In addition, it is predicted that a majority of people will reside in cities by the year 2050, compared to 37.2 per cent in 2020. 8. The ratio of water resources to water withdrawal could surpass 100% in the coming decades if water efficiency stays the same.

This study examines that Pakistan's rapid population growth, changing climate (droughts and floods), inadequate agricultural water management, ineffective infrastructure, and water pollution are the main reasons for the country's water issues, according to this report. The disparity between policies, changes, and their execution must be closed by creating a thorough implementation strategy. Not a water disaster, according to experts. Technology is necessary to use water effectively, but choosing the right innovation is also crucial to guaranteeing that the desired outcome is obtained. Farmers can use precision watering to irrigate their fields without flooding them. Drip irrigation is among modern agriculture's most significant innovations. Likewise, crops that require less water, such as sugar cane and rice, could take the place of others that do (Hashmi et al., 2025).

Figure 1: River flows and water availability

Table 2: River flows and Water Availability (1979-2015) (MAF)

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

Source: Water and Power Development Authority

Literature Review

Most of Pakistan's population makes their livelihood from agriculture, the country's primary source of income. It also substantially contributes to financial development and foreign exchange profits, battles rural poverty, maintains nutritional and food security, and offers essential supplies for

industry. This study looks at how the unusual modifications to ice and snow melt structures and changes in snowfall tendencies and timing caused by climate change might significantly affect the basin's management of water resources (Munir et al., 2021).

Life on Earth depends on water to survive. Fresh, clean water is essential for good living conditions and the maintenance of food chains. Pakistan's water supplies have been under stress and pressure, like many other nations, especially in Asia, for various reasons. These include high rates of population growth, aristocratic and feudal authority over areas that benefit the neighbourhood, rapid urbanization, climate change, social and local disparities, a lack of governmental accountability, and governance problems. This study examines the dynamic factors contributing to these issues and evaluates the consequences for human development (Khan & Khalid, 2016).

Pakistan is facing severe water scarcity despite its plentiful water resources. The present-day population of 225 million is projected to increase to 250 million by 2025. By 2025, Pakistan's water consumption is expected to reach 338 km³ at a yearly increase, whereas the country's water supply is only between 240 and 258 km³. 83% of the groundwater is utilized for agriculture and other uses, although roughly 74% of the available surface water is collected. This study examines Pakistan's surface and subsurface water resources, storage reservoirs, and sectoral utilization (Ishaque et al., 2023).

Climate change has a major effect on human health worldwide, especially for people living in underdeveloped nations. Although the government, educational institutions, and industrial water bodies are conducting water quality checks and providing medical services, the present methods of water purification, leadership, and governance still need to be improved (Ahmed et al., 2020).

Working on demand—and supply-side management solutions is challenging. Controlling groundwater abstraction requires the effective implementation of regulatory measures. Educational initiatives should raise awareness of all groundwater users to maximize profits from producing high-value crops and deploy water-saving technologies to reduce groundwater extraction (Qureshi, 2018).

The accessible nature of groundwater is one element that distinguishes welfare in Pakistan from poverty. Rapidly declining groundwater tables and rising amounts of salt in piped groundwater threaten the long-term sustainability of irrigated farming. Farmers require improved irrigation purposes and agronomic practices to regulate demand, and a deeper understanding of the socio-ecology and characteristics of groundwater is required before developing management strategies (Qureshi et al., 2010).

Pakistan already has a shortage of water for both rural and urban purposes. Numerous in-depth studies on the water sector, a national water policy, and a strategy for climate change are all limited in their implementation by institutional, political, and budgetary obstacles. Because of national and provincial laws controlling surface and groundwater leadership and the fair allocation of benefits and costs among stakeholders, integrated management of water resources and other innovative integrated solutions could not be implemented (Khan, 2019).

Climate change is now an inevitable phenomenon rather than a fantasy—South Asia's consequences of climate change, especially in Pakistan. The study examines the causes of the region's heightened susceptibility to climate change, describes the economic, social, and environmental consequences of recent floods, and evaluates the effectiveness of existing policies and programs in mitigating these impacts (Adnan et al., 2024).

Pakistan's water quality and management are terrible, particularly in the impoverished province of Baluchistan. All water-using businesses are increasing their demand, which is making water

shortages worse. There will be 247 million people in 2025, up from 175 million in 2010, and the adverse effects of climate change significantly influence the amount and quality of water. Concerns about internal security and ongoing political unrest deter investors from making short- to medium-term investments in Pakistan's water sector (Ishaque & Zia, 2025).

India's water hegemony as an upper riparian, population increase, excessive groundwater consumption, climate-induced water stress, ineffective irrigation, and insufficient storage capacity make water management the most significant issue facing Pakistanis in the twenty-first century. Without strict water management strategies and dam construction, the country would not be water secure (Nawaz et al., 2024).

Water is a vital element. Fresh, clean water must be available to maintain food chains and improve living conditions. However, there is a wider gap between water accessibility and demand due to decreasing water volume and increasing water demands. Knowing the water systems, agreeing on water distribution between provinces, and avoiding inconsistencies in Pakistan are important (Khan & Khalid, 2016).

The severe water scarcity in Pakistan results from inadequate storage infrastructure, inadequate water governance, and the adverse effects of climate change. Water availability per person is rapidly declining; it was 5,000 m³ in 1951, 1,100 m³ in 2005, and is predicted to drop to 800 m³ by 2025. By 2025, the worldwide population of 225 million is predicted to grow to 250 million. Pakistan's water usage is expected to increase at an average yearly rate of 10% to 338 km³ by 2025, compared to the 240–258 km³ of accessible water. Approximately 74% of the surface water that is accessible is collected, and 83% of the groundwater is used for agriculture and other purposes (Ishaque, 2023).

Unreliable piped water delivery and dangerously low groundwater levels are two issues Pakistani cities are increasingly dealing with. Theft and leaks in water distribution networks squander 35 to 40 per cent of piped water. The number of people living in cities will double by 2050, from 81 million in 2022 to 160 million in 2050, accounting for 37.7 and 52.2% of the overall population. It is difficult for these residents to get water, and getting the funds to pay for it is harder. Urban water rates are cheap and rarely changed despite recent reform initiatives. (Hashmi et al., 2025).

Research Methodology

A historical, descriptive, and analytical technique is used to proceed with the study and come to a conclusion. The qualitative approach is used. This study's data came from print publications, including books, papers, journals, and official reports. The research evaluates, with an emphasis on potential problems, the future of water security in Pakistan and calls for a thorough, multidisciplinary approach that incorporates stakeholder involvement, policy evaluation, data analysis, and technological assessment. To ensure water security in the future, more research and adaptation strategies are desperately needed as governmental policies change in response to these opportunities and problems.

Results and Discussion

The country's sustainable growth, food security, and public health are all seriously threatened by Pakistan's growing and pressing water shortage problem. Given the country's fast-growing population, currently over 240 million, water demands have increased while the amount of water accessible has decreased. More than 90% of Pakistan's freshwater supplies come from the Indus River system, which is important to the country. However, water waste has increased significantly due to inadequate infrastructure maintenance, ineffective irrigation techniques, and poor water

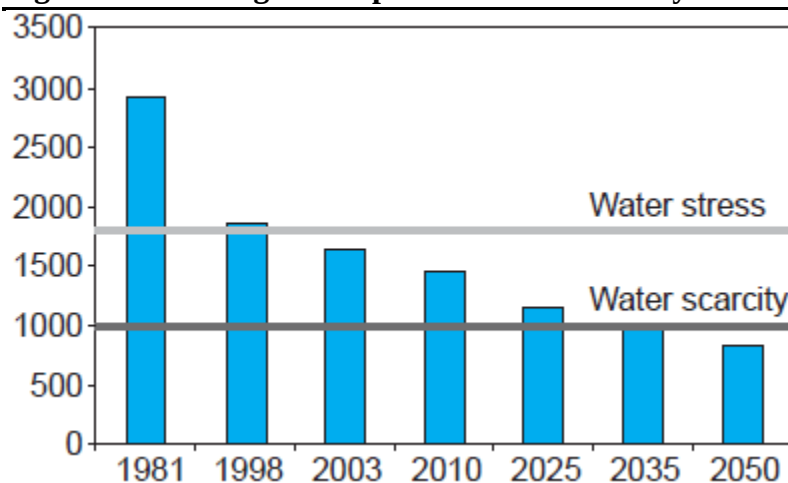
management. Unpredictable rainfall patterns, fewer glaciers melting due to warming temperatures, and protracted droughts that impact water availability are all consequences of climate change. Increased water pollution is another effect of urbanization and industrialization.

Water Scarcity Faced by Pakistan

Making a large portion of the available water unusable for agriculture or human consumption. The nation currently faces a situation where the amount of water available per person has fallen below the 1,000 cubic meters per year water scarcity level. According to some predictions, Pakistan may experience complete water scarcity by 2025 without immediate action. Contributing elements such as political inertia, a lack of public understanding, and disagreements with other nations over water rights make the situation more difficult. Pakistan must adopt integrated management of water resources plans, encourage water conservation, invest in cutting-edge irrigation systems, and strengthen regional collaboration on international water issues to solve this impending catastrophe. Pakistan is at a turning point in its water management. Due to the increasing demand from all sectors that use water, water shortages are getting worse very quickly. In addition to pressure to increase agricultural production of staples due to international food price spikes and rapid population growth (from 175 million in 2010 to an estimated 236 million by 2030 and 280 million by 2050), there is also a growing demand for cash crops, such as cotton, fruit trees, and tobacco, to boost rural incomes and create jobs to absorb the relatively young. The sourcing and use of water are impacted by climate change, which also has an increasing impact on water management due to a rise in flood and drought occurrences and a developing energy constraint (Ringler & Anwar, 2013)

A necessary component for the maintenance of life on Earth is water. Fresh and clean water availability is essential to sustaining food chains and improving living conditions. However, the gap between water accessibility and demand has widened due to decreased water volume and increased consumption. Like many other nations, especially in Asia, Pakistan's water resources are under pressure and overstressed due to several factors, including rapid urbanization, climate change, local and social differences, feudal and aristocratic dominance over community-beneficial areas, high population growth rates, a lack of institutional accountability, and governance issues.

Figure 2: Declining Per Capita Water Availability in Pakistan (meters³/capita/year)



Source: World Bank 2005.

Role of Non-State Actors

In Pakistan, non-state players are essential to solving the nation's escalating water security issues. These actors play a major role in water management, awareness, and innovation. They include non-governmental organizations, civil society organizations, academic institutions, international development agencies, business sector companies, and the media. Campaigns to raise public awareness about pollution prevention, sustainable use, and water conservation are actively carried out by NGOs and civil society groups (Qureshi, Gill & Sarwar, 2010). Essential research on water resources, the effects of climate change, and policy solutions is carried out by academic institutions and think tanks. They also support technology advancements like water purification systems and drip irrigation.

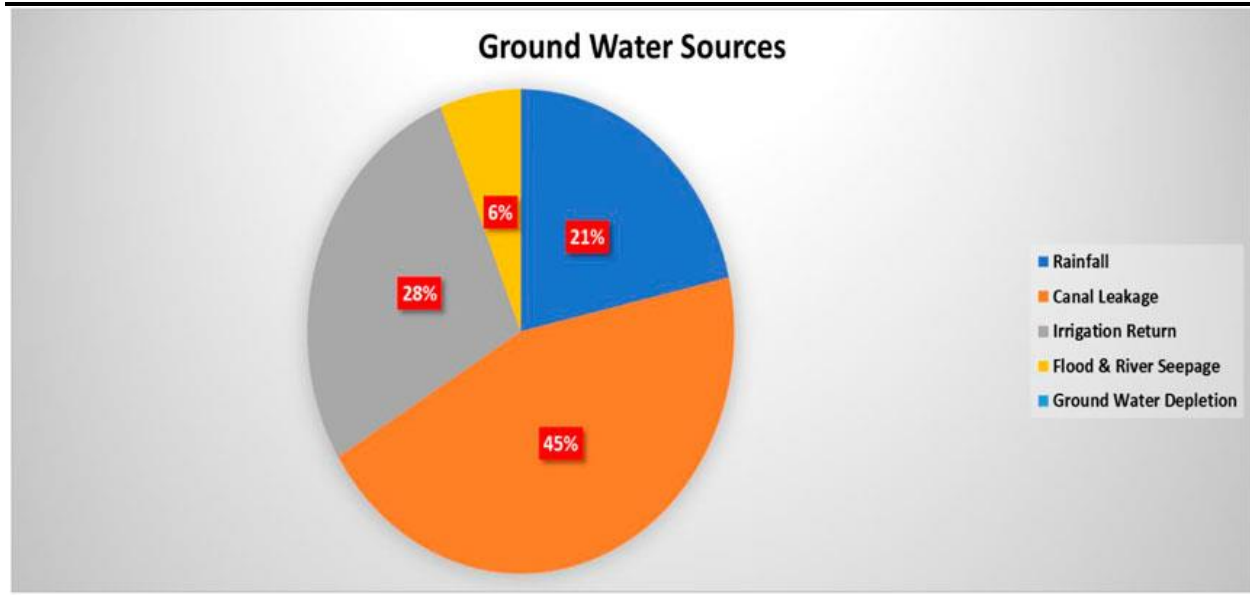
Concerns have been raised over the improper usage or administration of projects involving water. There have been allegations of excessive groundwater extraction for commercial purposes by some private corporations and even non-governmental organizations, which has led to depletion and harmed local populations. Without proper control, some bottled water corporations have taken advantage of water supplies, causing environmental damage and unequal water distribution. Furthermore, opaque donor-funded programs can occasionally lead to ineffective resource allocation and a failure to achieve long-term water security objectives. Water-related infrastructure or assistance may be monopolised in some places by politically connected parties, preventing marginalised groups from accessing it. These difficulties demonstrate the necessity of improved cooperation between state and non-state actors, more regulatory monitoring, and accountability in order to guarantee the efficacy and equity of initiatives to improve water security in Pakistan.

The country's water-stressed conditions are mostly abused by certain non-state actors and pressure organizations who take advantage of the underprivileged to further their own goals. Thus, it is vital to comprehend Pakistan's water accessibility, acceptable water distribution among provinces, water methods, inconsistencies, and requirements.

Rapid Groundwater Depletion

Rapid groundwater depletion is one of the biggest issues in important agricultural regions like Punjab and Sindh. Uncontrolled tube wells and excessive irrigation are causing the water table to drop. Furthermore, Pakistan's reliance on the Indus Basin as its only river system makes it more susceptible to geopolitical threats and climatic fluctuations, especially in light of India's obligations within the Indus Waters Treaty. According to the data, Pakistan uses over 90% of its water for agriculture, but a large portion of that is squandered because of ineffective irrigation techniques like flood irrigation. Nevertheless, the nation does not have an extensive national water strategy that covers conservation, pricing, and allocation.

The country's declining water supplies are not a sudden occurrence; rather, they are the result of a number of interrelated events. The disaster was caused by a water-intensive and deteriorating irrigation system, a lack of water infrastructure, and the general disregard for water governance by the succeeding administrations. Most significantly, the growing population is still a cause for concern because it has the enormous potential to raise consumption, which would put further strain on the limited supply of water. By 2025, the country's water demand-supply mismatch is predicted to reach 83-million-acre fields (MAF), per a 2015 International Monetary Fund study titled "Water Security Challenges." This is because it is anticipated that the water supply would stay at 191 MAF while the demand will rise to 274 MA (Quershi & Sarwar, 2010).

Figure 3: Groundwater sources in Pakistan (World Bank Report)

Climate Change

Climate change is another crucial factor to consider because it would hasten water-related disasters and diminish hydrological supplies. The Global Temperature Risk Index ranks Pakistan as the fifth nation most susceptible to the potential long-term consequences of environmental degradation, which include the resurgence of drought and floods, modifications in both the intensity and timing of precipitation and the disappearance of the Himalayan glaciers. Additionally, water security is seriously endangered by contamination with water from wastewater from factories, agricultural runoff, and sewerage, given that 80% of humanity lacks access to clean water.

Only its necessary quantity, both in terms of quality and quantity, has positive impacts because its scarcity can lead to food insecurity and other climate change-related consequences. At the same time, its abundance can cause havoc through floods and other natural disasters. Pakistan is "among the top 33 countries experiencing severe water stress," with Karachi as the world's sixth most water-insecure metropolis. According to forecasts, Pakistan is expected to experience severe water scarcity in 2025. Thus, this study aims to understand the idea of water security while considering Pakistan's current water availability situation and shifting climatic, meteorological, and rainfall patterns to project Pakistan's vulnerability index and offer solutions for future water-related issues.

Pakistan's water profile provides a representation of the severe problems with water security that have existed in the past, present, and future. It has experienced a dramatic change from a country with plentiful water resources to one "water-stressed." In 2018, the Pakistani Committee on Water Relations (PCRWR) conducted research that found that the situation worsened when Pak crossed the so-called "water stress line" in the year 1990 and then the "water shortage line" in 2005 (Khetran, 2023). According to the International Monetary Fund (IMF), Pakistan was third among 36 states facing a severe water deficit. During 1951 and 2017, the amount of drinking water supplied per person decreased from 5,650 cubic yards to 908 cubic meters annually; by 2025, it is expected to drop to 860 cubic meters. If an efficient water conservation plan is not implemented, Pakistan may face total water scarcity by 2040, with only 500 cubic meters of water available.

Indus Water Tension

Water conflicts between the provinces of Pakistan and India over the Indus Valley Basin System will also threaten water security in the next ten years. The average flow in the Indus Basin has decreased by 40%, primarily due to climate change. Tensions are rising due to Sindh and Punjab experiencing a severe water deficit, with each region blaming the other for allocating its share. Due to the extremely low water levels in Tarbela and Mangla Dam, there is a general fear of drought. Furthermore, Pakistan's water shortage will worsen by India's control over water headworks and the building of numerous run-of-the-river dams, including the Kishanganga project.

Figure 4: Indus rivers system in Pakistan



Findings

The results show that the main causes of Pakistan's water crisis are weak governance, population increase, and climate change. Pakistan's water security is inextricably tied to both state and human security. Water is still necessary for food, economic, environmental, and health security in terms of human security. Furthermore, in terms of disputes between India and Pakistan over water, the water issue can pose a danger to Pakistan's traditional security. Black, dystopian image of Pakistan's water security shows how deadly it is for both the people and the government (Mansoor, 2024).

The results make it evident that water security will have a significant impact on Pakistan's future. It has emerged as a potent non-traditional security concern that jeopardizes the two primary referent objects of security: “state” and “human.” Reduced water-related disasters and water-borne pollution, fewer water-related conflicts that may result from water sharing between and within states, and adequate water supply and quality for long-term socioeconomic growth are the cornerstones of water security. The impending water security catastrophe in Pakistan is predicted by the country’s severe water shortage and declining water quality.

Figure 5: Elements of the proposed water governance model



Challenges

Severe Water Scarcity: With estimates suggesting that water availability could fall to 500 cubic meters per capita by 2040, well below the water scarcity threshold, Pakistan is quickly transitioning from water stress to acute water scarcity. At least one month of severe water scarcity occurs yearly for more than 80% of the population.

Pakistan's population is estimated to surpass 300 million by 2050, significantly damaging its freshwater resources. The growing demand for household, commercial, and agricultural water leads to unsustainable water extraction. As temperatures rise, the glacial melt in the Himalayas is speeding up, threatening long-term water supplies and causing unpredictable water flows. Floods and droughts are occurring more frequently, which disrupts agriculture and lives.

Pakistan's water security faces many obstacles that could jeopardize the nation's environmental sustainability and socioeconomic stability. A primary obstacle is the swift increase in population, which is raising the need for water in the industrial, agricultural, and residential sectors. Alongside this is the antiquated and ineffective irrigation infrastructure, which, especially in the agricultural sector, which uses about 90% of the nation's freshwater, loses over 60% of its water owing to seepage and poor management. Another danger is climate change, which is causing irregular rainfall, melting Himalayan glaciers, and increased droughts and floods, all causing instability in the water supply.

Around 18.6 million acre-feet (MAF) of storage space is available in the Indus Basin, but this is insufficient to control supplies during dry years or satisfy future demands. The current system cannot store excess water from rainy years for use during dry ones.

Competition for water is fiercer due to population expansion and rising industrial and residential water demand, particularly between agriculture (which uses the bulk) and other industries. By 2030, excessive groundwater extraction primarily for irrigation could deplete supplies, worsening scarcity. Due to climate change, the Indus River's flow has decreased by roughly 40%, raising concerns about drought and low reservoir levels (such as those caused by the Tarbela and Mangla dams). Extreme weather occurrences like droughts and floods further strain water resources.

In India, disputes over water distribution between provinces (such as those between Sindh and Punjab) are made worse by upstream activity, such as dam construction that alters downstream flows. Rapid urbanisation raises water demand in cities where groundwater levels drop, and the

supply is unpredictable. Due to theft and leaks, around 43% of urban dwellers cannot access safely regulated water. Inefficient water use, canal leaks, and outdated irrigation systems lower total water efficiency. Waste and over-extraction result from improper pricing, regulation, and metering.

Excessive and uncontrolled groundwater extraction is causing water tables to drop in urban and agricultural areas in particular. Untreated home and industrial wastewater contaminates rivers and groundwater, reducing the availability of clean water. Agricultural runoff containing fertilizers and pesticides further contaminates water supplies (Masoor, 2025).

Opportunities

Reducing water losses and enhancing supply reliability can be achieved by constructing new reservoirs and small dams and updating irrigation and distribution infrastructure. Since agriculture utilizes the majority of water, increasing the effectiveness of water use in this sector is crucial to guarantee food and water security. Conflicts can be avoided, and sustainability can be enhanced by implementing integrated water resource management, encouraging fair water distribution, and upholding water-sharing agreements.

It is essential to make water infrastructure and management systems more resilient to handle extreme events and climatic unpredictability. Meeting rising urban demand can be facilitated by addressing urban water losses, investing in infrastructure for a safe water supply, and modifying rates. Water security initiatives can be supported by expanded responsibilities for donor organizations and diplomatic engagement, particularly concerning Trans boundary India's transboundary water issue.

Encouraging the use of water-efficient equipment and water-saving solutions like drip irrigation. Nationwide initiatives to raise awareness of the value of water conservation in local communities. To ensure water-efficient farming, move towards more irrigation techniques, soil moisture monitoring, and fewer water-intensive crops. Enforcing stringent provincial and federal water governance laws and regulations and strengthening organizations such as the Pakistan Council of Research in Water Resources (PCRWR) (Khetran, 2019).

Conclusion

The state of Pakistan's water security underscores the scope of the nation's issues. The rising gap between demand and supply for water, exacerbated by persistent shortages, is causing the country to approach extreme water insecurity. It is anticipated that social, technical, economic, environmental, political, legal, and ethical elements will cause this scenario to worsen even more. The two most important are the population boom and the shifting hydrology of the Indus Basin, which serve as triggers to intensify the negative consequences of other contributing elements. Growing populations and the effects of climate change are causing the per capita water supply to decline, which is driving up demand for water in the home, business, and, most importantly, agricultural sectors. The government's capacity to efficiently manage water supplies is severely strained by this growing demand, which might have disastrous social, political, and economic repercussions. Addressing these issues requires immediate and significant policy changes; otherwise, the nation faces severe instability that could endanger national security and human rights (Mansoor, 2025).

In the area of managing water resources, Pakistan is confronted with significant obstacles today. The country has a startlingly high rate of drinking water pollution, which impacts both urban and rural communities and exacerbates water pollution problems. There are flaws and

insufficiencies in the current WRM norms and regulations. Several issues, including urbanization, population expansion, climate change, and water contamination, seriously threaten the efficient management of water resources. The discharge of agricultural runoff, uncontrolled use, and insufficient wastewater treatment all contribute to the serious problems of groundwater contamination and depletion.

Recommendations

Pakistan's future water security necessitates a multifaceted approach that places equal emphasis on increasing water supply and reducing consumption. This means developing additional storage infrastructure, improving water resource management techniques, and addressing the root causes of water shortage, including population increase and climate change.

Pakistan must adopt strategies, including crop diversification, water harvesting, and the adoption of drought-resistant crops, to adjust to the changing environment. By doing this, farmers will be able to sustain their agricultural yield while adjusting to the changing environment. Pakistan must also put policies in place to curb population growth, like family planning and education initiatives. This will lessen the nation's finite water supply demand (Mukhtar, 2020).

Pakistan must invest in water distribution and storage facilities to enhance its water management. This will improve the amount of water available for agriculture and lessen water waste. Pakistan must engage in extensive reforestation projects to improve the soil's ability to retain water and reduce soil erosion. Rainfall will rise, raising the nation's overall agricultural output.

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