
# IMPLEMENTING INTEGRATED WATER RESOURCE MANAGEMENT (IWRM) FOR AGRICULTURAL SUSTAINABILITY IN PAKISTAN

EZBA WALAYAT KHAN

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# IMPLEMENTING INTEGRATED WATER RESOURCE MANAGEMENT (IWRM) FOR AGRICULTURAL SUSTAINABILITY IN PAKISTAN: LEARNING FROM BEST PRACTICES

Ezba Walayat Khan
Centre for Aerospace and Security Studies, CASS Lahore
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# ABSTRACT

Pakistan's agricultural sector is severely impacted by a fragmented water management system, resulting in inefficiencies and misuse of this critical resource. It is a matter of great concern that 50% of the water used in agriculture is wasted due to mismanagement. This paper highlights that the Indus Basin, which is essential for Pakistan's agriculture, confronts water challenges due to competing demands and changing climatic circumstances. The primary objective of this study is to examine how Integrated Water Resource Management (IWRM) can be implemented to address Pakistan's water resources challenges and promote sustainable agriculture. This paper provides an analysis of Pakistan's inefficient traditional irrigation systems such as *warabandi* and flood irrigation that result in significant water losses. Therefore, this paper provides lessons through four case studies regarding irrigation modernisation and advantages of implementing IWRM to enhance sustainable water management and agriculture in Pakistan. Moreover, this paper outlines a plan to implement IWRM for agricultural resilience. It concludes that holistic approach, stakeholder engagement, strengthening institutional frameworks and governance at different levels can enhance Pakistan's effective management of water resources that will ultimately support agricultural sustainability.



**Keywords:** IWRM, Integrated Water Resources Management, Sustainable Agriculture, Water Mismanagement, Irrigation Modernisation.

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# 1. INTRODUCTION

Agriculture plays an indispensable role in Pakistan's economic development, and is rightly regarded as the bedrock of the country's economy. It contributes approximately 22.9% to the Gross Domestic Product (GDP) of Pakistan and employs about 37.4% of the workforce.[1] The sector's supply of raw materials is critical for driving industrial growth, and ensuring food security. However, it is besieged by rampant water mismanagement, which threatens the overall agricultural sustainability in Pakistan.

In the realm of agricultural production, water is a sine qua non. Nevertheless, numerous countries encounter formidable challenges in agricultural productivity due to pervasive water scarcity, which jeopardises crop yields. The frequency of droughts and floods is already a major factor in crop failures across many regions and is aggravating severe food insecurity. It is anticipated that the global population is expected to reach 10 billion by 2050, agricultural production needs to expand by 50% compared to 2012, which will demand at least a 20% increase in water resources.

A number of climatic and non-climatic occurrences are straining water sector, while raising concerns about its capacity to provide water-related services that are affordable, resilient, and meet future expectations.[2] Due to shifting climate and altered rainfall patterns, both food security and economic stability are threatened worldwide.[3] The Organisation for Economic Co-operation and Development (OECD) has stated that

[1] "Pakistan Economic Survey 2022-23" (Government of Pakistan, Finance Division, 2023), https://www.finance.gov.pk/survey/chapters_23/02_Agriculture.pdf.

[2] *Water Resources Management* (De Gruyter, 2024), https://doi.org/10.1515/9783111028101-202.

[3] FAO, "The Rome Declaration on Water Scarcity in Agriculture," 2024, https://docs.google.com/document/d/1rPZMFcTplBzvMQlGHryeAzpSWi2nOcOp/edit.

Pakistan will be among the top 10 countries at risk which will encounter water-related challenges affecting agriculture in coming years.[4]

The irrigation systems of Pakistan, marked by inefficiency and outdated practices, severely undermine sustainable agriculture. Increased reliance on canal and flood irrigation leads to significant crop losses and uneven distribution of water. Moreover, fragmented water management and poor communication between federal and provincial authorities further complicate the issue. Therefore, comprehensive water management approach, such as Integrated Water Resource Management (IWRM) and irrigation modernisation is needed.

The main research questions guiding this study are, how IWRM can be tailored to address the specific challenges faced by Pakistan’s fragmented water management system? What lessons can be learned from successful international case studies of irrigation modernisation and implementation of IWRM that can be applied to improve and manage water use, considering importance of agriculture in Pakistan?

This paper evaluates whether the implementation of IWRM can solve Pakistan’s water inefficiency problem by balancing agricultural demands. For this study, the data has been collected from various secondary sources, including journal articles, books, national and international reports from Food and Agriculture Organisation (FAO), Global Water Partnership, WWF Pakistan, Pakistan Council of Research in Water Resources (PCRWR), United Nations Environment Programme (UNEP), Intergovernmental Panel on Climate Change (IPCC), and the World Bank.

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[4] Abdul Wahab Siyal et al., “The Importance of Irrigation Supply Chains within the Water Footprint: An Example from the Pakistani Part of the Indus Basin,” *Journal of Integrative Environmental Sciences* 20, no. 1 (December 31, 2023): 2208644, https://doi.org/10.1080/1943815X.2023.2208644.

It begins with an analysis of Pakistan's water resources. The study then examines the basic principles of IWRM and how they can be better incorporated into Pakistan's water management systems. In addition, the study draws lessons from case studies including China, South-India, and Murray-Darling Basin in Australia for irrigation modernisation and implementation of IWRM in Pakistan and finally provides policy recommendations.

## 2. PAKISTAN'S WATER PROFILE

Within a few decades, in Pakistan the water profile has transitioned from water abundance to extreme water scarcity.

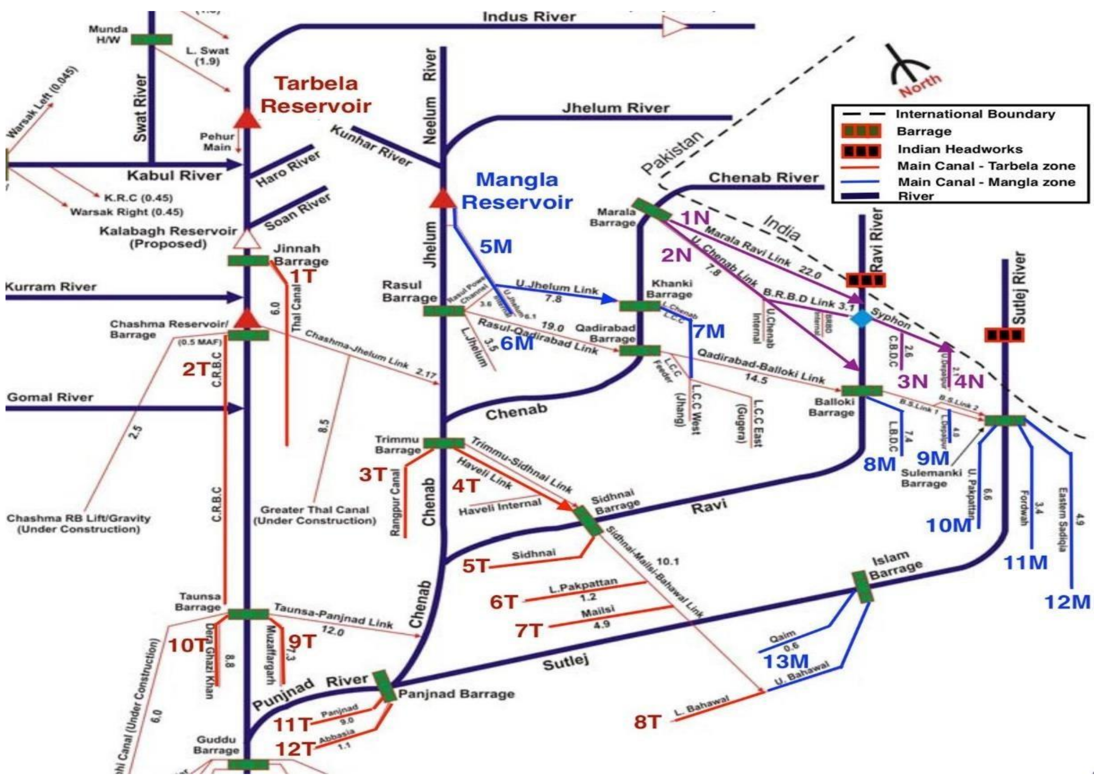


**Figure 1:** Pakistan's Indus Basin System.[5]

[5] Afreen Siddiqi, James L. Wescoat, and Abubakr Muhammad, "Socio-Hydrological Assessment of Water Security in Canal Irrigation Systems: A Conjoint Quantitative Analysis of Equity and Reliability," *Water Security* 4–5 (August 1, 2018): 44–55, https://doi.org/10.1016/j.wasec.2018.11.001.

The only basin that sustains Pakistan is the Indus River basin, Figure 1 shows the Indus Basin system of Pakistan, which is made up of the Indus, Chenab, Jhelum, Ravi, Beas, Sutlej, and Kabul rivers.[6]

The surface water primarily comes from the Indus River and its streams. A vast canal is used to shift about 122 kilometres of surface water annually for ground irrigation. Nevertheless, this surface water level is below that required for intensive agricultural systems in the Indus Basin. To make up for the shortage, groundwater is utilised. A total of 62 $km^3$ water is supplied per year by 1.36 million public and private wells. Only the province of Punjab has almost 1 million operational tube-wells. About 80% of groundwater abstraction comes from small, privately owned irrigation wells.[7]

## 2.1. Indus River Basin

The Indus River Basin, world's largest irrigated basin, has an average flow of 140 MAF[8] as illustrated in Figure 1. The distribution of the river is as follows: Pakistan (52.5%), India (33.5%), China (11%), and Afghanistan (3%).[9]

The Indus River serves as the principal source of irrigation water for Pakistan's agricultural lands. It constitutes the core agricultural region of the country, supplying over 90% of Pakistan's food resources.[10]

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[6] Ibid.

[7] Asad Qureshi and C.J. Perry, "Managing Water and Salt for Sustainable Agriculture in the Indus Basin of Pakistan," *Sustainability* 13 (May 10, 2021): 5303, https://doi.org/10.3390/su13095303.

[8] Angela Ortigara et al., "Indus Basin - Pakistan" (WWF, 2019), https://wwfint.awsassets.panda.org/downloads/wwf_pakistan_stewardship_web.pdf.

[9] Ameer Abdullah Khan, "Pakistan's Climate-Induced Water Scarcity and Its Impact on Agriculture," Hilal Publications, 2022, https://hilal.gov.pk/view-article.php?i=6347.

[10] Ana Magali Carrera Heureux et al., "Climate Trends and Extremes in the Indus River Basin, Pakistan: Implications for Agricultural Production," *Atmosphere* 13, no. 3 (March 2022): 378, https://doi.org/10.3390/atmos13030378.

The agricultural sector being the principal water consumer, utilises 93% of Pakistan's water[11] and the Indus Basin System stands as the primary source of freshwater for irrigation.

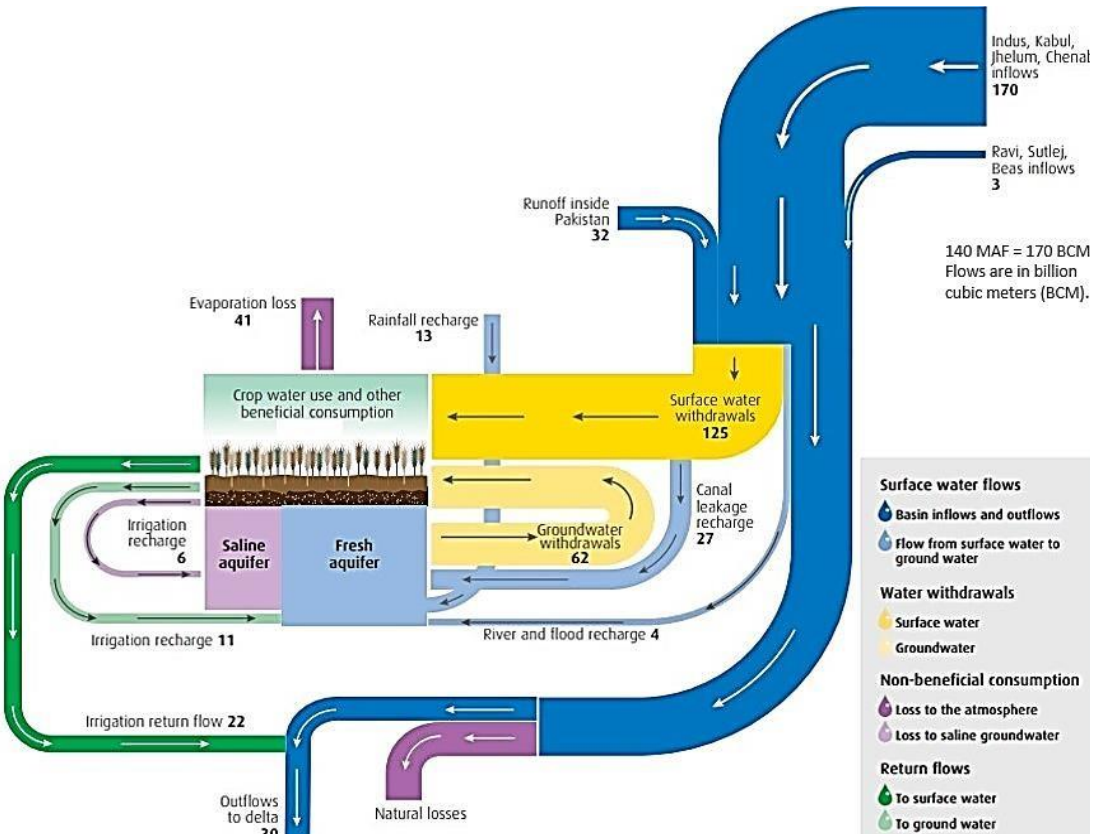


**Figure 2:** Average Annual Flow Rate of the Indus Basin.[12]

Currently, there is a tremendous pressure on Indus basin to meet the burgeoning demands for the domestic use, the agricultural services, and the infrastructure in the country.

Moreover, Pakistan is facing severe climate change, manifested in uneven weather patterns, and declining snowfall over the last five years.[13] The Indus basin is

[11] PCRWR, "Water Management," accessed August 10, 2024, https://pcrwr.gov.pk/water-management/.

[12] William J. Young et al., "Pakistan: Getting More from Water" (World Bank, 2019), https://documents1.worldbank.org/curated/en/251191548275645649/pdf/133964-WP-PUBLIC-ADD-SERIES-22-1-2019-18-56-25-W.pdf.

mainly dependent on melting glaciers and snow from the Hindu Kush, Karakoram and Himalayas that are also vulnerable to climate change.[14] International Water Management Institute (IWMI) estimates that Indus could turn into a river with seasonal flow by 2050 if Pakistan's northern glaciers retreat at the same pace as of now.

The Intergovernmental Panel on Climate Change (IPCC) A2 emission scenario, based on Fourth Assessment Report (AR4) gives projections of 17 General Circulation Models (GCMs) which indicate there will be significant temperature and precipitation changes in Pakistan as shown in the Table 1. This would negatively impact the basin affecting water availability and agriculture.[15]

| *Area* | *2020s* | *2050s* | *2080s* |
|---|---|---|---|
| | | Temperature change (°C) | |
| Northern Pakistan | 1.4 ± 0.1 | 2.7 ± 0.2 | 4.7 ± 0.2 |
| Southern Pakistan | 1.3 ± 0.1 | 2.4 ± 0.1 | 4.2 ± 0.2 |
| | | Precipitation change (%) | |
| Northern Pakistan | 2.2 ± 2.3 | 3.6 ± 3.2 | 1.1 ± 4.0 |
| Southern Pakistan | 3.1 ± 5.1 | 6.4 ± 7.5 | 4.3 ± 9.4 |

**Table 1:** Projections Based on IPCC-AR4.[16]

According to the latest IPCC's AR6, severe water scarcity impacts half of the world's population. A 1.5°C rise in temperature will result in water stress and a 24% increase in the probability of flooding. There is a 50% possibility that temperature will reach or surpass 1.5°C by 2040 possibly even sooner in the case of high emissions scenarios. [17]

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[13] Asif Mohmand, "Climate Crisis: Pakistan's Snowless Winter Sets Alarm Bells Ringing," 2024, https://thefridaytimes.com/24-Jan-2024/climate-crisis-pakistan-s-snowless-winter-sets-alarm-bells-ringing.

[14] Khizra Rashad, "The Indus River System: Another Victim of Climate Change," *Paradigm Shift* (blog), June 13, 2024, https://www.paradigmshift.com.pk/indus-river-system/.

[15] Winston Yu et al., *The Indus Basin of Pakistan: The Impacts of Climate Risks on Water and Agriculture* (The World Bank, 2013), https://doi.org/10.1596/978-0-8213-9874-6.

[16] Yu et al.

[17] Katherine Calvin et al., "IPCC, 2023: Climate Change 2023: Synthesis Report.," First (Intergovernmental Panel on Climate Change (IPCC), July 25, 2023), https://doi.org/10.59327/IPCC/AR6-9789291691647.

According to the United Nations report "Global Water Security 2023 Assessment" Pakistan is among the 23 countries where water availability has been reduced by more than 80%.[18] The depletion of water resources, combined with massive water losses, have adversely affected the agriculture, industries and even households. Also, rapid population growth, urban expansion, development, and elimination of industrial and agricultural wastewater has put water bodies at risk. Table 2 provides an overview of Pakistan's water profile.

| Aspect | Details |
|---|---|
| **Pakistan's Major Water Sources** | Surface Water (Indus River fed by Snowmelt and Rainfall), Groundwater[19] |
| **Water Inflow (PCRWR)** | 140 MAF from rivers, 7 MAF from rainfall |
| **Actual Surface Water Availability** | 92.5 MAF |
| **Average System Usage** | 103.5 MAF |
| **Decrease in Availability (2021-2022)** | 10.6% compared to average system usage |
| **Highest Decrease in Availability** | 18.5% (2018-2019) |
| **Current Reservoir Storage Capacity** | Total designed capacity: 15.75 MAF; Current capacity: 13.1 MAF |
| **Reservoir's Storage Duration** | Up to 30 days (International minimum requirement: 120 days). Advanced countries have storage for 1 to 2 years |
| **Under Construction Dams** | Diamer, Bhasha, Mohmand, Dasu |
| **Collective Designed Capacity of Under Construction Dams** | 12 MAF |
| **National Water Policy (2018)** | Revealed critical decline in water availability |
| **Per Capita Surface Water Availability (1951)** | 5,260 cubic meters per year |
| **Per Capita Surface Water Availability (2016)** | Around 1,000 cubic meters per year |
| **Projected Per Capita Availability (2025)** | About 860 cubic meters per year |

[18] Amin Ahmed, "UN Report Places Pakistan in 'Critically Water Insecure' Category," DAWN.COM, 2023, https://www.dawn.com/news/1743956.
[19] Iqtidar H. i Siddiqu, *Hydro Politics & Water Wars in South Asia* (Vanguard Books Pvt Ltd, 2013).

| | |
|---|---|
| **Minimum Water Requirement (per capita per year)** | 1,000 cubic meters to avoid food and health implications |
| **Transition Status** | From “water stressed” to “water scarce” by 2025 |

**Table 2:** Key Data and Issues Related to Water Resources.[20]

## 2.2. Mismanagement of Water Resources

The country suffers from chronic water scarcity due to a combination of factors including outdated infrastructure, unsustainable practices and administrative failures, placing Pakistan 14 among 17 states at high risk of water scarcity. The lack of a comprehensive water supply system in Pakistan tends to exacerbate the water crisis in the country.[21]

According to NASA’s findings, Indus River, from which Pakistan draws most of the water, is the second most water-stressed aquifer.[22] In terms of Pakistan’s water management, there is a lack of planning, storage and distribution. Unrelenting over-extraction of groundwater aggravates the problem, leading to agricultural shortfalls and threatening livelihoods of marginalised communities and farmers.

## 2.3. Inefficiencies in Agricultural Water Use

Irrefutably, water usage and agriculture are closely linked, it is crucial to acknowledge their intricate relationship and address pertinent concerns.[23] Pakistan’s

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[20] Ali Hamza, “From ‘Water Stressed’ to ‘Water Starved’ Pakistan,” The Nation, March 11, 2023, https://www.nation.com.pk/11-Mar-2023/from-water-stressed-to-water-starved-pakistan.

[21] Dr Moonis Ahmar, “Pakistan’s Inter-Provincial Water Conflicts,” The Express Tribune, February 6, 2024, https://tribune.com.pk/story/2455583/pakistans-inter-provincial-water-conflicts.

[22] Ghazala Anbreen, “Pakistan’s Coming Water Distress,” June 26, 2024, https://www.pakistantoday.com.pk/2024/06/26/pakistans-coming-water-distress/.

[23] Richard Niesenbaum, *Sustainable Solutions: Problem Solving for Current and Future Generations* (Oxford University Press, 2020).

irrigation system faces increasing challenges due to rapid degradation of surface and groundwater. A staggering 50% of agricultural water is wasted because of mismanagement.[24] The critical issues of depleted storage and dwindling water availability highlight the urgent need for appropriate reforms and strengthening of water management.

Additionally, poor irrigation systems and inefficiencies in water distribution systems worsen the situation.[25] Though Pakistan boasts one of the most extensive irrigation networks, but significant water loss is also reality. Following are the traditional and outdated irrigation systems in Pakistan.

#### 2.3.1. *Warabandi*

Pakistan's water distribution system in agriculture, called *warabandi* (wara-change, bandi-fixed), allocates water on a specific schedule. This is a traditional water allocation system, which mostly uses surface water supplied through canals and waterways. This often results in low water availability, as water is used even when it is not needed, leading to inefficiencies and reduced agricultural outcomes. Farmers at the tail end of the system face severe water scarcity. Also, the connivance between irrigation officials and powerful farmers amplify the crisis. To improve efficiency, wetland coverage and telemetry systems can be installed to conserve more than 5 million acre feet of water.[26]

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[24] Usman Hanif, "'Water Efficiency Is a Necessity,'" *The Express Tribune*, 2023, sec. News, https://tribune.com.pk/story/2408683/water-efficiency-is-a-necessity.

[25] Syed Rizwan Haider Bukhari, Amir Ullah Khan, and Shabana Noreen, "Optimizing Water Resource Governance for Sustainable Agricultural and Hydroelectric Development in Pakistan: An In-Depth Examination and Policy Prescriptions," *Journal of Development and Social Sciences* 5, no. 2 (April 13, 2024): 280–93, https://doi.org/10.47205/jdss.2024(5-II)27.

[26] Iffat Farooq, "Water Scarcity in Pakistan: Resource Constraint or Mismanagement," *Journal of Public Policy Practitioners* 2, no. 1 (June 30, 2023): 01–37, https://doi.org/10.32350/jppp.21.01.

### 2.3.2. Flood Irrigation

Flood irrigation is prevalent in Pakistan's Indus Basin Irrigation System due to its simplicity and historical integration. However, this method is inherently inefficient, as it wastes a lot of water through runoff and evaporation. Inadequate control of water use leads to significant losses, leading to water infiltration and increased soil salinity. Furthermore, traditional flood water irrigation is at odds with the water needs of modern crops and the impacts of climate change. National Water Policy 2018, approved by all stakeholders, has suggested on a ban on flood water irrigation as soon as possible.[27]

### 2.3.3. Tube Well Irrigation

In the recent context, irrigation with tube wells has become the dominant agricultural system of Pakistan, especially in areas where surface water is not sufficient. Tube wells are often not properly regulated and controlled downstream, resulting in uneven groundwater and excessive leakage.

The unabated installation of pumping wells has led to non-satisfactory water quality and environmental problems.[28] Furthermore, their usage has resulted in severe groundwater overdraft, causing rapid groundwater depletion, raising salinisation in Punjab and Sindh as shown in Figure 3.

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[27] Muhammad S. Shafique, "Flooding Practice in Pakistan & National Water Policy," 2019, https://www.linkedin.com/pulse/flooding-practice-pakistan-national-water-policy-muhammad-s-shafique.

[28] Amar Razzaq et al., "Analyzing Past and Future Trends in Pakistan's Groundwater Irrigation Development: Implications for Environmental Sustainability and Food Security," *Environmental Science and Pollution Research International* 30, no. 12 (March 2023): 35413–29, https://doi.org/10.1007/s11356-022-24736-5.

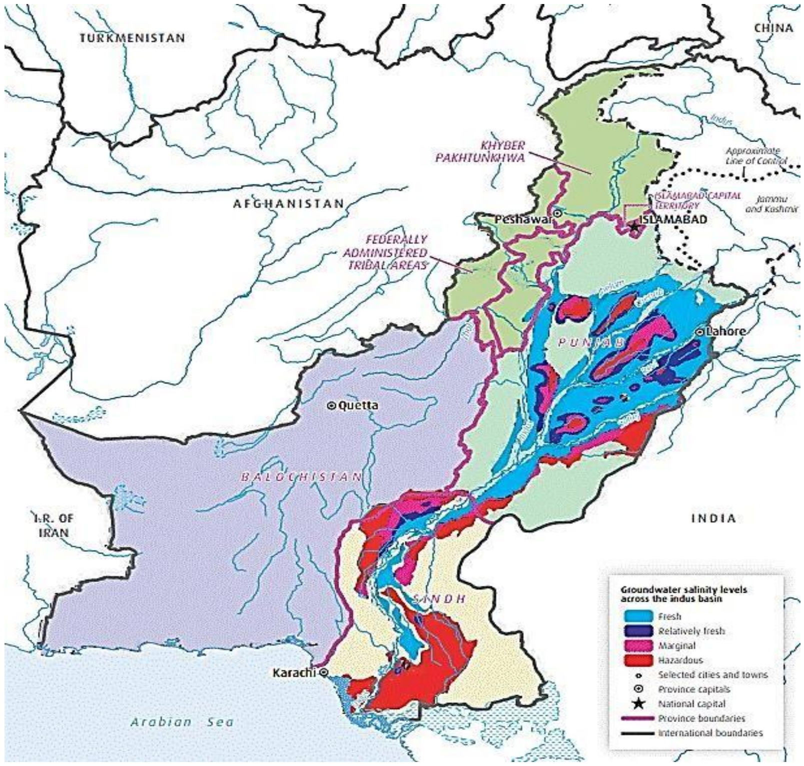


**Figure 3:** Salinity levels of groundwater throughout the Indus Basin.[29]

To address these challenges, an integrated approach is required for optimal water use and resilience.

## 3. INTEGRATED WATER RESOURCE MANAGEMENT

IWRM represents a paradigm shift in water resources management. IWRM is a framework designed to promote the management of water resources by considering the complex interactions between water, land, and environmental systems. This approach is rooted in the recognition that water resources are dynamic and interdependent systems

[29] Young et al., "Pakistan: Getting More from Water."

that requires coordinated management strategies for economic and social benefits.[30]

## 3.1. Characteristics of IWRM

### 3.1.1. Holistic Management

IWRM promotes a comprehensive approach that integrates management of all water resources, including surface water, groundwater, and water-related ecosystems.

### 3.1.2. Stakeholder Participation

In order to ensure sustainable water management, IWRM emphasises the importance of involving all pertinent parties, such as local governments, private sector, NGOs, and government agencies. Through multi-stakeholder involvement, IWRM aims to incorporate diversity of perspectives and knowledge, ensuring inclusive and equitable water management.

### 3.1.3. Sustainability

It is a fundamental principle of IWRM that seeks to balance social, economic and environmental objectives. This means not only meeting current water needs but also ensuring that water is conserved and protected for future generations. In this way, IWRM contributes to long-term economic growth and social welfare.

### 3.1.4. Decentralisation

IWRM recommends a decentralised decision-making process to increase local control and responsiveness. By delegating power and responsibility to local departments, IWRM enables sustainable and effective solutions to specific water

[30] UNEP, "Integrated Water Resources Management," November 16, 2023, https://www.unep.org/topics/fresh-water/water-resources-management/integrated-water-resources-management.

problems. This approach helps address local needs directly and encourages local ownership and responsibility in water management.[31]

IWRM is emerging as a viable alternative to the traditional sector-specific, top-down approach that is still ubiquitous in Pakistan. Table 3 presents the characteristics of traditional water management and IWRM, highlighting how each approach handles different aspects of water management.

| Aspect | Traditional Water Management | Integrated Water Resources Management (IWRM) |
|---|---|---|
| **Scope** | Often focused on single uses or sectors, such as irrigation or municipal supply. | Comprehensive approach considering all water uses and interactions within a watershed or basin. |
| **Holistic Management** | Typically fragmented, addressing water management in isolation from other systems. | Emphasises the interconnectedness of water systems, integrating management across sectors. |
| **Stakeholder Involvement** | Limited or minimal engagement of stakeholders. | Active involvement of a wide range of stakeholders, including local communities and various sectors. |
| **Sustainability Focus** | Often reactive with limited emphasis on long-term sustainability; focus on immediate issues. | Strong emphasis on balancing social, economic, and environmental factors for long-term sustainability. |
| **Decentralisation** | Centralised decision-making, often with less flexibility to local conditions. | Decentralised approach allows local-level management tailored to specific needs. |

**Table 3:** Comparison between Traditional and Integrated Water Resources Management (IWRM)

[31] Stockholm International Water Institute, "Principles and Practices of Integrated Water Resources Management," 2020, https://siwi.org/wp-content/uploads/2020/06/IWRM_Manual1_final.pdf.

### 3.2. Integrating IWRM for Agricultural Resilience

The IWRM promotes multi-sectoral planning,[32] and plays an important role in protecting the environment, encouraging economic development, and advancing sustainable agricultural practices.

Globally, water policy and management is increasingly acknowledging the intricate link between water resources. For example, intensive irrigation and agricultural runoff can reduce freshwater availability for drinking and industrial purposes, while wastewater pollution can degrade riverine ecosystems. Moreover, the need to allocate water for environmental protection may constrain the availability of resources for agricultural use. This highlights the importance of implementing IWRM for addressing inefficiencies and unsustainable practices associated with water use.[33]

The IWRM advocates a holistic approach for water management and emphasises the importance of stakeholder engagement by involving farmers, water users and local communities in decision-making, ensuring that agricultural practices are localised.

To address climatic unpredictability and extreme weather occurrences, it contains adaptive management practices, which lowers susceptibility. IWRM also

[32] UNEP, "What Is Integrated Water Resources Management?," September 22, 2017, https://www.unep.org/explore-topics/disasters-conflicts/where-we-work/sudan/what-integrated-water-resources-management.

[33] Global Water Partnership, "About IWRM - GWP," 2018, https://www.gwp.org/en/gwp-SAS/ABOUT-GWP-SAS/WHY/About-IWRM/.

considers watershed protection and fertile land for agricultural profitability. This implies that sustainable and resilient agriculture relies on IWRM.[34]

# 4. IWRM BEST PRACTICES

This section will examine the best practices especially in the successful implementation of Integrated Water Resource Management (IWRM) to enhance water security and improve agricultural productivity.

## 4.1. Development and Management of Groundwater Irrigation in Hengshui, China

China, with a large population in rural areas, has prioritised agriculture in its development policies. Since 1978, reforms have accelerated the growth of agriculture. Today, China feeds a fifth of the world's population with less than 10% of the world's arable land. To add to that, it is the leading importer of agricultural products,[35] reflecting China's major achievements in agriculture.

Hengshui is a city of the sixth most populous province, Hebei, of People's Republic of China (PRC) was experiencing water scarcity, characterised by extreme shortages in both surface and groundwater sources. The reliance on deep groundwater has caused the groundwater table to drop by 2 meters annually. This has led to severe ground settlement and saline water intrusion. Moreover, deeper wells driven up irrigation costs, and disputes over water use arose as agricultural benefits decline.

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[34] FAO, *Integrated Water Resource Management for Food Security and Climate Resilience* (FAO and UN Water, 2022), https://doi.org/10.4060/cb6241en.

[35] Statista, "Agriculture in China," Statista, 2023, https://www.statista.com/topics/7439/agriculture-in-china/.

In response to these challenges, several interventions based on IWRM principles were implemented. The district water management department promoted modreinsed irrigation systems. In 2002, the Ministry of Water Resources of PRC initiated water conservation pilot districts and selected Taocheng District for implementation. For groundwater management, a comprehensive framework was developed which consisted of government regulations, market incentives and public participation.

The establishment of Water Use Associations (WUAs) was a key measure of IWRM. These associations managed water resources and implemented water conservation practices. Their responsibilities included monitoring water consumption levels, rewarding water-saving practices, and penalising for excessive consumption. Water consumption certificates were distributed to every farm household, and guidance on water conservation techniques was given to increase awareness and compliance.

During 2003-2005, the use of these measures significantly reduced groundwater depletion from 2 meters to 1 meter. The participatory approach contributed to better management of water distribution and encouraged sustainable practices.

Technological solutions combined with operations and interventions proved effective. While technological innovations in irrigation were important, their success depended on integrating management by local bodies. The Chinese experience highlights the value of IWRM that combines technological development with participatory governance for agriculture.[36]

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[36] IWRM Action Hub, "China: Development and Management of Groundwater Irrigation in Hengshui," 2013, https://iwrmactionhub.org/case-study/china-development-and-management-groundwater-irrigation-hengshui.

## 4.2. Transformative Water Management Strategies for China's Rural Communities

Fujian's irrigation infrastructure is vital to the provincial economic development, but has struggled due to outdated usage patterns. Historically, China's centrally planned economy resulted in inadequate government-dependent irrigation systems, low agricultural productivity, and significant water losses. The objectives of the reforms initiated in 1992 to address these issues by implementing a two-pronged approach in line with the principle of IWRM that combines models of centralised and local interventions.

Fujian took measures to improve water management including, the establishment of WUAs to oversee local irrigation operations and infrastructure. This approach is consistent with IWRM's emphasis on aligning stakeholders in water management. The Fujian government provided guidance, subsidies, and support to nurture these associations. A total of 88 pilot sites were selected to implement new water management systems, improving infrastructure, reducing leaks and a better water distribution system.

Farmers received technical assistance and financial support was also provided for infrastructure maintenance and upgrades. The direct involvement of farmers in water management significantly increased water use efficiency, reduced waste, and improved productivity, all of which are central to IWRM. Fujian experience highlights the effectiveness of integrating participatory activities into IWRM programs, especially for small-scale farms.[37]

### 4.3. Amidst Extreme Weather in South India, Supporting Small Farmers involving Private Sector

Extreme weather events, including droughts and floods, are intensifying across India, severely impacting water access for drinking and agriculture. This is particularly detrimental in South India, where many farmers rely on rain-fed agriculture. States such as Andhra Pradesh, Karnataka, and Tamil Nadu are experiencing drastic water depletion, leading to acute shortages, and inter-state disputes.

Traditional water harvesting systems like irrigation tanks, Ooranies (surface water ponds) were used to meet local water needs. From October 2013 to March 2015, the DHAN Foundation, partnered with Global Water Partnership, implemented a program to enhance water and food security in Tamil Nadu, Andhra Pradesh, and Karnataka. The program focused on, rehabilitating 4 irrigation tanks in Tamil Nadu, constructing 17 ponds, eleven in Andhra Pradesh, six in Karnataka, and deepening Tamil Nadu's three Ooranies.

These efforts targeted to boost climate resilience and improve water access for approximately 1,350 households. Projects were executed through a community-based approach, enhancing local management and maintenance of water infrastructure. This project demonstrated the importance of private sector collaboration with government,

[37] IWRM Action Hub, "China: Innovative Water Resource Management Mechanism in Rural Communities," 2013, https://iwrmactionhub.org/case-study/china-innovative-water-resource-management-mechanism-rural-communities.

community engagement, and participatory management within the IWRM framework for effective results.[38]

## 4.4. Agricultural Benefits and Ecological Health in the Murray-Darling Basin

The Murray-Darling Basin, Australia's sixth-largest river basin at 1.07 million square kilometres, is crucial for irrigation and domestic use. It supports 40% of the country's food production and contributes $24 billion to the economy. Despite these advantages, 95% of the water in the basin is diverted for agricultural purposes, resulting in significant ecological stress, up to 450 mm.

A robust IWRM programme was established to address these challenges. The programme included a Murray-Darling Council of Ministers for high-level decision-making, and Basin Authority for management and a community advisory committee for awareness. Significant environmental effects from excessive water diversions were found in a water audit. This led to a prohibition on more diversions and AUD 500 million allocation for environmental water by the Committee on Agriculture (COAG).

This comprehensive approach supported sustainable agriculture by improving water use efficiency. The 17 Catchment Management Authorities operate on an adaptive management model to research, plan, manage and monitor the basin. This

[38] Global Water Partnership, "Augmenting Water Security and Food Security of Small Farmers in Andhra Pradesh, Karnataka and Tamil Nadu," 2018, https://www.gwp.org/en/learn/KNOWLEDGE_RESOURCES/Case_Studies/Asia/augmenting-water-security-and-food-security-of-small-farmers-in-andhra-pradesh-karnataka-and-tamil-nadu-491/.

enhanced water systems and improved information management while ensuring that agricultural needs were met while protecting the water resource.[39]

## 5. IMPLEMENTING IWRM IN PAKISTAN

The IWRM provides a framework for sustainable water management, enabling provinces to develop policies tailored to their specific needs. Instead of providing one-size-fits-all solutions, IWRM proposes an ongoing process of planning and implementation. This approach encourages Pakistan's provinces to develop customised approaches based on their needs to effectively address challenges. [40]

Due to Pakistan's dependence on agriculture, water management is essential to ensure adequate water supply to irrigation systems for growing crops. Agricultural systems can become more resilient, efficient, and sustainable by using IWRM, improving water and food security. The 2018 National Water Policy offers a systematic method for creating plans and strategies for the sustainable management of water resources, it is based on IWRM but needs effective implementation.

In Pakistan, sustainable management of water resources requires a comprehensive planning, management and monitoring with defined timelines. The planning phase must consider a holistic approach and focus on the most water stressed source. On the other hand, implementation needs to prioritise projects and systematically document best practices and lessons learned to improve future strategies. Finally, evaluation must revise interventions, assess the effectiveness of

[39] M.E. Qureshi, M. Kirby, and M. Mainuddin, "Integrated Water Resources Management In The Murray Darling Basin, Australia," 2004, https://icwrae-psipw.org/papers/2004/English/HR/E1-14.pdf.

[40] Bareerah Fatima et al., *Integrated Water Resources Management Implementation Guidelines for Pakistan* (Islamabad: Pakistan Council of Research in Water Resources : UNESCO Islamabad Office, 2021).

current programs, and engage other stakeholders as needed. The following Table 3 outlines the strategies for implementing IWRM to optimise agriculture in Pakistan, highlighting local, provincial, and federal collaborators.

| Timeline | Strategic Actions | Collaborators |
|---|---|---|
| **Short-Term** | 1. Enhance institutional coordination and capacity building in Irrigation, Agriculture, and Research.<br>2. To better reflect water value, incorporate infrastructure costs into water management assessments.<br>3. Transition to advanced irrigation systems. | Departments of Agriculture and Irrigation, Economic Research Institute, Agricultural Research Institutes, Parliament |
| **Medium-Term** | 1. Develop drought-resistant seeds to alleviate land and water pressure.<br>2. Focus on value addition at the farm level to reduce post-harvest losses and create employment opportunities.<br>3. Construct small dams to support localised water management.<br>4. Manage rangelands and pastures in arid areas. | Public and Private Research Institutes, ZTBL (for providing accessible loans), Provincial Irrigation and Agricultural Departments, Local Communities |
| **Long-Term** | 1. Establish clear water allocation and cultivation rights.<br>2. Explore the concept of Virtual Water i.e. raising awareness of the true value of freshwater resources. | Government Institutions, Local Communities |

**Table 4**: Implementing IWRM for Pakistan's Agriculture Sector.[41]

[41] Ibid.

# 6.0. RECOMMENDATIONS

## 6.1. Develop an IWRM Strategy at Provincial Level

Pakistan's National Water Policy of 2018, based on IWRM principles, requires each province to devise its own IWRM strategies. While Khyber Pakhtunkhwa (KP) and Balochistan have completed this task, Punjab and Sindh, crucial for the country's agriculture, have not yet developed their strategies. Given Punjab's role as the primary agricultural hub and Sindh's agricultural output, it is essential for these provinces to develop IWRM strategy to improve water use efficiency and boost agricultural growth.

## 6.2. Lessons from Case Studies

Pakistan's Indus Basin, major source of country's irrigation, serves 21.5 million hectares of agricultural land. However, the system is currently experiencing significant water stress. Lessons from the Darling Murray Basin in Australia provide valuable insights to integrate IWRM in the Indus Basin. Key strategies include adopting a holistic approach that integrates water management with land use and environmental sustainability, engaging diverse stakeholders to ensure comprehensive decision-making, and applying adaptive management practices supported by robust data. Fujian and south-Indian case studies can be applied to improve the livelihoods of large workforce that is associated with agriculture sector. China's Hengshui experience underscores the importance of adopting modernise solutions for Pakistan's agricultural sector.

### 6.3. Water Loss Mitigation and Modernising Irrigation Techniques

In Pakistan's agriculture sector, over 50% of water is lost during conveyance and application in the fields. In Punjab alone, approximately 40% of irrigation water is wasted due to the poor maintenance and outdated infrastructure of century-old community watercourses. The inefficiencies stem primarily from inadequate upkeep and conventional irrigation practices. Consequently, even modest improvements in water management could result in significant overall water savings to enhance agricultural productivity.

Following measures can help in this regard,

- Watercourse improvement will enhance conveyance efficiency and reduce losses from seepage, evaporation, and operational inefficiencies. Rebuilding channels that are lined and equipped with water control structures for optimal water distribution.
- Furrow irrigation, involving the creation of parallel channels along the field's slope, utilises gravity to distribute water efficiently and is particularly suited for row crops.
- Gated pipe irrigation, a modern approach, improves water use efficiency in arid regions by minimising seepage and evaporation losses, reducing land and maintenance requirements, and increased crop production.

### 6.4. Strengthening Institutional Frameworks and Governance for Water Resources Management

This entails strengthening the ability of water management organisations through focused training and resources, encouraging improved coordination between national, regional, and local organisations, and putting in place official procedures for inclusive stakeholder participation. There is a need for the development of adaptive management frameworks. Strengthening policy and regulatory frameworks in line with IWRM principles will ensure transparency and accountability. Furthermore, encouraging research and innovation will help solve local challenges and improve overall water management.

## 7. CONCLUSION

In conclusion, the implementation of IWRM is crucial to promote agricultural development and overcome multi-dimensional challenges related to water scarcity, climate change and the environmental degradation in Pakistan. This paper shows how IWRM can improve water use efficiency through an integrated holistic approach, and promote sustainable agricultural practices. It can be done by strengthening stakeholder engagement that will facilitate disparate governance structures and increase coordination between federal, provincial, and local agencies. This will ensure water management techniques are adaptable to the diverse needs of the provinces.

Pakistan can learn from the valuable insights gained from the case studies. This includes, investing in effective irrigation methods and technologies can help to optimise water use. Adopting innovative approaches, localised solutions, community involvement, and adaptive management techniques are imperative to lessen the negative effects on farmers. By putting these lessons into practice. To ensure sustainable agricultural outcomes and transform Pakistan's water management practices, it will be imperative to invest in modern irrigation technologies, and tailor IWRM to address specific local challenges.

# 8. BIBLIOGRAPHY

Ahmar, Dr Moonis. “Pakistan’s Inter-Provincial Water Conflicts.” The Express Tribune, February 6, 2024. https://tribune.com.pk/story/2455583/pakistans-inter-provincial-water-conflicts.

Ahmed, Amin. “UN Report Places Pakistan in ‘Critically Water Insecure’ Category.” DAWN.COM, 2023. https://www.dawn.com/news/1743956.

Anbreen, Ghazala. “Pakistan’s Coming Water Distress,” June 26, 2024. https://www.pakistantoday.com.pk/2024/06/26/pakistans-coming-water-distress/.

Bukhari, Syed Rizwan Haider, Amir Ullah Khan, and Shabana Noreen. “Optimizing Water Resource Governance for Sustainable Agricultural and Hydroelectric Development in Pakistan: An In-Depth Examination and Policy Prescriptions.” *Journal of Development and Social Sciences* 5, no. 2 (April 13, 2024): 280–93. https://doi.org/10.47205/jdss.2024(5-II)27.

Calvin, Katherine, Dipak Dasgupta, Gerhard Krinner, Aditi Mukherji, Peter W. Thorne, Christopher Trisos, José Romero, et al. “IPCC, 2023: Climate Change 2023: Synthesis Report.” First. Intergovernmental Panel on Climate Change (IPCC), July 25, 2023. https://doi.org/10.59327/IPCC/AR6-9789291691647.

FAO. *Integrated Water Resource Management for Food Security and Climate Resilience*. FAO and UN Water, 2022. https://doi.org/10.4060/cb6241en.

FAO. “The Rome Declaration on Water Scarcity in Agriculture,” 2024. https://docs.google.com/document/d/1rPZMFcTplBzvMQlGHryeAzpSWi2nOcOp/edit.

Farooq, Iffat. “Water Scarcity in Pakistan: Resource Constraint or Mismanagement.” *Journal of Public Policy Practitioners* 2, no. 1 (June 30, 2023): 01–37. https://doi.org/10.32350/jppp.21.01.

Fatima, Bareerah, Faizan ul Hasan, Muhammad Ashraf, and Anwaar Ahmad. *Integrated Water Resources Management Implementation Guidelines for Pakistan*. Islamabad: Pakistan Council of Research in Water Resources : UNESCO Islamabad Office, 2021.

Global Water Partnership. “About IWRM - GWP,” 2018. https://www.gwp.org/en/gwp-SAS/ABOUT-GWP-SAS/WHY/About-IWRM/.

Global Water Partnership. “Augmenting Water Security and Food Security of Small Farmers in Andhra Pradesh, Karnataka and Tamil Nadu,” 2018. https://www.gwp.org/en/learn/KNOWLEDGE_RESOURCES/Case_Studies/Asia/augmenting-water-security-and-food-security-of-small-farmers-in-andhra-pradesh-karnataka-and-tamil-nadu-491/.

Hamza, Ali. “From ‘Water Stressed’ to ‘Water Starved’ Pakistan.” The Nation, March 11, 2023. https://www.nation.com.pk/11-Mar-2023/from-water-stressed-to-water-starved-pakistan.

Hanif, Usman. “‘Water Efficiency Is a Necessity.’” *The Express Tribune*, 2023, sec. News. https://tribune.com.pk/story/2408683/water-efficiency-is-a-necessity.

Heureux, Ana Magali Carrera, Jorge Alvar-Beltrán, Rodrigo Manzanas, Mehwish Ali, Robina Wahaj, Mina Dowlatchahi, Muhammad Afzaal, et al. “Climate Trends and Extremes in the Indus River Basin, Pakistan: Implications for Agricultural Production.” *Atmosphere* 13, no. 3 (March 2022): 378. https://doi.org/10.3390/atmos13030378.

IWRM Action Hub. “China: Development and Management of Groundwater Irrigation in Hengshui,” 2013. https://iwrmactionhub.org/case-study/china-development-and-management-groundwater-irrigation-hengshui.

IWRM Action Hub. “China: Innovative Water Resource Management Mechanism in Rural Communities,” 2013. https://iwrmactionhub.org/case-study/china-innovative-water-resource-management-mechanism-rural-communities.

Khan, Ameer Abdullah. “Pakistan’s Climate-Induced Water Scarcity and Its Impact on Agriculture.” Hilal Publications, 2022. https://hilal.gov.pk/view-article.php?i=6347.

Mohmand, Asif. “Climate Crisis: Pakistan’s Snowless Winter Sets Alarm Bells Ringing,” 2024. https://thefridaytimes.com/24-Jan-2024/climate-crisis-pakistan-s-snowless-winter-sets-alarm-bells-ringing.

Niesenbaum, Richard. *Sustainable Solutions: Problem Solving for Current and Future Generations*. Oxford University Press, 2020.

Ortigara, Angela, Sohail Ali Naqvi, Lindsay Bass, and Nicole Tanner. “Indus Basin - Pakistan.” WWF, 2019. https://wwfint.awsassets.panda.org/downloads/wwf_pakistan_stewardship_web.pdf.

“Pakistan Economic Survey 2022-23.” Government of Pakistan, Finance Division, 2023. https://www.finance.gov.pk/survey/chapters_23/02_Agriculture.pdf.

PCRWR. “Water Management.” Accessed August 10, 2024. https://pcrwr.gov.pk/water-management/.

Qureshi, Asad, and C.J. Perry. “Managing Water and Salt for Sustainable Agriculture in the Indus Basin of Pakistan.” *Sustainability* 13 (May 10, 2021): 5303. https://doi.org/10.3390/su13095303.

Qureshi, M.E., M. Kirby, and M. Mainuddin. “Integrated Water Resources Management In The Murray Darling Basin, Australia,” 2004. https://icwrae-psipw.org/papers/2004/English/HR/E1-14.pdf.

Rashad, Khizra. “The Indus River System: Another Victim of Climate Change.” *Paradigm Shift* (blog), June 13, 2024. https://www.paradigmshift.com.pk/indus-river-system/.

Razzaq, Amar, Hancheng Liu, Meizhen Xiao, Khalid Mehmood, Muhammad Aamir Shahzad, and Yewang Zhou. “Analyzing Past and Future Trends in Pakistan’s

Groundwater Irrigation Development: Implications for Environmental Sustainability and Food Security.” *Environmental Science and Pollution Research International* 30, no. 12 (March 2023): 35413–29. https://doi.org/10.1007/s11356-022-24736-5.

Shafique, Muhammad S. “Flooding Practice in Pakistan & National Water Policy,” 2019. https://www.linkedin.com/pulse/flooding-practice-pakistan-national-water-policy-muhammad-s-shafique.

Siddiqi, Afreen, James L. Wescoat, and Abubakr Muhammad. “Socio-Hydrological Assessment of Water Security in Canal Irrigation Systems: A Conjoint Quantitative Analysis of Equity and Reliability.” *Water Security* 4–5 (August 1, 2018): 44–55. https://doi.org/10.1016/j.wasec.2018.11.001.

Siddiqu, Iqtidar H. i. *Hydro Politics & Water Wars in South Asia*. Vanguard Books Pvt Ltd, 2013.

Siyal, Abdul Wahab, Winnie Gerbens-Leenes, Maite M. Aldaya, and Rozina Naz. “The Importance of Irrigation Supply Chains within the Water Footprint: An Example from the Pakistani Part of the Indus Basin.” *Journal of Integrative Environmental Sciences* 20, no. 1 (December 31, 2023): 2208644. https://doi.org/10.1080/1943815X.2023.2208644.

Statista. “Agriculture in China.” Statista, 2023. https://www.statista.com/topics/7439/agriculture-in-china/.

Stockholm International Water Institute. “Principles and Practices of Integrated Water Resources Management,” 2020. https://siwi.org/wp-content/uploads/2020/06/IWRM_Manual1_final.pdf.

UNEP. “Integrated Water Resources Management,” November 16, 2023. https://www.unep.org/topics/fresh-water/water-resources-management/integrated-water-resources-management.

UNEP. "What Is Integrated Water Resources Management?," September 22, 2017. https://www.unep.org/explore-topics/disasters-conflicts/where-we-work/sudan/what-integrated-water-resources-management.

*Water Resources Management*. De Gruyter, 2024. https://doi.org/10.1515/9783111028101-202.

Young, William J., Arif Anwar, Tousif Bhatti, Edoardo Borgomeo, Stephen Davies, William R. Gartwaite III, E. Michael Gillmont, et al. "Pakistan: Getting More from Water." World Bank, 2019. https://documents1.worldbank.org/curated/en/251191548275645649/pdf/133964-WP-PUBLIC-ADD-SERIES-22-1-2019-18-56-25-W.pdf.

Yu, Winston, Yi-Chen Yang, Andre Savitsky, Donald Alford, Casey Brown, James Wescoat, Dario Debowicz, and Sherman Robinson. *The Indus Basin of Pakistan: The Impacts of Climate Risks on Water and Agriculture*. The World Bank, 2013. https://doi.org/10.1596/978-0-8213-9874-6.