



Sustainable Agriculture and Water Scarcity in the Indo-Pak Indus Basin: Diplomatic Approaches to Boost Productivity

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ABSTRACT

The Indus Waters Treaty (IWT), signed in 1960, was designed to prevent water conflict between India and Pakistan. Seven decades later, glacier retreat, erratic monsoons, unilateral hydropower development, and the 2025 political suspension of treaty cooperation have exposed its structural inadequacy. This rapid systematic literature review examines how diplomatic stagnation and environmental change interact to undermine sustainable agriculture in the Indo-Pak Indus Basin. Following PRISMA 2020 guidelines, 1,450 records were screened; 142 studies met inclusion criteria after quality appraisal using the Mixed Methods Appraisal Tool. Five themes emerged: IWT fragility under climate stress, the weaponisation of water as diplomatic leverage, a widening technological gap between Indian and Pakistani irrigation systems, institutional collapse at the Permanent Indus Commission, and cascading socio-economic impacts on farming communities. The synthesis finds that agricultural vulnerability in the basin is primarily driven by institutional failure and political mistrust rather than by absolute water scarcity. Cooperative mechanisms have stalled while unilateral upstream infrastructure decisions deepen downstream insecurity. Policy recommendations include embedding a Climate Clause in a revised IWT, establishing a Food-Water-Energy Nexus governance authority, and institutionalizing data-sharing protocols between riparian states.

1. Introduction

Few resources are as politically loaded as a river that crosses a border. The Indus Basin is home to millions of people, is critical to irrigation, food production, and drinking-water security in India and Pakistan, and is the hub of agricultural development. World Bank facilitated the Indus Waters Treaty (IWT) of 1960, which had been in force since the treaty's inception over six decades ago, before and after wars, even during the period of frequent political tensions (Ghosh, 2021). But climate change, population growth, greater water consumption, and a growing sense of nationalism have put the treaty under unprecedented pressure. The event of 2025 when the cooperative engagement was suspended after a militant attack was a point of significant

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rupture of the existing water-governance arrangement, and posed basic questions on the future of transboundary water management.

The IWT distributed water between the east (India) and the west (Pakistan), with the eastern rivers being Ravi, Beas and Sutlej and the western rivers being Indus, Jhelum and Chenab, and thus the treaty was an old and important basis for water management in the region (Wolf & Newton, 2008). Agriculture in Pakistan is highly reliant on the irrigation of the Irrawaddy Basin and in India, dams and hydropower projects have been built on the western rivers, which are considered as non-consumptive use rights of river water (Wirsing & Jasparro, 2014). For Pakistan, such developments are seen as threats to its water security. These concerns were exacerbated in the 2025 crisis, when India decided to withhold cooperation under the treaty and began to use more assertive statements about water flows (Reuters, 2025). So the controversy isn't just about technical allocation it's about national security and geopolitical competition. Geographically, technically and economically, India has an edge over Pakistan in terms of upstream interests, whereas Pakistan has tried to garner international attention to its downstream vulnerabilities (Zeitoun & Warner, 2006). As a result, the Indus Basin is no longer just a water-sharing arrangement based on historical reciprocity, but is now becoming a space where climate change, water-intensive farming, nationalistic considerations and strategy are increasingly overlapping.

The 1948 water blockade by India created a lasting foundation of mistrust in Pakistan's water diplomacy, while global conflicts demonstrate how water competition can threaten livelihoods and stability (Salman & Upriety, 2002; Swyngedouw, 2005). The 2025 IWT suspension intensified agricultural uncertainty, exposing farmers to irrigation shortages, climate variability, and disrupted river flows. These developments threaten SDG 2 and SDG 6 by undermining food and water security. Although Pakistan has access to precision irrigation, solar pumps, and drip technologies, limited funding, weak farmer awareness, and political instability continue to restrict their widespread adoption (Ali & Erenstein, 2017). This research, therefore, investigates the interplay between water scarcity, agriculture, and diplomacy in the Indo-Pak context. It uses a rapid systematic literature review approach to examine peer-reviewed studies, legal treaties, conflict resolution case studies, and hydrological data. The aim is to identify key barriers to sustainable agriculture, evaluate the breakdown of cooperative mechanisms, and recommend practical diplomatic and environmental strategies to increase agricultural productivity and ensure water justice in the region.

2. Literature Review

The Indus Basin is a critical resource for both India and Pakistan, supporting agriculture, livelihoods, and food security for hundreds of millions of people (Salman & Upriety, 2002). The 1960 Indus Waters Treaty (IWT), negotiated with World Bank mediation, sought to reduce conflict by allocating the eastern rivers—Ravi, Beas, and Sutlej—to India and the western rivers—Indus, Jhelum, and Chenab—to Pakistan. The treaty represented an important achievement in transboundary water diplomacy (Wouters & Immerzeel, 2016). However, disagreements over Indian hydropower projects on the western rivers have repeatedly emerged, particularly concerning flow regimes and storage capacity (Mirza, 2018). These disputes have increasingly overlapped with the broader Kashmir conflict, making technical water disagreements more politically sensitive (Wolf, 2011). By 2025, increasingly assertive statements from Indian leadership regarding the treaty intensified Pakistani concerns about downstream water security (Ahmed & Hussain, 2025).

Agriculture remains the economic foundation of the Indus Basin, but its sustainability is threatened by water scarcity, inefficient irrigation, land degradation, salinity, and declining groundwater levels (FAO, 2021). In Pakistan, approximately 80 percent of cultivated land depends on Indus Basin irrigation, while conventional flood irrigation, canal seepage, and evaporation contribute to substantial water losses (Ali & Erenstein, 2017; Qureshi et al., 2020). Climate change further compounds these pressures because the basin is highly dependent on Himalayan glaciers and increasingly variable precipitation patterns (Immerzeel et al., 2020). Accelerated glacier melt may initially increase river flows before declining glacier reserves eventually reduce water availability, creating simultaneous risks of flooding and future drought (Khan & Koch, 2020). Recent drought conditions, including reported reductions in Pakistan's wheat production, illustrate the agricultural consequences of increasing climatic variability (NHESS, 2024).

These environmental and agricultural pressures increasingly intersect with diplomatic tensions. Between 2020 and 2025, water politics became more closely associated with nationalist narratives and strategic competition. India's suspension of elements of the IWT and continued development of hydropower projects on the Chenab and Jhelum intensified concerns about the future of transboundary water governance (Times of India, 2025; Financial Times, 2025). Pakistan has characterized such developments as threats to downstream security and potential manifestations of hydro-hegemony, whereas India maintains that its activities fall within the rights provided by the treaty for limited hydropower generation (Ahmed & Hussain, 2025; Mehta, 2025). The divergence demonstrates that water disputes cannot be understood solely through technical allocation rules; they are increasingly shaped by wider geopolitical and security considerations.

Consequently, sustainable agriculture and water diplomacy must be addressed through an integrated framework. Improving irrigation efficiency alone cannot resolve the basin's problems because agricultural resilience is closely connected to political relations, institutional capacity, and cross-border cooperation (Mustafa et al., 2022). Recent research therefore supports basin-

wide approaches involving scientific data sharing, equitable water management, coordinated agricultural policies, and stronger institutional mechanisms (Qureshi et al., 2020). Innovative financing instruments, including water funds and payments for ecosystem services, could further encourage sustainable water use and conservation (Dasgupta et al., 2019). Such an integrated approach would link agricultural modernization with diplomatic cooperation, strengthening both water security and long-term regional stability.

3. Methodology

A **Rapid Systematic Literature Review (RSLR)** was adopted to critically examine and synthesize scholarly studies, policy documents, and institutional reports on sustainable agriculture, water scarcity, climate change, and Indo-Pak water diplomacy in the Indus Basin. Unlike a conventional systematic review, which may require extensive time to complete, the RSLR uses streamlined yet rigorous procedures to provide timely evidence on rapidly evolving issues (Khangura et al., 2012; Tricco et al., 2017). The review focused on five themes: historical and contemporary water conflicts and treaties; sustainable agricultural practices and water-use efficiency; climate-change impacts on water availability and agriculture; recent diplomatic developments and geopolitical tensions; and approaches integrating diplomacy with sustainable agriculture. The protocol followed PRISMA principles adapted for rapid reviews and specified the research questions, search strategy, eligibility criteria, screening procedures, data extraction, and analysis.

A systematic search was conducted in **Scopus, Web of Science, PubMed, Google Scholar, FAO and World Bank repositories, UNEP publications, and relevant South Asian research institutes**, covering English-language literature published between 2000 and 2025. Search terms combined concepts such as “Indus Waters Treaty,” “water scarcity,” “water conflict,” “water security,” “sustainable agriculture,” “climate-smart agriculture,” “water use efficiency,” “India,” “Pakistan,” “diplomacy,” “climate change,” and “trans-boundary water management” using Boolean operators. Approximately **1,450 records** were identified; after removing **350 duplicates**, 1,100 records underwent title and abstract screening, followed by full-text assessment of 210 studies. Literature was included where it addressed Indus Basin water issues, Indo-Pak water diplomacy, climate impacts, sustainable agriculture, or related geopolitical concerns, and comprised peer-reviewed research, official reports, and government or institutional publications. Quantitative, qualitative, and mixed-method studies were considered to ensure broad coverage of the evidence base.

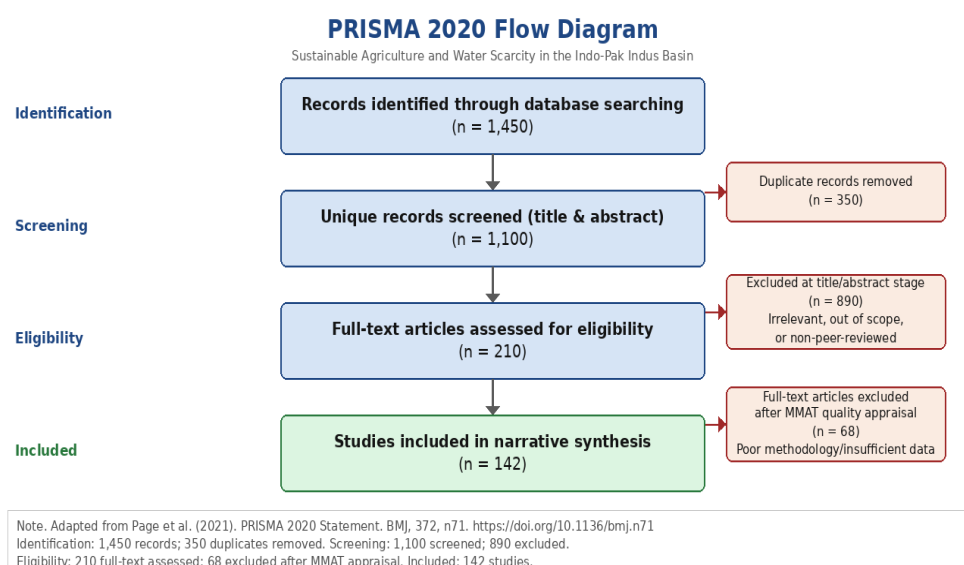


Figure 1. PRISMA flow diagram of study identification, screening, and inclusion, adapted from Page et al. (2021).

Results and Findings:

The reviewed literature consistently revealed five major themes: Sustainable Agriculture, Water Scarcity, Climate Change, and India-Pakistan Water Diplomacy. The themes reflect that the Indus Basin crisis has now become more than just a matter of interpretation of the treaty; it is now also a matter of uncertainty about the environment, technological differences, mistrust of institutions, and local social pressures.

Fragility of the Indus Waters Treaty in the Context of Climate Change: The Indus Waters Treaty (IWT), which was once called a successful example of transboundary water diplomacy, is now seen as failing to cope with the current climate. There are several studies that suggest that the treaty was formulated in a relatively stable hydrological context and that projections of glacier melt, changing precipitation conditions, seasonal variability and climate uncertainty are not adequately covered (Iqbal & Roy, 2022).

Water Scarcity as a Diplomatic Flash point: Water scarcity is now a major issue of the Indo-Pak relations. Water is no longer just a technical resource-management challenge, and is now associated with national security and strategic leverage in the literature. This change was illustrated in the 2025 standoff, where Pakistan asserted its rights to India's water infrastructure through international legal avenues, while India stood firm on treaty rights.

Asymmetric Technological and Agricultural Capacities: The literature reviewed also recognised that there are gaps between the technological and agronomic capacities of both India and Pakistan. Digital irrigation, solar irrigation, precision agriculture, and data-driven agricultural planning are becoming more common in India, especially in agricultural regions facing water scarcity like Punjab and Haryana (Bandyopadhyay, 2023). At the downstream side, the communities are facing water scarcity, loss of crops and salinity issues are becoming more frequent, especially in Sindh (Khan & Mehta, 2025).

Breakdown of Cooperative Mechanisms and Institutional Trust: Another major finding is that of institutional mistrust. Under the IWT, established as a forum for ongoing communication and dispute management, the Permanent Indus Commission has been having trouble keeping working relations active, effective, and efficient. Lesser institutional involvement and political/third party involvement has affected the trust in existing mechanisms (Sharma & Ali, 2024).

Localized Water Insecurity and Societal Impact: The impacts of water insecurity are not just between countries but also on farmers and the poor. Ahmad and Gul (2024) attribute growing socio-economic pressures on the farming communities in India and Pakistan to the dwindling water availability and crop failures. Women and children may be especially affected when water scarcity adds to the labour needs of households in the fields and for water, and, when men migrate, it can push additional labour onto the shoulders of the rural households.

The 2026 Escalation, From Legal Abeyance to War Rhetoric and Internal Fracture: During 2026 the trends noted above were further accentuated. The legal battle over the IWT intensified when India refused to accept the jurisdiction and scope of the arbitration process, and Pakistan still considered the treaty-based processes as critical for safeguarding Pakistan's water rights. (Britannia, 2026; DD News, 2026). Political rhetoric also continued to be securitized, with high-ranking officials on both sides attributing water management issues to terrorism, deterrence and even potential armed conflict (Business Today, 2026a; Business Today, 2026b).

4. Discussion

This section critically interprets the findings presented in the Results section, drawing on both theoretical frameworks and practical realities to assess the implications of Indo-Pak water diplomacy and sustainable agriculture in the context of the Indus Basin. The themes identified—fragility of the Indus Waters Treaty (IWT), water as a diplomatic flashpoint, technological asymmetry, breakdown in institutional trust, and local water insecurity—offer layered insights into the complex water-agriculture-diplomacy nexus in South Asia. What the synthesis makes clear is that water scarcity in this basin has stopped being purely an environmental story. It now functions as a geopolitical trigger in its own right. The IWT survived six decades of turbulence, but the combination of uneven hydrological development and a changing climate has tested it in ways its original drafters did not anticipate (Sharma & Ali, 2024). The 2025 standoff over hydroelectric projects was not just a dispute about engineering specifications; it was a sign that diplomatic patience on both sides had run out, and that unilateral action was becoming the default response rather than the last resort. The interpretation of this shift is critical. The literature shows that earlier diplomatic frameworks were not built to manage dynamic, rapid-onset environmental phenomena, which require real-time data exchange, technological transparency, and adaptive water sharing protocols (Iqbal & Roy, 2022; Farooqi et al., 2024). Instead, the treaty continues to be governed by fixed allocations and pre-digital monitoring tools, leaving space for contestation and politicization.

Water scarcity is no longer a neutral domain—it has become a symbol of national strength and vulnerability. Pakistan's position as a lower riparian nation inherently places it in a reactive position, where Indian infrastructural expansion is seen as a direct threat, not only to agricultural security but also national sovereignty (Khan & Mehta, 2025). The diplomatic posturing on both sides is influenced by internal political pressures, media rhetoric, and historical grievances, compounding the water issue into a multifaceted challenge. Moreover, the disparities in technological innovation between India and Pakistan, as seen in AI-supported irrigation or data-driven crop planning, have widened the sustainability gap. While India moves towards smart agriculture, Pakistan remains heavily reliant on canal-based systems and monsoon predictability (Ahmad & Gul, 2024; Bandyopadhyay, 2023). This technological asymmetry not only impairs productivity but also breeds diplomatic resentment, as water becomes associated with inequality in development rights.

Theoretical Integration: Hydropolitics explains water as a source of geopolitical power, while Environmental Security links scarcity and climate change to national security. Political Ecology highlights unequal social impacts, whereas Complex Interdependence emphasizes the need for sustained institutional cooperation. Together, these frameworks explain power asymmetries, insecurity, inequality, and declining Indo-Pak cooperation.

Practical Implications: Precision farming, solar irrigation, digital water accounting, and climate-smart agriculture should be given special priority in Pakistan, and cooperative planning and prior notification in India should be enhanced in the context of upstream projects (Farooqi et al., 2024). Climate change, real time data sharing and dispute resolution mechanisms should be updated in the Indus Waters Treaty, and there should be other avenues for dialogue, such as the SAARC and BIMSTEC (UNEP, 2025). The World Bank and UNEP should provide support for mediation, shared systems of data, joint agricultural projects, and community-based water governance with farmers, NGOs, women and climate organisations (World Bank, 2023).

Policy Recommendations

The pressures on the Indus Basin are hydrological, political, and technological at once, and policies that address only one of these dimensions are not going to hold. What follows is a set of recommendations that operate at multiple levels simultaneously, drawing on the literature reviewed and on frameworks that have worked in comparable trans-boundary settings elsewhere.

Revamping the Indus Waters Treaty (IWT) with a Climate Clause: A 1960 treaty cannot carry the weight of a 2026 climate crisis. The IWT has no provisions for climate variability, no adaptive governance mechanisms, and nothing approaching basin-wide environmental oversight.

Establishing an Independent Food-Water-Energy (FWE) Nexus Strategy: Food, water, and energy in the Indus Basin do not behave as separate systems, but they are almost always governed as if they do.

Promoting Smart Water Diplomacy: Conflict management is the floor, not the ceiling, for water diplomacy. Smart water diplomacy means building proactive cooperation that does not depend on a crisis to get started.

Smart Education and Climate Literacy: Public awareness and institutional knowledge remain limited on climate-related water governance. Educational reforms should proceed along three lines.

Joint Water Purchasing and Resilience Funds: Infrastructure gaps and unequal access compound water insecurity in ways that technical fixes alone cannot resolve. Financial mechanisms are needed that build shared resilience rather than just funding individual projects.

Empowering Local Institutions and Civil Society: Local peace councils encourage village-level water-sharing agreements and conflict resolution models.

5. Conclusion

This study set out to understand the relationship between sustainable agriculture, water scarcity, and Indo-Pak diplomacy in the Indus Basin, with the 2025 water standoff as its most urgent contemporary reference point. The finding that anchors everything else is this: the Indus Waters Treaty, which successfully prevented direct water conflict for over six decades, is no longer fit for the hydrological and political environment it now has to govern (Zawahri & Mitchell, 2018; Qamar & Saleem, 2023). Across the five themes the review identified, three practical gaps stand out. The treaty needs to be modernised with climate clauses and real dispute-resolution mechanisms that both parties actually accept. The Food-Water-Energy Nexus, widely discussed in the literature, is almost entirely absent from governance structures on both sides. And the technology gap between India and Pakistan in water management is widening in ways that generate diplomatic grievance as well as agricultural inefficiency. Water diplomacy cannot address any of these while remaining isolated from broader regional cooperation (Gleick, 2020; Zeitoun et al., 2017). Sustainable agriculture in this basin is not a technical challenge with a technical solution. It is bound up with water equity, ecological stability, and the question of whether two nuclear-armed neighbours can cooperate on anything at all.

Limitations of the Study

This study has several limitations. The rapid systematic literature review prioritizes timeliness over comprehensiveness, potentially underrepresenting grey literature, historical data, ethnographic evidence, and indigenous knowledge (Arksey & O'Malley, 2005). Its emphasis on recent climate and post-2010 evidence may overlook earlier institutional developments. Policy recommendations remain analytical rather than empirically tested. Limited access to reliable data on water flows, treaty compliance, and diplomatic communications introduces uncertainty (Qamar & Saleem, 2023). Finally, the exclusive use of English-language sources may omit important Urdu and Hindi literature concerning community-level water conflicts and local water-use practices.

Future Research Directions

The limitations above point fairly directly toward where the research agenda needs to go next. Six directions stand out.

- First, empirical testing of proposed policy models – including climate-based IWT amendments and cross-border water trading arrangements – through pilot projects, economic feasibility studies, and environmental impact assessments combining hydrological data, diplomatic archives, and stakeholder interviews (Gleick, 2020).
- Second, climate security model-ing that integrates conflict sensitivity mapping at the basin level, drawing on tools such as the Water Peace and Security Global Early Warning Tool adapted for the Indo-Pak context (Peters et al., 2021).
- Third, longitudinal community-level studies using ethnographic and participatory methods in Punjab, Sindh, and Kashmir to examine how water stress intersects with identity, migration, gender, and health.
- Fourth, regional comparisons with Trans-boundary basins such as the Mekong and the Nile to identify transferable governance lessons (Zeitoun et al., 2017).
- Fifth, interdisciplinary exploration of remote sensing, machine learning, and block chain applications for real-time treaty compliance monitoring, flood early warning, and detection of illegal water abstraction.
- Sixth, a multilingual scoping review incorporating Urdu, Hindi, Punjabi, and Pashto sources to broaden the cultural and narrative base of the literature.
- Collectively these directions point toward a research agenda that is more applied, participatory, and cross-disciplinary – one capable of bridging the science-policy gap and moving from analysis toward actions.

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