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Water for Food: Legal and Environmental Dimensions of Agricultural Water Trade in South Asia

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Abstract

This paper provides a comprehensive legal analysis of water trade agreements in South Asia, focusing on their challenges, opportunities, and future directions, particularly in relation to agriculture. South Asia, home to several transboundary rivers, has long faced complexities in managing shared water resources. The legal frameworks governing water trade between countries like India, Pakistan, Nepal, and Bangladesh often face disputes due to competing demands, political tensions, and climate variability. These agreements are critical for the region's agricultural sector, which relies heavily on consistent water supply for irrigation and food production. The study highlights the challenges arising from existing agreements, such as inadequate dispute resolution mechanisms, lack of environmental safeguards, and insufficient consideration of the agricultural impact. It also explores opportunities for improved regional cooperation, sustainable water resource management, and better alignment of water trade agreements with climate adaptation strategies. Further, the paper discusses the need for future reforms that address the changing needs of agriculture, as the region faces increased water scarcity due to climate change. The research emphasizes the importance of integrating legal, environmental, and agricultural perspectives to ensure that water trade agreements foster long-term sustainability and food security in South Asia

Key Words: *Water Trade Agreements, South Asia, Agriculture, Transboundary Water Resources, Irrigation.*

"Climate Emergency is a race we are losing, but it is a race we can win."

- Antonio Guterres

Introduction

Background of Water Trade in South Asia

Water trade in South Asia is shaped by the region's unique geography, with major transboundary rivers such as the Indus, Ganges, Brahmaputra, and Meghna flowing across multiple countries, including India, Pakistan, Bangladesh, Nepal, and Bhutan. These rivers are critical lifelines for agriculture, domestic use, and industry, making water a highly contested and valuable resource in the region. Historically, water disputes have emerged due to the uneven distribution of water, seasonal variability, and competing demands from upstream and downstream users.

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To manage shared water resources, countries in South Asia have developed bilateral agreements such as the Indus Waters Treaty (1960)[3] between India and Pakistan and the Ganges Water Sharing Treaty (1996)[4] between India and Bangladesh. These treaties aim to regulate water allocation and minimize conflicts; however, they often face challenges related to enforcement, geopolitical tensions, and changing environmental conditions. In addition, climate change is exacerbating water scarcity and unpredictability, further straining existing agreements and cooperation mechanisms.

The agricultural sector, which is heavily dependent on reliable water supply for irrigation, is deeply affected by the outcomes of these water trade agreements. As agriculture forms the backbone of the economies of these countries, ensuring equitable and sustainable water sharing is critical for regional stability, food security, and economic growth.

While the Indus Waters Treaty[5] (between India and Pakistan) and the Ganges Water Sharing Treaty[6] (between India and Bangladesh) are among the most well-known water agreements in South Asia, there are other important agreements and cooperative efforts involving various South Asian countries:

1. Mahakali Treaty (1996)[7] – India and Nepal - This agreement governs the sharing of the waters of the Mahakali River, which forms part of the boundary between India and Nepal. It also covers the construction of the Pancheshwar Multipurpose Project for hydroelectric power and irrigation.
2. Koshi Agreement (1954)[8] – India and Nepal - This treaty relates to the Koshi River, where India agreed to construct a barrage to control flooding and provide irrigation. However, it has faced criticism over equitable benefits to Nepal and downstream impacts.
3. Treaty of the Teesta River (pending)[9] – India and Bangladesh - The Teesta River, a major tributary of the Brahmaputra, has long been a point of contention between India and Bangladesh. While a treaty has been in negotiation for years, no formal agreement has been finalized due to political sensitivities, especially within Indian states like West Bengal.a
4. Brahmaputra River Basin[10] – India, China, Bhutan, and Bangladesh - Although there is no formal multilateral treaty, the Brahmaputra River is of immense importance to several countries. China and India, as the upper riparian states, have begun bilateral cooperation on sharing hydrological data, but no binding agreement exists for comprehensive water sharing. Bangladesh, as the downstream nation, is particularly vulnerable to water shortages and flooding.

[3] Indus Waters Treaty, India-Pak., Sept. 19, 1960, 419 U.N.T.S. 126.
[4] Treaty on Sharing of the Ganga/Ganges Waters at Farakka, Bangl.-India, Dec. 12, 1996, 36 I.L.M. 519 (1997).
[5] Supra Note 3
[6] Supra Note 4
[7] Mahakali Treaty, India-Nepal, Feb. 12, 1996, 36 I.L.M. 531 (1997).
[8] Agreement Between His Majesty's Government of Nepal and the Government of India on the Koshi Project, Nepal-India, Apr. 25, 1954, 1954 U.N.T.S. No. 262.
[9] No formal treaty exists; negotiations continue. Reference to pending status: Ministry of External Affairs, Government of India, Joint Statement on Teesta River Sharing Discussions, available at https://mea.gov.in.
[10] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), Transboundary Water Management in the Brahmaputra Basin (2021), available at https://www.unescap.org.

5. Bangladesh-Nepal Cooperation[11] - Although there is no formal agreement, Bangladesh and Nepal have expressed interest in cooperating on water resources, particularly in the areas of hydropower development and sharing water flows, recognizing the importance of transboundary cooperation.

While these agreements demonstrate the efforts made by South Asian countries to manage shared water resources, they often face challenges such as unilateral actions, political tensions, and inadequate dispute resolution mechanisms. Many agreements are bilateral in nature, limiting broader regional cooperation, which is essential given the interconnectedness of South Asia's rivers and their critical role in agriculture and sustainable development.

Importance of Water For Agriculture

Water is an essential resource for agriculture, especially in South Asia, where the majority of the population relies on farming for livelihoods and food security. Agriculture in this region is predominantly rain-fed or irrigation-dependent, making water availability a critical determinant of crop productivity and agricultural sustainability. The importance of water for agriculture can be understood through several key factors:

i. Irrigation and Crop Production

Irrigation is the backbone of agriculture in South Asia[12], allowing for the cultivation of crops throughout the year, especially in regions where monsoon rains are insufficient or unreliable. Crops like rice, wheat, sugarcane, and cotton, which are staples in the region, are heavily dependent on consistent water supply.[13] Irrigated agriculture is far more productive than rain-fed agriculture, contributing significantly to food security and economic stability.[14] Water shortages or uneven distribution can result in crop failure, leading to food scarcity and economic losses.

ii. Food Security and Livelihoods

Water availability directly impacts food security in South Asia, where a large portion of the population relies on subsistence farming. Adequate water ensures that crops are grown in sufficient quantities to meet both domestic consumption needs and export demands. Additionally, reliable water supply sustains the agricultural sector, which provides employment to millions of people across India, Pakistan, Bangladesh, Nepal, and other South Asian nations. Without proper water management, rural communities are vulnerable to poverty and malnutrition.

iii. Multi-Cropping and Crop Diversification

[11] Nishchal N. Pandey & Mahesh Raj Bhatta, Enhancing Nepal-Bangladesh Relations, ISAS Insights (Jan. 4,2023), available at https://www.isas.nus.edu.sg/papers/enhancing-nepal-bangladesh relations/#:~:text=In%20April%201976%2C%20the%20two,as%20banking%2C%20finance%20and%20insurance.

[12] Tushaar Shah et al., Energy-Irrigation Nexus in South Asia: Improving Groundwater Conservation and Power Sector Viability (Revised 2d ed., Int'l Water Mgmt. Inst. 2004), ISBN: 92-9090-588-3, ISSN: 1026-0862.

[13] Ownership Dynamics and ESG Commitment: An Empirical Analysis of the Indian Tourism Industry. (2024). AEIDA: Journal of Multidisciplinary Studies , 1(1), 43-50. http://aeidajournal.org/index.php/AEIDA/article/view/5

[14] Jay Narayan Vyas, The Sustainability of Irrigated Agriculture in India, 10 World Aff. 64 (2006).

Regions with ample water resources can engage in multi-cropping, where different crops are grown on the same land in a single year. This allows for diversification in agricultural production, increasing both income and food security. However, the lack of water severely restricts this practice, forcing farmers to rely on a limited range of crops that are often less profitable or nutritious.

iv. Impact on Irrigation Systems

South Asia's extensive canal and groundwater-based irrigation systems depend on stable water resources. Major rivers like the Indus, Ganges, and Brahmaputra provide water for large irrigation networks, which supply water to millions of hectares of farmland. Proper water trade agreements and cooperation among riparian countries are crucial for maintaining these irrigation systems, ensuring water is allocated efficiently and equitably to support agriculture.

v. Climate Change and Water Scarcity

Climate change is increasingly affecting the availability of water in South Asia. Rising temperatures, erratic monsoon patterns, and decreasing water flows in major rivers are leading to water scarcity, directly impacting agriculture. Farmers are often forced to adopt unsustainable practices such as over-extraction of groundwater, which further exacerbates the problem. As agricultural production declines due to water stress, it threatens not only local food systems but also global food supply chains.

vi. Sustainable Agricultural Practices

Water is also crucial for implementing sustainable agricultural practices. Efficient water use through techniques such as drip irrigation, rainwater harvesting, and soil moisture conservation helps reduce wastage and enhances productivity. However, many of these practices require substantial investments and infrastructure, which are often lacking in rural parts of South Asia.[15]

vii. Economic Contribution

Agriculture contributes significantly to the GDP of South Asian countries, and water is the primary input that sustains this sector. In countries like India, agriculture accounts for a major share of employment and rural income. The economic well-being of farming communities is closely tied to water availability, and any disruption in water supply, whether due to climate change, over-extraction, or mismanagement, can have severe repercussions on the economy.[16]

viii. Hydrological Dependencies and Regional Tensions

The agricultural sector in South Asia is not only dependent on domestic water sources but also on transboundary rivers shared by neighboring countries. Water trade agreements and cooperation are essential for ensuring that upstream water usage does not adversely affect downstream agricultural needs. Conflicts over water sharing can destabilize regional relations and lead to shortages that harm agricultural productivity, threatening regional food security.

[15] Amanda Farthing, Irrigation and Water Management: Ensuring Sustainable Agriculture and Environmental Stewardship, 6 J. Agric. 103 (2023).

[16] Pritha Datta, Bhagirath Behera & Dil Bahadur Rahut, Climate Change and Indian Agriculture: A Systematic Review of Farmers' Perception, Adaptation, and Transformation, 8 Envtl. Challenges 100543 (2022), https://doi.org/10.1016/j.envc.2022.100543.

Overall, water is the lifeline of agriculture in South Asia, and its management is vital for sustaining crop production, ensuring food security, and supporting the livelihoods of millions. Given the pressures of climate change, population growth, and regional tensions over water resources, the sustainable and equitable management of water is crucial for the future of agriculture in the region.

Virtual And Regional Impacts Of Water Trade On Agriculture

Virtual water trade[17] refers to the concept of trading goods and services that indirectly involve the transfer of water used in their production. In the context of agriculture, this involves the exchange of food crops and agricultural products, where the water consumed in producing these goods is considered a form of 'virtual' water. In South Asia, virtual water trade has significant implications for both national and regional water resources, as well as the agricultural sector.

In South Asia, where water resources are unevenly distributed across countries, virtual water trade can be both a solution and a challenge for agricultural sustainability. Countries that export water-intensive crops, such as rice, wheat, and sugarcane, are essentially exporting large amounts of water embedded in these products.[18] This can have a direct impact on domestic water availability, especially in regions facing water scarcity or excessive water extraction.

For instance, India, one of the largest exporters of rice globally, uses significant amounts of water to grow paddy crops, particularly in water-stressed areas like Punjab and Haryana[19]. This export-driven virtual water trade puts immense pressure on the groundwater resources of these regions, leading to over-extraction and declining water tables. The over-reliance on water-intensive crops for export markets thus jeopardizes local water sustainability and agricultural productivity in the long run. Additionally, India exports water through sugarcane production, another highly water-intensive crop, worsening the water crisis in key agricultural zones.

Similarly, Pakistan, a major exporter of cotton[20], engages in virtual water trade that places stress on its already fragile water systems, particularly in the Indus River basin. Cotton production requires substantial irrigation, contributing to water depletion in the arid regions of the country. As Pakistan exports cotton and textile products, it effectively exports large quantities of virtual water, further straining its domestic agricultural resources. Given the ongoing water scarcity in the country, this virtual water trade negatively impacts long-term agricultural sustainability.

On the other hand, virtual water trade offers opportunities for Bangladesh and Nepal, which are less involved in exporting water-intensive crops. These countries, while primarily importers of agricultural products, benefit from virtual water trade by reducing their direct

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[17] Mohammad Delpasand, Omid Bozorg-Haddad, Erfan Goharian & Hugo A. Loáiciga, Virtual Water Trade: Economic Development and Independence Through Optimal Allocation, 275 Agric. Water Mgmt. 108022 (2023), https://doi.org/10.1016/j.agwat.2022.108022.

18 Sustainable Investing in India: The Moderating Role of Firm Size on Financial Performance. (2024). AEIDA: Journal of Multidisciplinary Studies , 1(1), 35-42. http://aeidajournal.org/index.php/AEIDA/article/view/4

19 U. Surendran, P. Raja, M. Jayakumar & S. Rama Subramoniam, Use of Efficient Water Saving Techniques for Production of Rice in India Under Climate Change Scenario: A Critical Review, 309 J. Cleaner Prod. 127272 (2021), https://doi.org/10.1016/j.jclepro.2021.127272.

20 Rahul M. Lad & Ravindra G. Jaybhaye, Water Politics in Pakistan: The Internal and External Dynamics, 27 Water Pol'y 40 (2025), https://doi.org/10.2166/wp.2024.098.

water consumption. By importing food from neighboring countries like India, they offset their own agricultural water use[21], preserving their limited water resources for other uses, such as drinking water and industrial needs. This trade dynamic allows Bangladesh to focus on crops that are less water-intensive and more suited to its climatic and hydrological conditions, thereby maintaining a balance between agricultural output and water availability.

However, virtual water trade also presents certain challenges for agricultural policy in the region. Governments and policymakers must carefully weigh the economic benefits of exporting agricultural products against the long-term sustainability of domestic water resources. In many cases, agricultural subsidies and export incentives promote the growth of water-intensive crops, exacerbating water shortages and depleting groundwater reserves. This imbalance calls for a shift toward more sustainable farming practices and cropping patterns that are in line with the region's water realities. Encouraging farmers to diversify their crops and adopt water-efficient agricultural practices, such as drip irrigation or switching to less water-demanding crops, can help mitigate the negative impact of virtual water trade.

Moreover, virtual water trade has the potential to influence regional water diplomacy. As South Asian countries are connected through shared rivers and agricultural trade, managing virtual water flows through trade can help ease tensions over water scarcity. Cooperative strategies that involve sharing virtual water data, coordinating water management policies, and promoting sustainable agricultural practices can foster a more balanced approach to water usage. This can enhance regional food security and reduce conflict over physical water resources by allowing countries to import water-rich products instead of competing for limited transboundary water supplies.

It is a fact that virtual water trade has profound impacts on South Asian agriculture. While it provides economic opportunities through the export of agricultural products, it also places unsustainable pressure on water resources in certain regions. The challenge for South Asia lies in managing virtual water trade in a way that balances economic benefits with environmental sustainability, ensuring that agricultural practices do not further deplete the region's already scarce water resources. A comprehensive approach involving changes in cropping patterns, irrigation practices, and regional cooperation is essential to address the challenges posed by virtual water trade and safeguard the future of agriculture in South Asia.

The Role of Water Trade in Regional Agriculture is increasingly significant, particularly in areas like South Asia, where transboundary water resources directly impact agricultural productivity. Water trade, both formalized through treaties and informal arrangements, refers to the sharing, allocation, and management of water resources between countries or regions to meet agricultural and other needs. In regions where rivers and groundwater basins span multiple political boundaries, water trade agreements ensure equitable access to water, which is vital for sustaining agricultural operations.

In South Asia, the Indus, Ganges, Brahmaputra, and other river systems serve as lifelines for agricultural activities across several countries. Water trade agreements, such as the Indus Waters Treaty (1960)[22] between India and Pakistan and the Ganges Water Sharing

[21] Brindha Karthikeyan, International Virtual Water Flows from Agricultural and Livestock Products of India, 161 J. Cleaner Prod. (2017), https://doi.org/10.1016/j.jclepro.2017.06.005.
[22] Indus Waters Treaty, India–Pak., Sept. 19, 1960, 419 U.N.T.S. 126.

Treaty (1996)[23] between India and Bangladesh, are prime examples of how structured water-sharing frameworks help regulate access to these vital water sources. These treaties ensure that water is distributed based on agreed terms, enabling farmers in different regions to receive a reliable water supply for irrigation.

For countries heavily dependent on agriculture, such as India, Pakistan, and Bangladesh, securing water through these agreements is crucial for food security. A predictable and consistent water supply allows for better planning of crop cycles, irrigation scheduling, and the overall agricultural economy. Without such agreements, downstream countries would face unpredictable water shortages during critical growing seasons, which could lead to decreased crop yields and potential food crises.

Moreover, water trade allows for the development of joint projects, such as the construction of dams, irrigation canals, and reservoirs, which can optimize water use for agricultural purposes. For example, the Mahakali Treaty (1996)[24] between India and Nepal involves both countries benefiting from hydropower and irrigation projects on the Mahakali River, helping them better manage water for agriculture.

However, the effectiveness of water trade in supporting regional agriculture can be hampered by political tensions, poor enforcement of agreements, and fluctuating water availability due to climate change. Droughts, floods, and changing rainfall patterns complicate water-sharing dynamics, leading to disputes or breaches of agreements, which can harm agricultural output.

1. China-India Water Relations on the Brahmaputra River: The Brahmaputra River, originating in China and flowing through India and Bangladesh, is critical for agriculture in Assam and Bangladesh. In recent years, China's construction of dams and water-diversion projects upstream has raised concerns in India and Bangladesh about reduced water flow, especially during the dry season. This has led to concerns about the impact on rice and tea cultivation in Assam, as the region heavily relies on Brahmaputra's water. Although no formal water trade agreement exists between China and India on the Brahmaputra, there have been periodic discussions to ensure transparency in water flow data, essential for agricultural planning.
2. Indus Waters Treaty under Strain (India-Pakistan): The Indus Waters Treaty (1960), which governs the use of the Indus River system between India and Pakistan, has faced challenges in recent years. Both countries rely heavily on the Indus River for agriculture, particularly in Pakistan's Punjab and Sindh provinces. Political tensions have strained the treaty, and climate change has further exacerbated water availability issues. In 2023, Pakistan raised concerns about India's construction of hydroelectric projects on the Indus tributaries, fearing reduced water flow to its agricultural lands. Despite these tensions, the treaty has largely held up, demonstrating the importance of water trade for agricultural stability.
3. Nepal-India Water Cooperation (Kosi and Gandak Projects): Nepal and India share multiple rivers that are crucial for agriculture in both countries. Recent developments include the construction of irrigation canals and water storage infrastructure under joint projects like the Kosi and Gandak agreements. These projects provide water for millions of hectares of farmland in Bihar (India) and parts of Nepal, helping mitigate drought risks and improving agricultural output.

[23] Treaty Between the Government of the Republic of India and the Government of the People's Republic of Bangladesh on Sharing of the Ganga/Ganges Waters at Farakka, India–Bangl., Dec. 12, 1996.
[24] Supra Note 7

The successful implementation of these agreements has bolstered agricultural productivity, particularly for staple crops like rice and wheat.

These examples illustrate the ongoing relevance and challenges of water trade agreements for agricultural sustainability in South Asia. The effective management of shared water resources is critical for ensuring the long-term viability of agriculture in the region, particularly in light of political tensions and the growing impact of climate change.

The crucial question that arises is does Water trade and management Challenges the Environment further or it complements the environmental cause ?

Water trade and water management can both challenge and complement the environment, depending on how these systems are implemented.

Challenges to the Environment:

Water trade agreements, especially those involving dam construction or water diversion projects, can disrupt natural ecosystems. Dams alter river flows, which can harm aquatic ecosystems by changing water temperatures, sediment transport, and nutrient distribution. For example, fish migration patterns are often affected, leading to reduced biodiversity.[25]

Water management systems that do not account for sustainable limits can lead to over-extraction of groundwater and surface water, depleting resources faster than they are replenished. Over-extraction can cause aquifers to dry up, lead to soil degradation, and affect natural habitats that depend on regular water flows.[26]

Water trade can contribute to environmental degradation when increased water availability leads to intensified agricultural activities. The use of chemical fertilizers and pesticides often results in polluted runoff entering rivers and groundwater systems, causing eutrophication, loss of biodiversity, and contamination of drinking water supplies.[27]

Large-scale water management projects, such as the construction of reservoirs or transfer of water across regions, can increase greenhouse gas emissions during construction and operation. These projects can also lead to deforestation, further contributing to climate change.

Ways Water Trade and Management Can Complement the Environment:

Proper water management encourages efficient use of water resources, which can benefit the environment. Technologies like drip irrigation and rainwater harvesting reduce water waste and improve water use efficiency in agriculture, helping to conserve freshwater supplies.

Water management systems, such as dams and reservoirs, can help prevent floods and store water for use during droughts. This can protect ecosystems from extreme weather events, ensuring more stable environments and improving resilience to climate change.

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[25] Matthew McCartney, Caroline Sullivan & Mike Acreman, Ecosystem Impacts of Large Dams, Sch. Arts & Soc. Sci. Papers (2001).

[26] Peter G. Cook et al., Sustainable Management of Groundwater Extraction: An Australian Perspective on Current Challenges, 44 J. Hydrology: Reg'l Stud. 101262 (2022), https://doi.org/10.1016/j.ejrh.2022.101262.

[27] Martin J. Luna Juncal, Pietro Masino, Edoardo Bertone & Rodney A. Stewart, Towards Nutrient Neutrality: A Review of Agricultural Runoff Mitigation Strategies and the Development of a Decision-Making Framework, 874 Science of the Total Environment 162408 (2023), https://doi.org/10.1016/j.scitotenv.2023.162408.

Well-designed water trade agreements can incorporate provisions for environmental flows—ensuring that rivers maintain a minimum flow level to support ecosystems. This type of management supports biodiversity and preserves wetlands, rivers, and forests that are critical for ecological balance.

By regulating water use through trade and management, countries can promote sustainable agriculture. When water is shared fairly and used efficiently, it helps maintain soil health and prevents land degradation, which in turn supports long-term environmental sustainability.

Water trade and water management have the potential to either challenge or complement the environment, depending on their design and implementation. Unsustainable practices, such as over-extraction and pollution, can harm ecosystems and biodiversity. However, when managed carefully, water trade can promote efficient water use, protect ecosystems, and improve resilience to climate change. Sustainable policies and legal frameworks are essential to ensure that water management balances the needs of agriculture and human consumption with environmental preservation.

Political Challenges and Disputes in Water Trade

Water trade agreements in South Asia face significant political and sovereignty challenges, as shared water resources like the Indus, Ganges, and Brahmaputra rivers flow across multiple nations with competing claims. Downstream countries fear upstream nations may control or divert flows, jeopardizing agriculture, drinking water, and economic stability. For instance, the Indus Waters Treaty (1960) between India and Pakistan often becomes contentious when India undertakes upstream projects, while the Teesta River dispute between India and Bangladesh is stalled due to resistance from India's West Bengal state. Similarly, China's control over the Brahmaputra headwaters raises concerns in India and Bangladesh about reduced downstream water flows due to dam construction and diversion projects. Political mistrust and the use of water as a geopolitical tool exacerbate these tensions, making enforcement of agreements challenging.

Within India, interstate disputes further complicate water management. Key conflicts include the Cauvery River dispute[28][29] between Karnataka and Tamil Nadu, the Krishna River dispute[30] [31]involving multiple states, and the Ravi-Beas dispute between Punjab and Haryana[32] over the Sutlej-Yamuna Link canal. These disputes arise from competing agricultural and industrial demands, worsened by India's constitutional framework where water is primarily a state subject. This leads to jurisdictional overlaps and resistance to central interventions, making resolution difficult.

Dispute resolution mechanisms are often undermined by a lack of binding enforcement, lengthy legal processes, and overlapping domestic and international legal frameworks. For instance, while the Indus Waters Treaty includes provisions for neutral arbitration, escalating political tensions hinder effective enforcement. Climate change further complicates water-sharing agreements as changing hydrological patterns and reduced river flows render older treaties obsolete. Addressing these issues requires transparent dialogue, confidence-building measures, and adaptive legal frameworks that integrate climate

[28] State of Karnataka v. State of Tamil Nadu, (1991) 1 SCC 600 (India).
[29] The Cauvery Water Disputes Tribunal Award, Ministry of Water Resources, Government of India (2007).
[30] The Krishna Water Disputes Tribunal (KWDT) Award, Ministry of Water Resources, Government of India (2013).
[31] State of Andhra Pradesh v. State of Maharashtra, (1976) 2 SCC 751.
[32]Punjab v. Haryana, AIR 2002 SC 1453.

change and seasonal variability considerations. Strengthened regional cooperation and enforceable mechanisms are essential for sustainable water management in South Asia.

Agricultural Pressures and Demands

Agricultural pressures and demands on water resources have grown significantly due to the increasing need to feed a rapidly expanding global population. Agriculture is the largest consumer of freshwater, accounting for approximately 70% of global water withdrawals[33], and in many regions, this percentage is even higher. The demand for water in agriculture is driven by the need to irrigate crops, sustain livestock, and maintain large-scale farming operations. As food production needs intensify, especially in water-scarce regions, this pressure on available water resources has created critical challenges in maintaining a balance between agricultural use and the sustainable management of water supplies.

One of the major contributors to agricultural water demand is irrigation, which is essential for cultivating crops in arid and semi-arid regions. In many parts of the world, such as India, China, and the United States, vast areas of farmland rely on irrigation to produce staple crops like rice, wheat, and corn. However, irrigation practices are often inefficient, with significant water losses due to evaporation, runoff, and poor infrastructure. In regions with outdated irrigation systems, such as flood irrigation, water use is particularly wasteful, putting additional strain on freshwater resources. This unsustainable use of water not only depletes surface and groundwater sources but also reduces the availability of water for other sectors, including domestic and industrial use.

The agricultural sector's pressure on water resources is further exacerbated by the increasing cultivation of water-intensive crops, such as cotton, sugarcane, and almonds, in regions where water scarcity is already a concern. For instance, the cultivation of crops like sugarcane in drought-prone areas of Maharashtra[34], India, has led to overexploitation of groundwater resources, causing aquifers to dry up and reducing water availability for other critical uses. Similarly, in California, the cultivation of almonds, which require large amounts of water, has contributed to significant groundwater depletion during periods of drought.[35] These agricultural practices highlight the need for better water management strategies, such as crop diversification and the adoption of less water-intensive farming methods, to reduce the strain on water supplies.

Livestock farming also contributes to agricultural pressures on water resources. The production of meat and dairy products requires large volumes of water, both directly for the animals and indirectly for growing the feed crops they consume. In addition, the water footprint of animal-based products is significantly higher than that of plant-based foods.[36] As global meat consumption increases, the demand for water in livestock production continues to rise, placing additional pressure on already stressed water systems. This

[33] Tom Tabler & Joseph Chibanga, Water Scarcity in Agriculture: The Greatest Threat to Global Food Security, Univ. of Tenn. Extension Publ'n W 1252 (2024), https://utia.tennessee.edu/publications/wp-content/uploads/sites/269/2024/07/W1252.pdf.

[34] Sneha Kulkarni, Vinay Kumar, Vinayak Bhanage & Shirishkumar Gedam, Exploring the Association Between Changing Crop Types and Water Scarcity: A Case Study over West-Central India, 11 Climate, no. 5, May 2023, https://doi.org/10.3390/cli11050093.

[35] Bekele Shiferaw, Addressing Groundwater Depletion: Lessons from India, the World's Largest User of Groundwater, World Bank: IEG Blog (Aug. 23, 2021), https://ieg.worldbankgroup.org/blog/addressing-groundwater-depletion-lessons-india-worlds-largest-user-groundwater.

[36] P.W. Gerbens-Leenes, M.M. Mekonnen & A.Y. Hoekstra, The Water Footprint of Poultry, Pork and Beef: A Comparative Study in Different Countries and Production Systems, 1–2 Water Resources & Industry 25 (2013), https://doi.org/10.1016/j.wri.2013.03.001.

growing demand for water in agriculture raises concerns about the sustainability of food production, especially in regions facing chronic water shortages.

Climate change further compounds the pressures on water resources for agriculture. With changing weather patterns, prolonged droughts, and unpredictable rainfall, farmers face greater uncertainty in securing reliable water supplies for their crops. This forces many to turn to unsustainable groundwater extraction, which depletes aquifers and reduces long-term water availability. In many areas, such as parts of India, Africa, and the Middle East, over-extraction of groundwater has led to falling water tables and deteriorating water quality, making it harder to meet agricultural water needs in the future.[37]

Overall, agricultural pressures and demands on water resources are a key factor in global water scarcity. The competing needs for water in agriculture, coupled with inefficient practices, water-intensive crops, and livestock farming, contribute to the overuse and depletion of freshwater resources. Addressing these pressures requires implementing more efficient irrigation systems, promoting sustainable farming practices, and improving water management policies to ensure that agriculture can meet the growing food demand without compromising the availability of water for future generations.

Conclusion

The intersection of water trade agreements, agriculture, and environmental sustainability in South Asia presents a complex yet critical challenge. As the region navigates these issues, it is essential to consider the legal, agricultural, and environmental implications to ensure equitable and sustainable management of water resources.

Legal Implications, Water trade agreements in South Asia have historically been vital in managing the allocation of shared water resources among countries with competing needs. However, the existing legal frameworks, such as the Indus Waters Treaty and the Ganges Water Treaty, were established under different environmental and political conditions. To remain effective, these agreements must evolve to address contemporary challenges, including those posed by climate change and increased water demand. Reforms should focus on incorporating adaptive mechanisms to handle extreme weather events and fluctuating water availability. Additionally, legal frameworks must facilitate better cooperation and data-sharing among nations to manage transboundary water resources effectively and resolve disputes amicably. Strengthening dispute resolution mechanisms and ensuring transparent, enforceable agreements will be crucial in maintaining regional stability and fostering collaborative water management.

Agricultural Implications, Agriculture is the largest consumer of water in South Asia, and water trade agreements significantly impact agricultural productivity and food security. Direct and indirect effects of these agreements influence irrigation practices, crop yields, and overall agricultural output. While some agreements have facilitated improvements in irrigation infrastructure and agricultural productivity, others have led to disputes that affect farmers' access to water. Aligning water trade agreements with contemporary agricultural needs involves adopting sustainable water management practices, promoting water-efficient technologies, and addressing regional disparities in water distribution. Ensuring that agreements consider the diverse agricultural contexts of different regions will help mitigate the risks of reduced productivity and food insecurity.

[37] Joseph Omeiza Alao, A.Y. Bello, H.A. Lawal & D. Abdullahi, Assessment of Groundwater Challenge and the Sustainable Management Strategies, 2 Results in Earth Sciences 100049 (2024), https://doi.org/10.1016/j.rines.2024.100049.

Environmental Implications, The environmental impacts of water trade agreements are profound, as water management practices directly affect ecosystems and biodiversity. Unsustainable water use, driven by legal and agricultural demands, can lead to ecosystem degradation, reduced river flows, and loss of wetlands. Climate change further complicates these issues, altering water availability and exacerbating environmental stress. Future water trade agreements must prioritize environmental sustainability by integrating principles of integrated water resource management (IWRM) and promoting practices that protect and restore ecosystems. Sustainable water management should include measures to reduce the environmental footprint of water use, such as minimizing pollution, conserving natural habitats, and maintaining ecological flow regimes in rivers.

In summary, addressing the legal, agricultural, and environmental implications of water trade agreements in South Asia is essential for ensuring the long-term sustainability of water resources. Reforming legal frameworks to adapt to contemporary challenges, aligning agricultural practices with sustainable water use, and prioritizing environmental conservation will be critical in managing the complex interplay of interests and impacts associated with shared water resources. By adopting a holistic approach that balances these dimensions, South Asia can navigate the challenges of water management and build a more resilient and equitable system for the future.