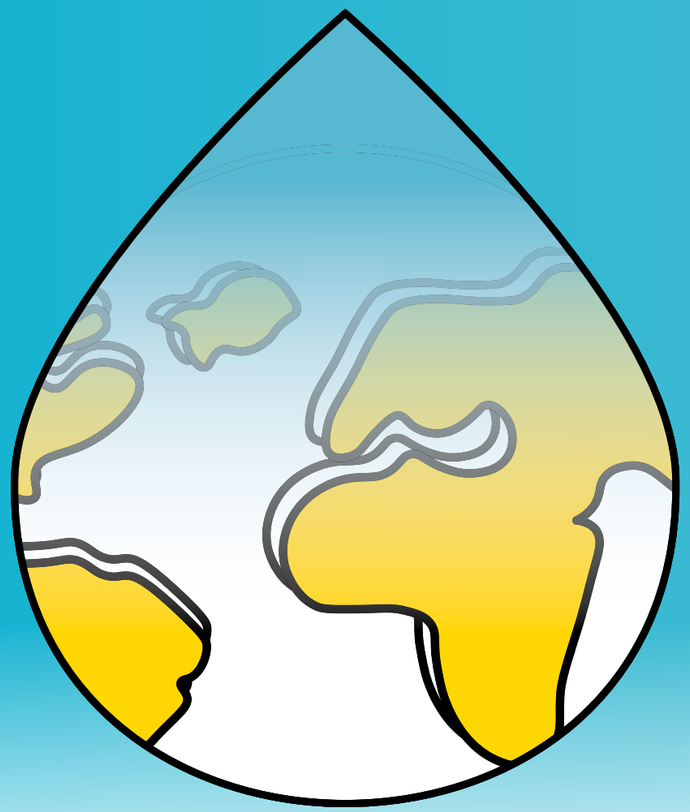

Flowing into Uncertainty:

Climate Change and Water Security Risks

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For India, the rivers are not only the heart and soul of their culture but also of their growth, with 12 major rivers running through the country. However, its water resources are precious. Despite India being home to over 18% of the world's population, it possesses only 4% of the world's water resources, many of which are polluted by wastewater, intensive agriculture, infrastructure development, and industrial production (World Bank, 2022). Over recent decades, India's booming economy, population growth, and rapid urbanisation have contributed to India's water stress, compounded by its scarce natural water resources (Asian Development Research Institute (ADRI), 2024). A significant portion of the water is used for irrigation, and it is projected that by 2025, more than 80% of the demand will be for irrigation alone. Extreme climatic changes could further threaten the sustainable water supply for agricultural production. Not only is India affected by water stress, but many surrounding countries face similar challenges shaped by analogous climates and interconnected river systems. Nations such as Bangladesh, Pakistan, and Nepal depend heavily on shared river basins like the Ganges, Brahmaputra, and Indus. These basins are crucial for sustaining the agricultural sectors, which are primary contributors to these countries' economies (United Nations Educational, Scientific and Cultural Organization. 2023)

The region's geopolitical dynamics add another layer of complexity to water security. Transboundary rivers can be a source of cooperation or conflict, depending on how their management is handled. Existing agreements and treaties have aimed to balance the distribution and administration of these shared waters, yet challenges persist (World Bank, 2022). With climate change, there is an upcoming thirst for solutions as global warming aggravates changes in rainfall patterns, disrupting traditional water cycles (Intergovernmental Panel On Climate Change (IPCC), 2023). How will climate change affect the current water stress in Asia? Are existing treaties capable of addressing the challenges posed by climate change, or is a more cooperative solution needed? Given the looming risks from water scarcity and climate-induced conflicts, this paper delves into a critical question: How do water stress and climate change shape the geopolitical landscape of Asia? This article provides an overview of two main water-stress-related conflicts in Asia, focusing on their implications for geopolitical stability. It highlights the various factors contributing to water stress and insecurity, including hydrologic and socio-economic environments, and examines how water scarcity impacts security and inter-nation relations.

Through detailed case studies of India, Pakistan, and China, the article illustrates how water stress has heightened tensions and threatens regional stability. Ultimately, it contends that water scarcity, intensified by climate change, is a noteworthy catalyst for conflict and instability in Asia. The article suggests that this issue should be addressed within existing or future treaties to ensure effective management of limited water resources.

1. Water – A Vital Lifeline

We all need water to survive. Living under constant water stress can endanger jobs, resources, food and energy security and threaten global peace and security. However, what exactly is defined as water stress? *"Water stress measures the ratio of total water demand to available renewable surface and groundwater supplies."* (Kuzma et al., 2023, p. 11). Demand, in this definition, is interchangeable with withdrawal. While there are other indexes used to calculate water scarcity or water stress, this cal-

culation is the most common way to calculate blue water stress in a specific area. Blue water and green water are the two types of freshwater on earth. Blue water is the water found in lakes, rivers, groundwater or frozen in glaciers and the polar caps, whilst green water refers to rainfall and moisture in the soil (Falkenmark & Rockström, 2006). Water stress is most acute in regions where the demand significantly exceeds the available supply. As visible in Figure 1, the so-called water risk atlas, those regions most underwater stress are coloured dark red. In Asia, the Indus River basin, shared by India and Pakistan, and the Brahmaputra River, originating in China, are prime examples of areas experiencing severe blue water stress.

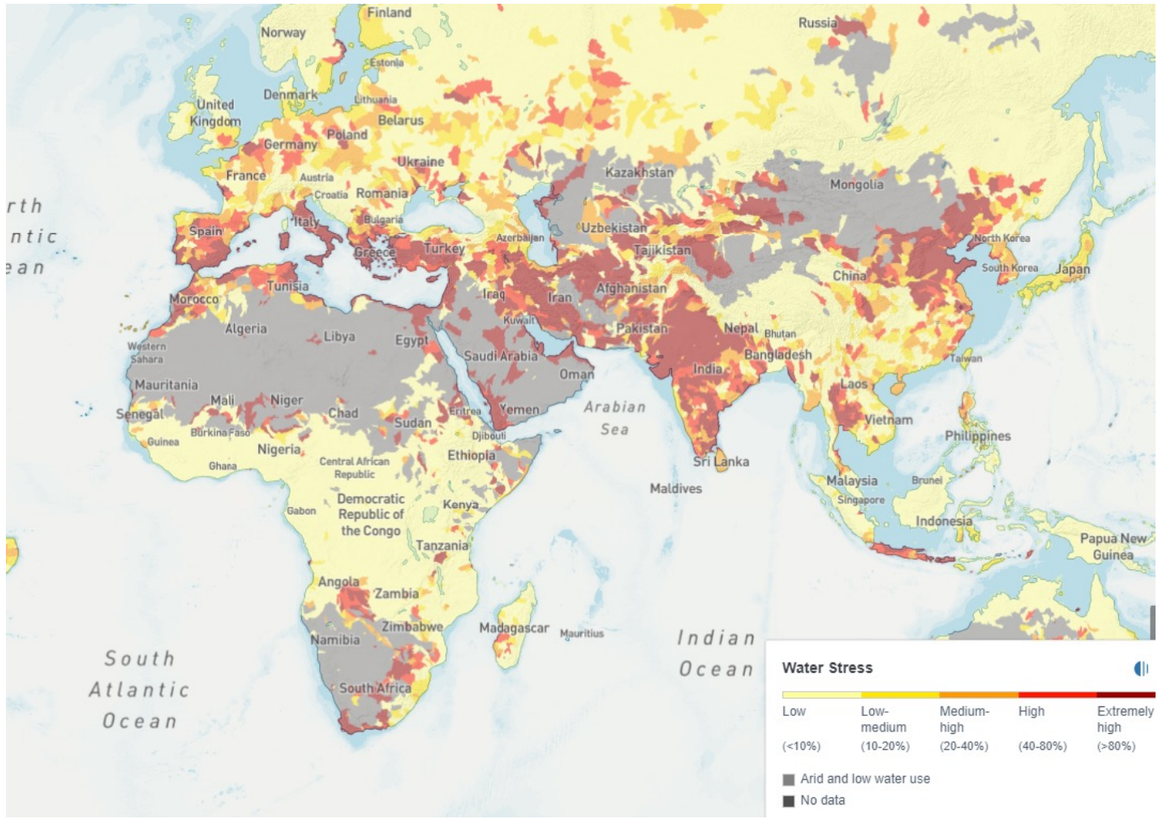

Figure 1: Regions with the Highest Water Stress, highlighted in dark red on the Water Risk Atlas map (World Resources Institute, 2024)

2.Water Accessibility and Availability

When our favourite flow of life is depleted by heat, countries may not only face severe thirst but also experience escalating inter-nation conflicts and intensifying existing disputes. One of the objectives of sustainable development goals (SDGs) is to ensure that all individuals have access to safe and affordable drinking water. The fulfilment of this goal depends on availability and access. How can we be certain that there will be enough water for all humans and the entire ecosystem upon which our survival depends?

While water seems like an endless source in many countries and is easily accessible, it is not so for everyone. A study by Mekonnen and Hoekstra (2016) found that 71% (4.3 billion people) of the global population live under conditions of moderate to severe water scarcity for at least one month of the year. The number of people experiencing severe water scarcity during at least four to six months per year is estimated to be up to 2.9 billion. Even though over 70% of the earth's surface is covered by water, it does not mean that all water can be used. Availability does not equal accessibility. The term water availability refers to what quantity of water is physically available and whether that available water is actually of quality, e.g. safe to use. Accessibility, on the other hand, depends on various factors, such as physical access, economic access, culturally acceptable access, and political access. All the factors summarising availability and accessibility have to be present to ensure water security.

Taking a glance at the most important factors they can be broken down into three main categories. What determines water security seems to be the a.) Hydrological environment, b.) the socio-economic environment and c.) change in the future environment (e.g. climate change). This article will investigate the case studies based on these three main factors.

2.a. Hydrological Environment

The hydrological environment includes, as previously stated, naturally occurring water resources, such as surface and groundwater. The key determinants for natural water availability are precipitation patterns, river flows and the presence of aquifers. Regions with low precipitation rates and high evaporation rates, such as arid and semi-arid zones, are prone to water scarcity. The countries discussed in the case studies fall within these zones. Even if the total quantity of annual rainfall in a region is substantial, it might be unevenly distributed across time with seasonal fluctuations. Subsequently, the region will still experience periods of scarcity (UN Water, 2020).

2.b. Socio-Economic Environment

Population growth, urbanisation, and economic development increase the demand for water in domestic, agricultural, and industrial sectors, thereby putting pressure on water resources. Economic disparities worsen unequal access to water, with affluent communities securing ample water supplies while marginalised groups face chronic shortages (Mekonnen & Hoekstra, 2016). Additionally, political issues and conflicts significantly affect water security. Transboundary water disputes, for instance, arise when rivers and aquifers cross national borders, leading to tensions and potential conflicts over water allocation. These disputes can hinder cooperative water management and development efforts, resulting in more severe water scarcity for certain groups of people or nations. In essence, the intertwined economic, social, and political factors underscore the complexity of water security challenges and the need for comprehensive approaches to address them.

2.c. Future Environment and Climate Change

Changes in the future environment pose an additional significant threat to water security. Rising temperatures lead to increased evaporation rates, altering precipitation patterns and reducing snowpack and glacial melt, which are critical sources of freshwater in many regions. The IPCC projects that climate change will intensify the water cycle, causing more severe and frequent droughts and floods. This variability will challenge water management systems, particularly in regions already experiencing stress. Changes in climate also affect the quality of water, as higher temperatures can worsen pollution levels and disrupt ecosystems that purify water naturally, further reducing the amount of water that is readily available (IPCC, 2021).

As one can imagine, the mentioned factors do not act in isolation but flow together in complex ways. For example, socio-economics development can both mitigate and exacerbate hydrologic impacts through good or poor water assessment and management strategies. In the same way, advanced water management technologies and infrastructure can improve efficiency and reduce scarcity, but economic activities like mining and industrialisation can degrade available water resources (UN-Water, 2019). Each of the three elements—the hydrological environment, the socio-economic context, and future developments like climate change—contributes to water insecurity in unique ways and carries distinct risk factors.

Water Stress:
Water stress measures the ratio of total water demand to available renewable surface and groundwater supplies. This condition occurs when the demand for water exceeds the available amount during a certain period or when poor quality restricts its use.

Water scarcity aggravates existing social problems, especially poverty. In communities, it is generally the poor who are the first to suffer when water levels drop, facing heightened challenges in accessing safe and affordable water. Naturally, the lack of water especially impacts the poor, who rely on agricultural production for their livelihoods. As agricultural output declines, communities are forced to import food at much higher prices, compromising food security. In proportional terms, the poor pay more for their water than richer people and receive water of lower quality. Also, women tend to suffer greater losses than men due to the degradation of water resources (Castro, 2004)

At the WEF 2015, water was ranked as the predominant risk to societies. Nevertheless, water, environmental factors, and food security are not considered under the traditional security paradigm. The traditional concept of security is confined to military and defence. In the 21st century, with a growing population, there is a race for resources, and water, in particular, is a crucial component in each sector. Any discourse or policy decision addressing traditional challenges to national growth or new challenges such as migration, refugees, or natural disasters will be incomplete without a clear understanding of the water. Recognising the fundamental aspects of water—its composition, uses, ownership, and users reveals that water security is a key challenge that transcends borders, necessitating new and bold thinking (Vishwanth, 2019). While water may not be the first weapon that comes to mind in international conflicts and security challenges, it is becoming an increasingly significant issue exacerbated by climate change.

3. Water Wars in Asia – A Growing Threat?

While outright "water wars" are not a foregone conclusion, the potential for conflicts over water is real and growing. Triggers for such conflicts include unilateral water projects, lack of effective transboundary water agreements, and climate change exacerbating existing water shortages.

In India, Pakistan, and China particularly, these effects are acutely felt. In India, approximately 70% of the country's agriculture is dependent on groundwater (World Bank, 2019). Over-extraction has led to a sharp decline in water tables (the level below which the ground or soil is saturated with water), threatening crop yields and farmer livelihoods. Pakistan faces similar challenges. The country is highly dependent on the Indus River, which supplies 90% of its agricultural water (Adeel, 2017). Rapid population growth and inefficient water management have led to severe water stress, particularly in Sindh and Balochistan provinces. This situation is exacerbated by transboundary water disputes with India, impacting water availability downstream (Mustafa, 2010.)

To explore the individual conflicts in Asia more thoroughly, we will examine two specific river systems: the Indus River and the Brahmaputra River. Is there a real chance of water wars? Additionally, what changes have occurred in these areas over time regarding water availability and temperature fluctuations?

3.a. Indus River Basin

While no conflict has occurred solely due to water issues, water scarcity has been a significant contributing factor to tensions in the Indus River region. Challenged by many conflicts, marked by diverse territorial disputes and occasional attempts at diplomacy and reconciliation, are the two countries India and Pakistan. Their relationship has been strained for various reasons, and water issues have not necessarily eased the tensions.

To understand the root causes of these conflicts, we need to look back at the history of the two nations. In the summer of 1947, the partition of the British Indian Empire led to a watershed moment in both British Imperial and South Asian history. It resulted in the creation of Pakistan as a homeland for Muslims, while India emerged as a secular state with a large Hindu majority and a significant Muslim population (Roy, 2014). Consequently, India became the upper riparian and Pakistan the lower riparian region (regions or countries bordering on transboundary inland water), meaning India controlled the headwaters of the rivers that flowed into Pakistan. This geographical division made Pakistan highly dependent on upstream water flows controlled by India, threatening its agricultural productivity and water security and potentially leading to conflicts. Thus, the legacy of partition and the resulting hydropolitical dynamics have created a persistent source of tension between the two countries, making water a critical yet contentious issue in their bilateral relations.

Figure 2: The Indus River Basin (Pravettoni, 2015)

The Indus River system is a crucial source of fresh water and vital not only for agricultural production and drinking water for humans, animals, and plants but also for maintaining whole riverine and deltaic ecosystems. With a total length of 318 kilometers, it flows from the Tibetan plateau to the Arabian Sea (see Figure 2). For Pakistan, it is the only freshwater source in the country and provides 80% of the water consumed. The Indus basin, one of the largest river basins in Asia, spans approximately 1 million square kilometres. It extends

across north-eastern China, eastern India, north-western Afghanistan, and the plains of Punjab, Sindh, and Khyber Pakhtunkhwa in Pakistan (Nasir & Akbar, 2012).

In 1960, the two rival countries signed the Indus Water treaty, insinuated by the World Bank after nine years of negotiations. In the middle of so many conflicts and tensions in the area, this treaty is a notable achievement. But how does the Indus Water Treaty work? The Indus Water Treaty (IWT) is often cited as one of the few fruitful settlements of boundary water basin conflicts, having stood the test of time for over six decades. The treaty allocated control of three eastern rivers (Ravi, Beas, and Sutlej) to India and three western rivers (Indus, Jhelum, and Chenab) to Pakistan. Under the IWT, water governance determines who gets what water, when, and how much, as well as who has the right to water-related benefits (Kalair et al., 2019)

> The key to preventing water conflicts lies in enhancing cooperation, building robust international water management frameworks, and addressing the underlying socio-economic and environmental issues that contribute to water scarcity.

According to a stakeholder analysis by Shah and Panchali (2017), some water experts in the Pakistani government regard the treaty as a robust document that effectively addresses all issues in the Indus Basin. However, other experts express concerns about climate change and advocate for these issues to be incorporated into the treaty. Regarding groundwater mining, there is concern that excessive groundwater extraction on the Indian side of the border might impact the groundwater gradient, potentially harming Pakistan. From the Indian point of view, the key theme is that there is a political deadlock and lack of prioritisation, which hinders cooperation between India and Pakistan. Water is a state subject in India, and there are more disputes within states over water sharing and hydropower development than at the transboundary level. As for climate change, Indian officials regard it as an emerging issue and further research is needed. Moreover, they do not consider it beneficial to raise the issue with the water commissioner or to adapt the treaty until more comprehensive and collaborative research on climate change and its impact on the Indus River basin has been conducted. They recognise that the issue of groundwater mining in India is becoming increasingly serious, and research on this topic would be beneficial.

With the changing environment, older treaties might not be accurate enough to pick up the right solutions to the conflict, and wrong rules might be in place. One major issue is the altered precipitation patterns in the Indus basin, leading to variability in river flows. This variability disrupts the predictable allocation of water stipulated by the treaty, creating tensions between the two countries. Periods of intense rainfall and glacial melt can cause severe flooding, while extended droughts lead to water scarcity, straining the treaty's framework, which was designed based on historical flow data that are increasingly unreliable due to climate change (Wescoat, 1991). Furthermore, climate change-induced extreme weather events, such as flash floods and prolonged droughts, exacerbate existing political and social tensions between India and Pakistan. The treaty lacks provisions for cooperative adaptation strategies to address these emergent challenges, making it increasingly inadequate in fostering long-term water security in the region. Overall, the lack of data complicates hydrological assessment and modelling work, which makes it difficult to know the current state of the basin, the challenges it faces, and how these may be addressed. Cooperative research and data collection on how the river basin is changing in the face of climate change would be an important step to flow into the future with more safety (Azeem & Panchali, 2017).

3.b. Brahmaputra River

The Yaluzangbu-Brahmaputra River serves as the lifeblood of regional security discussions, its flow symbolising the interconnected nature of stability and cooperation in the area. As the world grapples with the climate crisis, nations are increasingly turning to renewable energy sources to reduce their carbon footprint. One such effort is China's ambitious hydropower development plan on the Brahmaputra River. This initiative aims to harness the river's vast potential to generate clean energy.

Originating in the Himalayan Mountain range, the Brahmaputra River flows east through southern China, into eastern India, and further into Bangladesh. As shown in Figure 3, the Ganges and Brahmaputra rivers converge with the Meghna River to form one of the world's largest river deltas (Nepal & Shrestha, 2015).

All of the riparian countries – India, China, and Bangladesh - are under increasing pressure due to climate change, severe water scarcity, and rising demands from population growth. It is, therefore, no surprise that

Figure 3: Map showing the major rivers of Ganges and Brahmaputra in northeastern India (Wikimedia Commons, 2011).

the water management and distribution of the Brahmaputra River system is becoming an important point on the political agenda. Recent water and infrastructure developments have influenced Sino-Indian relations, which historically have been shaped by mutual distrust and diplomatic engagements. Since the 1950s, India and China have engaged in various forms of dialogue to address water-related issues, although progress has often been hampered by broader geopolitical tensions. (Fent et al., 2019).

Additionally, climate change issues are becoming more relevant. Climate models project a faster rise in both maximum and minimum temperatures in the Brahmaputra Basin from 2000 to 2100. By the end of the century, the average temperature of the basin is projected to increase by up to 3.5 °C. Changes in temperature will lead to changes in the water cycle. Climate change will likely decrease the water availability of the river (Immerzeel, 2008). At the same time, it is predicted that the volume of water flowing through the river (river discharge) and the duration of flood waves would increase during both the pre-monsoon and monsoon seasons due to changing weather and precipitation patterns (Ghosh & Dutta, 2012). Extreme events, therefore, might become more frequent. It is essential to remember and not underestimate that river systems interact with each other as interconnected entities. For instance, climate change could significantly impact meltwater in the Indus Basin, potentially leading to an increased flood risk in the Brahmaputra Basin (Nepal & Shrestha, 2015).

India fears that the Chinese hydropower projects could reduce water flow during dry seasons and cause sudden floods during monsoons. Despite China's assurances that these dams are "run-of-the-river" projects, which supposedly do not store or divert significant amounts of water, mistrust persists (Saleem, 2024). The development of the power plants poses significant challenges for downstream countries like India and Bangladesh, which rely heavily on the river for their water needs. The Brahmaputra is a lifeline for these countries, providing water for agriculture, drinking, and industrial purposes. The development of power plants poses significant challenges for downstream countries like India and Bangladesh, which rely heavily on the river for their water needs. Any alteration in the river's flow can have profound impacts on these regions, jeopardising food security, economic stability, and social harmony.

This scenario presents a paradox: while China's move towards hydropower is a step towards solving the climate crisis, it simultaneously exacerbates water scarcity issues for downstream countries already stressed by climate change. China's hydropower plans on the Brahmaputra are part of its broader strategy to increase its renewable energy capacity, aiming to peak carbon emissions before 2030 and achieve carbon neutrality by 2060. Hydropower, which is a reliable and continuous source of clean energy, is a key component of this strategy. The Brahmaputra offers significant potential for hydropower generation due to its steep gradient and high flow volume. Proposed projects include several dams and reservoirs, the most notable being a dam at the Great Bend, expected to produce more electricity than the Three Gorges Dam. (Shrestha et al., 2021).

One of the primary concerns is the potential for reduced water flow downstream. Large dams can significantly alter the natural flow of rivers, affecting water availability in downstream regions, trapping sediments, reducing water quality, and disrupting the natural timing of river flows, which are crucial for agriculture and fisheries. The Brahmaputra has been a source of diplomatic friction between China, India, and Bangladesh for decades, with China's unilateral decision to proceed with these projects without consulting downstream neighbours exacerbating these tensions and raising fears of future water wars. Or as Peter Bosshard of the International Rivers Network says: "Rivers unite us, but dams divide us" (BBC News, 2014, para. 11).

If these plans move forward, the Himalayan region will soon have the world's highest concentration of dams, with vast implications for its landscape, ecology, and economy. Diverting the river would cause a significant drop in water levels as it enters India, leading to severe impacts on agriculture and fishing in downstream areas due to increased salinity. By hastily building dams on the Brahmaputra, both nations risk creating environmental impacts beyond the river's capacity, threatening the livelihoods of over 100 million people who depend on its waters (Mahapatra & Ratha, 2016). Further, the reality of the situation is challenging to grasp. The dams are hidden from view, nestled in remote valleys and deep mountain gorges. In these secluded areas, the persistent tension between politics, development, and the environment plays out, creating a complex and partly invisible conflict.

The situation is further complicated by the lack of a comprehensive water-sharing agreement among the riparian countries. Unlike the Indus Waters Treaty between India and Pakistan, there is no binding international agreement governing the use of the Brahmaputra's waters (Biswas, 2008).

Several dilemmas hamper effective transboundary water cooperation. Firstly, the broader Sino-Indian diplomatic relations are often strained due to border disputes and political rivalries, affecting trust and cooperation on water issues. Secondly, China has little motivation to engage in cooperative water management without clear benefits, especially since it perceives itself as shouldering more responsibilities while receiving negative feedback from India. This is due to China's upper riparian status and the significant impact its water management decisions can have downstream. The future of Sino-Indian water relations will likely depend on the broader geopolitical dynamics and the willingness of both nations to engage in meaningful dialogue and cooperation. The potential for conflict remains, but so does the opportunity for collaboration if both countries can navigate their differences and prioritise sustainable and equitable water management (Feng et al., 2019).

4. Conclusion

Water scarcity in Asia, driven by climate change and rapid population growth, presents a substantial threat to regional stability and security. Against this background, this paper inquired the cases of the Indus and Brahmaputra rivers to illustrate the intricate balance required to manage transboundary water resources amidst political tensions and environmental changes. In response to the research question, this article finds that existing treaties like the Indus Waters Treaty have provided a framework for cooperation but must be adapted to address emerging challenges such as climate change. The key to preventing water conflicts lies in enhancing cooperation, building robust international water management

frameworks, and addressing the underlying socio-economic and environmental issues that contribute to water scarcity. Without comprehensive agreements and cooperative management, the potential for conflict remains high. To mitigate these risks, nations must prioritise sustainable and equitable water management practices, invest in research and technology, and engage in continuous dialogue to build trust and foster regional cooperation. Addressing water security with a forward-thinking approach is essential to ensure the well-being and prosperity of millions of people dependent on these vital water resources. As we navigate these challenges, we must remember to make waves with innovative solutions and keep our heads above water to secure a sustainable future. Water truly is the lifeblood of our planet, and ensuring its availability and accessibility is principal for our collective well-being.

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