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Research article

Metabolic rift theory and the complexities of water conflict between India and Pakistan: A pathway to effective environmental management

Shajara Ul-Durar [a,b,*], Muzammel Shah [e], Marco De Sisto [d], Noman Arshed [c]

[a] University of Sunderland, The School of Business Management, Edinburgh Building, Chester Road, Sunderland, SR1 3SD, United Kingdom
[b] Durham University, Business School, Mill Hill Lane, Durham, DH1 3LB, UK, United Kingdom
[c] Department of Economics, Division of Management and Administrative Science, University of Education Lahore, Pakistan
[d] School of Management, RMIT University, 445 Swanston Street, Melbourne, VIC, 3000, Australia
[e] Air University, HRM at Air University School of Management (AUSOM), Islamabad, Pakistan

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ABSTRACT

The exacerbation of the historical and geopolitical tensions between India and Pakistan, largely attributed to colonial legacies, is further amplified due to climate change-induced water conflicts. These environmental management issues stemming from the climate crisis are urgent, demanding innovative and collaborative solutions. The primary aim of this article is to elucidate the complexities of the water conflict between India and Pakistan and propose more effective environmental management strategies that will ultimately foster regional peace and stability. The article applies the metabolic rift theory, a sociological approach, to comprehensively explain crisis-led ecological challenges in the Indo-Pak context. By applying this theory, the article reveals that collective environmental management strategies, particularly those aimed at water resource management, can significantly mitigate the impact of climate crisis and the related climate-induced conflicts. The study also proposes a need-based approach to environmental management, stressing the importance of having integrated water resource planning (harmoniously) shared between India and Pakistan. This includes ensuring sustainable wastewater treatment, securing freshwater quality, and guaranteeing an equitable distribution and utilization of water resources between these two nations.

1. Introduction

Tragic geopolitical conflicts or tensions jeopardize global peace and pose significant economic challenges. They also prevent entire nations from adopting effective climate change and global environmental management strategies. Conflicts and wars have directly impacted the ecological environment and biodiversity worldwide, with factory leakage and military weapons causing massive damage to wildlife habitats and human living environments during such conflicts. Pollution of groundwater and soil supplies are gravely endangering human health, wildlife, and the natural environment's worth. Downing et al. (2005) have already pointed out the ecological (devastating) outcomes of civil wars in Cambodia, Mozambique, and Rwanda, where forests and marine life have been wiped out. Attention has also been drawn to the conflicts' effects on how the global environment and climate are governed. Energy prices, in particular, are immediately driven up by conflict in a chain reaction involving war, economic penalties, and geopolitical risk aversion (Ianchovichina and Ivanic, 2016).

In response to the detrimental consequences of geopolitical conflicts on global peace, nations have expedited the development of long-term renewable energy projects (e.g., wind power initiatives in the UK and the Netherlands) to reduce dependence on foreign energy sources such as natural gas (Ambrose, 2020). These efforts contribute positively to climate governance, facilitating the transition to low-carbon and renewable energy sources. Nevertheless, the energy transformation and upgrading process is intricate, particularly in the short term, due to limitations in resource endowment and the stability and affordability of renewable energy (Zahid et al., 2021). Consequently, certain nations have announced the reactivation of coal-fired power plants to conserve natural gas and meet internal energy demands (Xu and Singh, 2021). Moreover, the increase in military weapons usage and production, along with post-war reconstruction, have exacerbated the global warming

* Corresponding author. University of Sunderland, The School of Business Management, Edinburgh Building, Chester Road, Sunderland, SR1 3SD, United Kingdom.
E-mail addresses: Shajara.ul-durar@sunderland.ac.uk, Shajara.ul-durar@durham.ac.uk (S. Ul-Durar), Muzammel.shah@mail.au.edu.pk (M. Shah), marco.desisto@rmit.edu.au (M. De Sisto), noman.arshed@ue.edu.pk (N. Arshed).

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effect. Recent international conflicts have diminished the likelihood of achieving global carbon emission reduction goals, thus intensifying the severity and complexity of global environmental and climate concerns. Consequently, the achievements of global environmental governance have been undermined as limited awareness of the environmental issues arising from political conflicts hampers the development of effective environmental policies.

In this context, the conflict between Pakistan and India is one of the longest and most deadly in the world (Shidore, 2020, p1). This rivalry is characterized by several concurrent risk factors such as a shared land border, a bitter territorial dispute, a history of conflicts fought in the shadow of nuclear weapons, the ready spark of terrorism, and the rising hostility over the shared Indus River basin – their major source of water. On top of these historical and geopolitical factors, environmental and climate change challenges are also exacerbating the Indo-Pak conflict. India and Pakistan both have significant water shortages. For this reason, both countries signed the Indus Waters Treaty (IWT) in 1960 under the aegis of the World Bank to address any arising disputes. The treaty assigns the waters of the eastern rivers – the Ravi, Beas, and Sutlej – to India, while the waters of the western rivers – the Indus, Jhelum, and Chenab – are allocated to Pakistan. This treaty stands as a symbol of peaceful conflict resolution and is significant because, despite the geopolitical tensions, both countries have adhered to the provisions of the treaty for over six decades (Qureshi, 2017). Thus, the IWT regulates water resource sharing and serves as a beacon of potential cooperation and negotiation between the two nations. Both governments have also implemented policies and initiatives to improve water management and conserve water resources while working together to develop multilateral agreements on water management. Despite this, the downstream actor, Pakistan, remains subject to considerably more restrictions than India since it has only a 30-day water storing capacity compared to 170 days in India. However, both countries face extreme water stress, especially when their water storing capacity is compared with other nations, such as Egypt with 700 days capacity, to provide an example (Dawn, 2021). Furthermore, Himalayan glaciers are melting and the Indus River basin has reported yearly heavier rains with more erratic flow patterns and a greater danger of devastating floods (Bloomberg, 2022; Fox, 2022; Schauenberg, 2022). This is even more sensitive for Pakistan which, according to the ND-Gain climate change vulnerability index, bears the highest risk of hazard, vulnerability, and coping capacity compared to all its neighbors after only Bangladesh (Chen et al., 2015; INFORM, 2019). Parvaiz (2022) reports that farmers have recently lost about 70% of their crops because of dry spells and floods in Pakistan and the relative increasing cost of carbon (Wyns, 2022).

The severe impacts of climate change, along with a fast-growing population, have placed unprecedented pressure on the IWT and led to poor trust and misunderstandings between the parties. With superior water storing capacity upstream by India, Pakistan fears that India may manipulate dam storage levels to intensify downstream floods using the drawdown flushing method, which is the worst-case situation for Pakistan (Shidore, 2020, p. 10). Though most of the concerns are being addressed (Shidore, 2020), the increasing water storage capacity of India is of concern to Pakistan in meeting the river flow requirement in the Indus Delta to avoid seawater intrusion. On the other hand, India is worried that Pakistan may falsely accuse it of water tampering to gain geopolitical advantage using the floods brought on, in part, by climate change. Using the Indus waters against Pakistan, however, India is subject to several significant limitations (Climate Diplomacy, 2022). The dispute over water resources between Pakistan and India has led to a deterioration of environmental management in both nations (Birch et al., 2006). In India, dams and irrigation projects have increased groundwater salinity, soil degradation, and the destruction of wildlife habitats. In Pakistan, infrastructure development has led to deforestation, erosion, and water pollution. Both countries have taken steps to address the environmental impact of the water conflict. The government has implemented policies such as establishing catchment area treatment and river basin management schemes to improve water management in India. Studies like the SESA Team (2013) have pointed out that this policy has improved water availability and ecological health. The Pakistani government has established the Indus Basin Development Authority (IBDA) to oversee water resource management and conservation efforts. IBDA is partially successful in managing water resources but still faces challenges in terms of political will (FAO, 2021).

There have been protracted discussions about whether or not violent conflict and climate change are related. While some studies have found no direct link between climate change and conflict, findings have not been consistent or robust (Koubi, 2019). Experts also emphasize the need to consider specific local or national contexts when examining this relationship (Mach et al., 2019). Moreover, most research examining the relationship between conflict and climate change has not been undertaken in the Asian region despite the fact that it is anticipated to be the most influenced by climate change (Adams et al., 2018). Nevertheless, there has been an increase in scholarly interest in the area with mounting evidence that a connection between climate change and conflict exists (Adams et al., 2018; Koubi, 2019; Mach et al., 2019). As a result, policymakers should be mindful of the dangers of conflict associated with climate change. This study offers ideas on the precise means of connecting climate and conflict between India and Pakistan following the severity of climate change in this region. The detrimental effects on citizen welfare in both regions due to the prolonged absence of peace-building efforts are also emphasized. This study contends that climate change has further exacerbated this conflict as its consequences continue to spread throughout the region. To do this, the authors have applied the metabolic rift theory and the need-based approach within the context of the India-Pakistan water conflict.

The metabolic rift theory, originally formulated by Marx (1976), offers valuable insights into the consequences of industrial capitalism on the delicate balance between humans and nature. According to this theory, the relentless advancement of industrialization creates a profound and irreversible rupture, known as the metabolic rift, which results in both environmental degradation and socioeconomic inequalities. By applying this theory to the context of the India-Pakistan conflict over water resources, one can argue that the growing populations, rapid industrialization, economic growth, and adverse effects of climate change on water availability have given rise to a metabolic rift (Clark and Foster, 2009). This rift manifests as an increasingly skewed utilization and distribution of shared water resources – the Indus River – thereby disrupting the ecological equilibrium and exacerbating geopolitical tensions between these two nations (Akhter, 2015; Wolf et al., 2003). In response to this metabolic rift, a need-based approach emerges as a viable solution with considerable merits (Qureshi et al., 2010). Such an approach would prioritize the fundamental human and ecological needs for water over industrial and agricultural demands. It would also consider the ecological capacity of the Indus River and the basic water requirements of the populations in both countries. Focusing on essential needs and promoting sustainable practices makes it possible to address the metabolic rift, alleviate conflicts over water resources, and achieve more equitable and sustainable outcomes (Gain et al., 2016). However, this necessitates substantial cooperation, policy coordination, and the implementation of sustainable water management practices between India and Pakistan.

Overall, the paper contributes to the literature by examining the specific case of the India-Pakistan water conflict within the broader context of geopolitical conflicts, environmental management, renewable energy, and the relationship between climate change and conflict. The practical implications include the need for improved environmental policies, sustainable water management practices, and international cooperation to address the ecological, environmental, and geopolitical challenges associated with water resources in the region.

2. Material and methods

This study aims to conduct a comparative review of empirical patterns pertaining to geopolitical and environmental indicators in India and Pakistan to assess the consequences of the metabolic rift. The ontological perspective of this study is centered around understanding the alarming environmental challenges and their intricate interconnections with socio-political dynamics, ultimately impacting the standard of living in the region. In terms of epistemology, this study adopts a positivist approach to compare observable facts and outcomes arising from the India-Pakistan conflict (Althouse et al., 2023).

To assess the rift between India and Pakistan quantitatively, the empirical data of India and Pakistan are collected from reputable secondary data sources like World Development Indicators (WDI), Worldwide Governance Indicators (WGI), Climate Change Knowledge Portal, International Country Risk Guide (ICRG), UN-Water, Food and Agriculture Organization (FAO) and Map of Life Indicators. These data sources record the data for these indicators representing the causes and consequences of the rift between India and Pakistan. The population period for the study spans from 1947 to 2023, covering the available data for India and Pakistan.

Including Sri Lanka and Bangladesh in this study provides a comparative analysis to provide a broader perspective on the commonalities and complexities of water conflicts and environmental management in the region. They have been chosen for comparison due to their geographic proximity to India and Pakistan and their experiences with water-related challenges (Hanasz, 2015).

The variables identified for comparison in this study are adapted from literature and discussed in the context of conflict between India and Pakistan. They allow comprehensive assessment of various dimensions of conflict. The annual total freshwater withdrawals percentage of total resource and total water withdrawals per capita in cubic meters was discussed by Vinke et al. (2017). Cooling degree days is discussed in the context of global warming (Saeed et al., 2021; Zakar et al., 2020), and political stability and the absence of violence index is compared in South Asian countries (Krepon, 2003). Amir-ud-Din et al. (2020) discussed that the contention between India and Pakistan led to deviation in government spending on health and education. External conflict risks also play a role in defining environmental sustainability (Ahmed et al., 2022) and the species habitat index was compared in South Asia by Hasnat et al. (2018). These socio-political variables consequently respond to the conflict between India and Pakistan.

This study has advocated the need-based approach to address issues. This approach seems analogous to Integrated Water Resource Management (IWRM) but a need-based approach is more region-specific, flexible and adaptable (Chanan et al., 2004). Although both strategies share the overarching goal of water sustainability, a need-based approach has a special focus on tailoring strategies in evolving context-specific needs. It tries to address the situation by prioritizing the specific needs and inclusivity of the vulnerable and affected communities.

3. Metabolic rift and ecological challenges in India and Pakistan

South Asia is one of the world's most susceptible regions to climate change. In addition to having one of the highest rates of poverty in the world (Turk, 2013), it is one of the most water-stressed regions (HT Correspondent, 2023; Pratap, 2018), along with the Gulf and MENA countries. This is demonstrated below in Fig. 1. Similar to this region, India and Pakistan also have high water withdrawals per capita for agriculture, industry, and household usage (Fig. 2), placing them at risk of calamity. This withdrawal rate in 2010 supersedes neighboring countries like Bangladesh (35.87 billion m3) and Sri Lanka (12.95 billion m^3). These high withdrawal rates indicate the dependency of these countries (especially Pakistan) on the river water, rekindling the claim on Indus River water. Climate change threatens South Asia's agrarian population (Mishra et al., 2016). South Asia has remained primarily agricultural and rural owing to its large population and limited industrialization. Most people reside in rural areas and depend on industries like farming, forestry, fisheries, and cattle that lack water management (Maqbool, 2022), all vulnerable to climate change-led temperature variability (Hanif et al., 2010). At the current rate of global warming, two-thirds of the glaciers in the Himalaya, Karakorum, and Hindukush (HKH) region of Asia will directly affect access to fresh water for approximately 250 million people (Arshed et al., 2021).

South Asia's water problems stem from a plethora of complex sources (Kraska, 2003; Qureshi, 2017). Since water mismanagement led water scarcity continues to be one of the main unsolved problems between Pakistan and India, the lack of a desirable normative framework for transboundary water sharing exacerbates the issue of water sharing for the existence of the two proclaimed nuclear weapon states in that

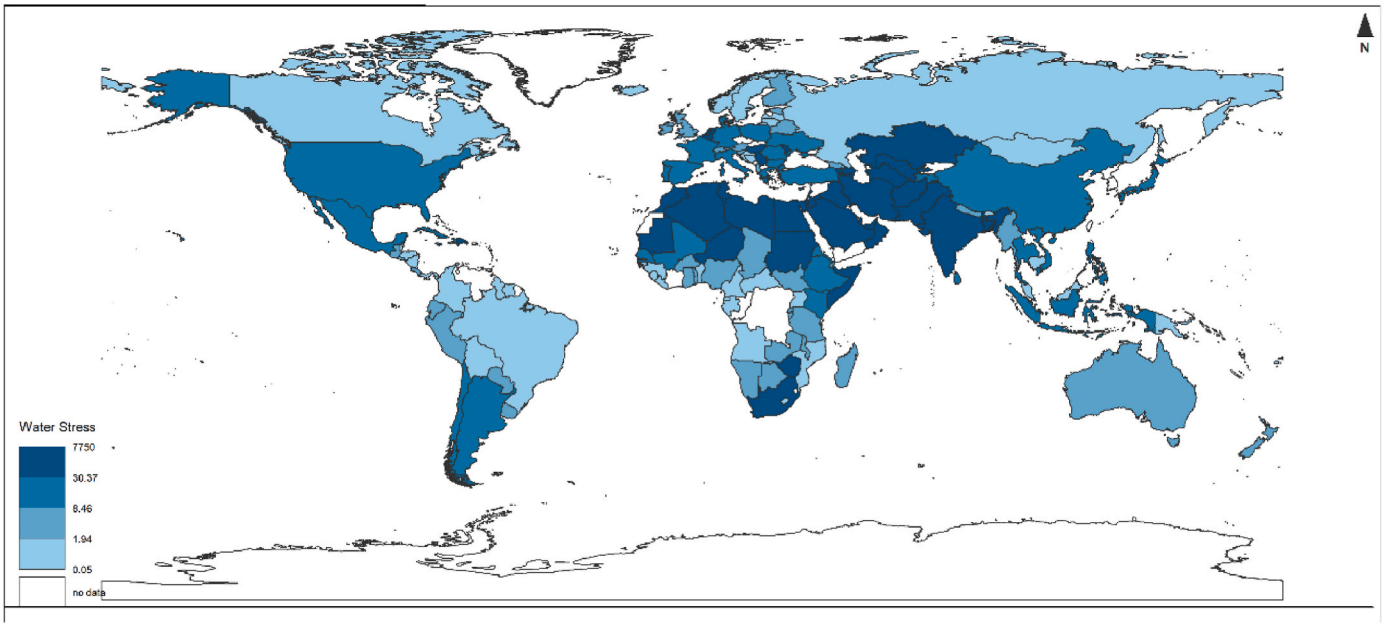

Fig. 1. Global freshwater stress. Source: Author self-construction using UN Water data.

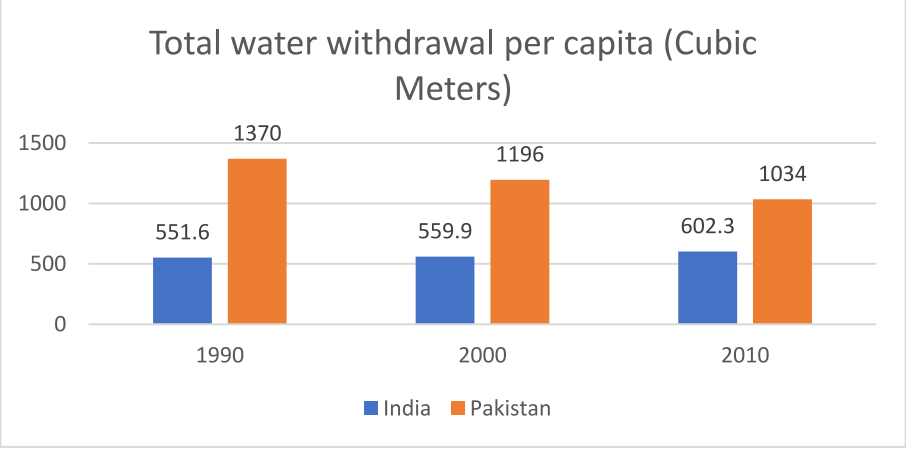

Fig. 2. Fresh water withdrawals per capita. Source: Author self-construction using AQUASTAT – FAO data.

region (Miner et al., 2009). Even though the South Asian region has agreements and treaties governing water sharing, it lacks water-sharing principles (Biswas, 2011; Chellaney, 2011; Griffin, 2018; Priscoli and Wolf, 2009; Rahaman, 2006; Swain, 2004). The presence of two states in South Asia with nuclear weapons (India and Pakistan) may be a more worrying problem than the influence of human activities as water is still one of the main unsolved concerns between these two South Asian nations (Abbas, 1984; Dar, 2011). Water management in Pakistan is of major concern where there is high river water demand to maintain minimum river flow to Arabian Sea to avoid seawater intrusion in Indus Delta (Ali et al., 2017; Janjua et al., 2021; Kahlown and Majeed, 2003).

Rural people who depend primarily on agriculture for their livelihoods and areas with active armed conflict are especially vulnerable to climate-related conflict. Risks of climate-related conflict can be reduced by using climate adaptation measures that lessen the adverse effects of climatic disasters. In recent years, world leaders and international policymakers have turned their attention to the security implications of climate change. Climate change's potential to incite ferocious intra-state conflict is a leading security worry (UN Security Council, 2021). Researchers have been concentrating on determining whether there is a connection between war and climate change and, if so, how it is connected due to the increased interest in this possibility. Studies examining the connections between Southeast Asian warfare and climate change have recently increased.

For operationalization reasons, conflict is defined as intra-state violence on various dimensions. While smaller-scale civil strife may consist of violent protests, riots, or forced evictions, larger-scale civil conflict may encompass insurgencies, rebellions, and terrorist activity. The findings of this research will benefit the development of prevention and mitigation strategies for conflict related to climate change. Fig. 3 shows the patterns of political stability between India and Pakistan measured by International Country Risk Guide, with Pakistan having improved the political landscape in the early 2000s regarding handling internal and external conflicts. No other region in the world 'combines the same magnitude of population, scarcity of rainfall, dependency on agriculture, the scope for mega-dam projects, and sensitivity to climate change as those at stake within the wider Himalayan region' according to environmental historian Kenneth Pomerantz (Khan et al., 2022, p. 7). In accordance with the reports, increasing global warming (which is persistently increasing in both countries, as seen in Fig. 4 below) would operate as a catalyst for water-conflict situations with decreasing precipitation and rising evaporation in some regions, causing the predictable climate patterns to become irregular. The whole region, including Bangladesh and Sri Lanka, is facing a similar situation.

Pressure on governments to cut off the water supply to their neighboring states would increase if there were recurrent episodes of flooding or drought that caused severe human misery. Therefore, climatic and socioeconomic changes have altered the discussion and setting of collaboration over the Himalayan Rivers. Until now, traditional diplomacy was considered sufficient for transboundary negotiations and

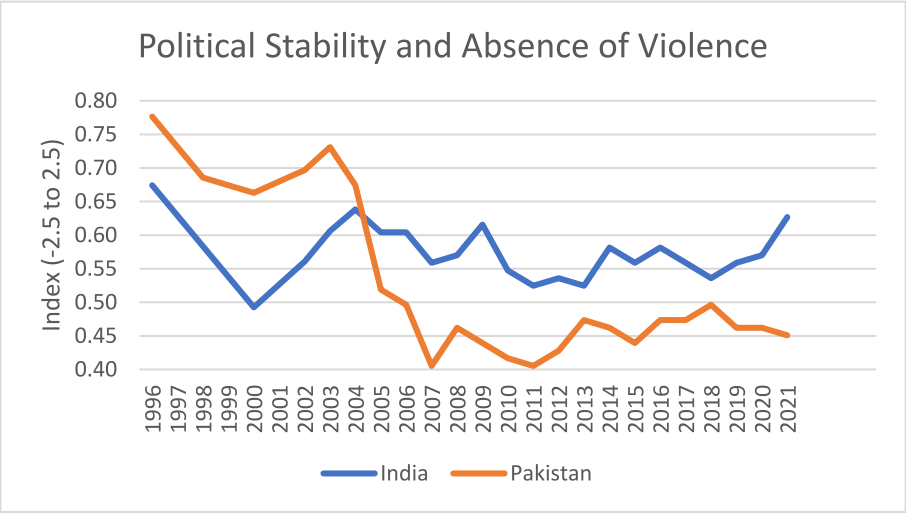

Fig. 3. Political Stability and Absence of Violence in Pakistan and India. Source: Author self-construction using Worldwide Governance Indicators data.

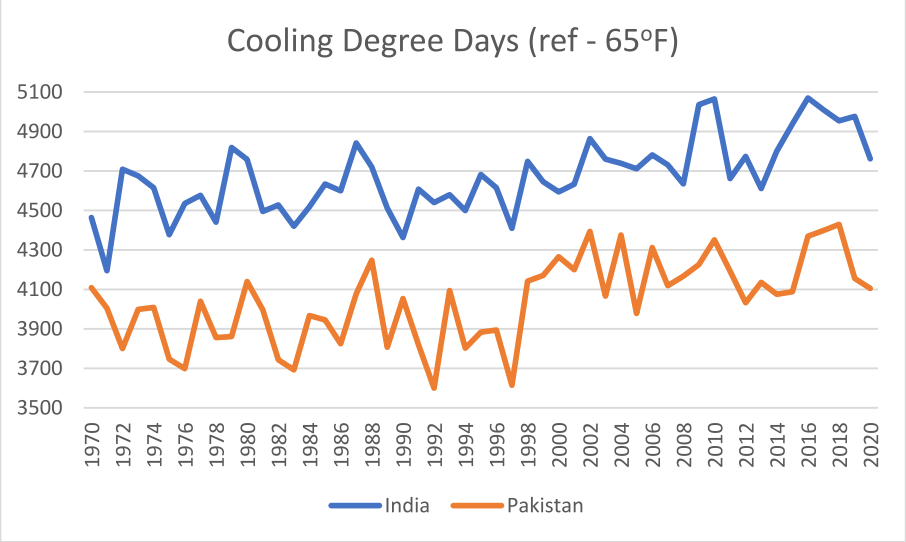

Fig. 4. Global warming in India and Pakistan. Source: Climate change knowledge portal, world bank.

rivers were supposed to have a stable and constant future in South Asian intergovernmental negotiations over water sharing. However, these presumptions suffered a severe setback when global warming impacted glacier melting, jeopardizing the rivers' ability to run steadily and continuously. Rapidly expanding industrial economies in China, Pakistan, and India will increase the demand for river water for agricultural and hydropower projects during dry seasons. Numerous legitimate concerns have been raised by a wave of these projects in the area in recent years (Khan et al., 2022).

Climate change is only one of many factors placing an unprecedented amount of strain on the IWT which controls how the waters of the basin are shared. The disputed territory of Kashmir and its surrounding areas will result in more erratic flow patterns and a greater danger of devastating floods. India and Pakistan are extremely water-stressed nations (Munir et al., 2021). Dam designs are influenced by environmental deterioration and climate change, allowing for bad faith behavior and misunderstandings between the parties. Pakistan's most significant worry is India's manipulation of dam storage levels to amplify downstream floods. On the other hand, India is concerned that Pakistan may falsely accuse India of water tampering to gain geopolitical advantage using the floods brought on, in part, by climate change. However, India confronts numerous significant obstacles in using the Indus River as a weapon against Pakistan. Pakistan, the downstream actor, is subject to considerably more restrictions. India could potentially violate the Indus Waters Treaty but it is unlikely they will do so. The Pak-China strategic alliance raises tensions in South Asia comprising collaborative hydropower projects. To transition from its primary notion of dividing water resources to cooperative and sustainable management, the IWT urgently needs to include new factors like growth of population needs, on-farm water management, water storage capacity management, and environmental effects (Khan et al., 2022).

Conflict is a situation where one country's behavior is irreconcilable with that of another. States compete for power, position, and alliances in the international system because they aim to have the most power relative to other states (Sharma, 2012). Both India and Pakistan historically prioritized deterrence against each other and the necessary funds for it. Other allocations of funds are not prioritized (thus less details are available), for example the allocation of funds to health and education in 2020 was 55% for India and 3.41% for Pakistan per the statistics provided by World Bank. Conflict is a recurring issue in South Asia. Numerous concerns, including Kashmir, terrorism, water, transit, involvement of an outsider in the South Asian region, and boundary delineation, led to confrontation between India and Pakistan.

Before 1947, Pakistan and India were both part of British India. However, Kashmir has become the dominant dispute determining the relationship between the two neighbors and it has overpowered all other issues. Economic conflicts over natural resources often involve water. Water is a natural resource that flows across states, crossing borders like globalization does. With respect to the three eastern tributaries of the Indus (Ravi, Beas, and Sutlej), Indian Punjab emerged as the upper riparian after partition in 1947 and Pakistani Punjab emerged as the lower riparian. British India laid the framework for the water-sharing agreement between Pakistan and India. The Indus basin's six rivers — the Indus, Ravi, Beas, Jhelum, Sutlej, and Chenab — have their origins in the Himalayas and flow through India and the Indian states of Jammu and Kashmir before entering Pakistan. The portion of Jammu and Kashmir that is under Pakistani control are also included in the regime. In 1948, Pakistan and India settled to pay fees for the restoration of water flow (Dar, 2011). However, the conflict did not end until both countries signed the Indus Waters Treaty (IWT) in 1960, which Pakistan had originally rejected in 1951, claiming it was unfair (Haines, 2014).

According to the World Bank's formula, Pakistan was granted lesser riparian rights on the Indus, Chenab, and Jhelum rivers. After India's government rejected Pakistan's 1949 request to take the Indus River dispute to court, the IWT was signed to establish rules for water sharing between the two nations (Haines, 2014). India kept the right to use the three western rivers (the Indus, Chenab, and Jhelum) for producing hydroelectric power even though Pakistan was given ownership of them (Uprety and Salman, 2011). Furthermore, despite their tense relations, the IWT has survived all hostilities between India and Pakistan (Gulhati, 1973). India's use of upper riparian rights as these rivers travel through Indian-held Kashmir has given rise to several challenges to the Indus Waters treaty. India's construction of the Salai Dam on the Chenab River was the first violation of the Indus Waters Treaty (Baqai, 2005). In 1970, the project was started. Pakistan complained that the dam's capacity and design dishonored the Indus Waters Treaty. The issues were explicitly raised when the two countries started negotiations about the dam's construction in 1975 (Baqai, 2005). A deal was reached about the Salai dam that stipulated India would not make any additional changes to the project's design. It committed to lowering the dam's height to 40 feet and closing all sluice gates within a year of the project's completion.

In 1985, a new conflict arose due to India's decision to build a barrage on the Jhelum River immediately below Wullar Lake. The lake, considered the most comprehensive lake on the continent, is approximately 5180 feet above sea level in Indian Kashmir, 25 km north of Srinagar. The lake impeded the Jhelum River (Aziz, 1986; as cited in

Misra, 2007). From the south and the west, the Jhelum River enters and exits the lake. India started the project because Wullar Lake is a natural water reservoir and a familiar project. The barrage would control the water flow for navigation downstream (Phadnis, 1998).

The rationale of the project was to maintain a higher water level during dry periods when the river's normal discharge drops to just 2000 cusecs at a depth of about 2.5 feet. In addition to an operational level of five 17,790 in the Wullar Lake, navigation requires a minimum depth of four feet and a flow of 4000 cusecs. This reduction makes navigation impossible, especially on the 20 km stretch that connects Wullar Lake with Baramula via Sopore (Baqai, 2005). Pakistan vehemently disagreed with the Indian position and saw it as a breach of the Indus Waters Treaty. According to Article III (I) of the Treaty, India must refrain from interfering with the waters unless it is necessary for one of three specific reasons: domestic usage, agricultural use, or non-consumptive use. The production of hydroelectric power via a run of the river plant falls into the first three uses. Using the water for non-consumptive purposes includes using it for navigation and other activities as long as the amount of water returned to the river is not reduced. The dam's design is what Pakistan objects to since it believes it violates the conditions of the treaty. Another point of debate involved the barrage's storage capacity. Pakistan also objected to India's development of the Tulbul waterway project in 1984. The crisis persisted despite ongoing, fruitless negotiations between the two nations. The two nations have undertaken ten rounds of unsuccessful secretary-level negotiations on the matter. Wullar barrage is on the agenda of the much-heralded June 23, 1997 accord, during which the two nations agreed to undertake a composite discussion on numerous sensitive matters.

The Kishanganga River, also known as the Neelum River, and the Gurez Valley was to be dammed with a structure 103 m high according to an Indian government proposal. The river turns sharply near Shardi's point, flows southwest, and eventually joins the Jhelum River at Muzaffarabad (Baqai, 2005). A sizable reservoir is intended to be part of the Kishanganga River project. A 21.66 km tunnel will be constructed from the reservoir allowing the Kishanganga River to flow through Bonar Naia and into the Jhelum River (Noshab and Mushtaq, 2001). Waters from Kishanganga would be diverted to Wullar Lake in Bandipora. A diversion of around 100 km will be necessary for a hydroelectric project built at the Wullar barrage. According to Pakistan's argument, the Neelum-Jhelum link project, which Pakistan started in 1988, would suffer due to the project. Therefore, the 100 km diversion would be against the IWT which prevents shifting the flow of the Jhelum River from one tributary to another (Grover and Arora, 1998).

The hydropower project in Baglihar is the most recent offence against the Indus Waters Treaty (Baqai, 2005). Upstream of the Salal dam, in the Chenab River's catchment basin, is where this project was constructed. The Indus Waters Treaty has once more been broken in this case. With Pakistan's consent, India can conduct any project on the Jhelum and Chenab rivers. As India continues to construct over Pakistan's objections, this specific project has caused a great deal of concern on the Pakistani side. The topic has yet to be discussed bilaterally. Pakistan addressed the World Bank with the problem and construction has been put on hold until the World Bank rules on the matter. According to Pakistan, the Sawalkot dam on the Chenab River and the Dulhasti hydroelectric project both violate the Indus Waters Treaty (Baqai, 2005).

4. The impact of water conflict between India and Pakistan on environmental management

Sharing resources has become increasingly complicated due to globalization and environmental issues. Demand for water resources is rising due to dwindling water supplies, rising populations, and inadequate water management in emerging nations. Conflict is bred by the increased need for control over water resources brought on by water scarcity. There are both intrastate and interstate conflicts on display.

Below, Fig. 5 highlights the state of external conflicts interfering with the governments in India and Pakistan. It is created from data on wars, cross-border conflicts, and foreign pressures. It is evident from Fig. 6 that both nations had seen severe conflict tenures in the 1980s and late 1990s. The graph also shows recent dipping trends (increasing risks) in both countries.

The current water crisis has challenged the policy to find a way of sharing water to spur cooperation and development among the neighbors. Another issue is using shared water basins to reduce tensions rather than heighten them between states (Wolf, 2000). Although conflict predominated in India and Pakistan's bilateral interactions there has also been a constituency for collaboration. The Indus Waters Treaty (IWT) reflects this cooperation (Sharma, 2012).

The IWT continues to be a key historical document governing the division of river waters between the two rival governments. The World Bank's innovative thinking, India and Pakistan's readiness to 'approach the issue as a technical problem' (Kux, 2006), and the international community's overall financial backing were recognized as reasons for the treaty's success. However, as the 20th century ended, this cooperation started to veer into a confrontation over plans to build on the western rivers in the parts of Kashmir that India governs. Pakistan's approach to defending its national interests in Kashmir has changed. The underlying issue of water allocation, however, is constantly upsetting the balance and causing relations between India and Pakistan to become polarized and passionate, thus the situation is very different now. Pakistan has long believed India is disobeying and construing the treaty against its interests. India believes Pakistan is overreacting and its concerns are unrealistic. The point is that in the relationship between Pakistan and India water is currently much more political and strategic than ever. Ironically, a treaty that should have marked courage and desire to face upcoming problems has become a political time bomb after 51 years (Sinha, 2010).

In order to settle all lingering disputes, India and Pakistan have entered a critical stage in their bilateral relationship. One of the components of the peace process is the water issues such as the Baghilar and Tulbul projects. The Baglihar power project, a part of the composite discourse located on the Chenab River in Doda, was arbitrated, and Pakistan has chosen not to pursue the subject any further. It was conceptualized in 1992, construction started in 1999, and was finished on October 10, 2008. Permanent Indus water commissioner-level negotiations between India and Pakistan occurred in Delhi on June 2, 2010. Pakistan dropped its opposition to the Uri-II (240 MW[capacity] built on the Jhelum River in the Kashmir valley) and Chutak hydel power (44 MW built on the Suru, a tributary of the Indus River in Kargil) projects in Jammu and Kashmir during these negotiations (Parsai, 2010). The disagreements continue around the proposed Nimoo Bazgo hydropower project (45 MW in Leh), the Tulbul navigation project or the Wular barrage project (Jhelum River, Sopore), and the defunct Kishanganga project (a tributary of Jhelum water diversion, defunct since 1990).

Climate change increased the demand for freshwater in Pakistan and India, urging these countries to manage the availability and storage of water environmentally. The Indus Waters Treaty (IWT) of 1960 is a multilateral agreement negotiated between Pakistan and India that allocates the rights to use the waters of the Indus River and its tributaries. This agreement has served as a critical source of regional stability for over half a century but its implementation has been increasingly strained in recent years. The dispute over water resources between India and Pakistan has led to a deterioration of environmental management in both countries. In India, dams and irrigation projects have increased groundwater salinity, soil degradation, and the destruction of wildlife habitats in the region. Map of life indicators (Fig. 6 below) reported that, in India and Pakistan in 2014, approximately 14% of the wildlife's habitat had been lost compared to 2001. In Pakistan, infrastructure development has led to deforestation, erosion, and water pollution. Both countries have taken steps to address the environmental impact of the

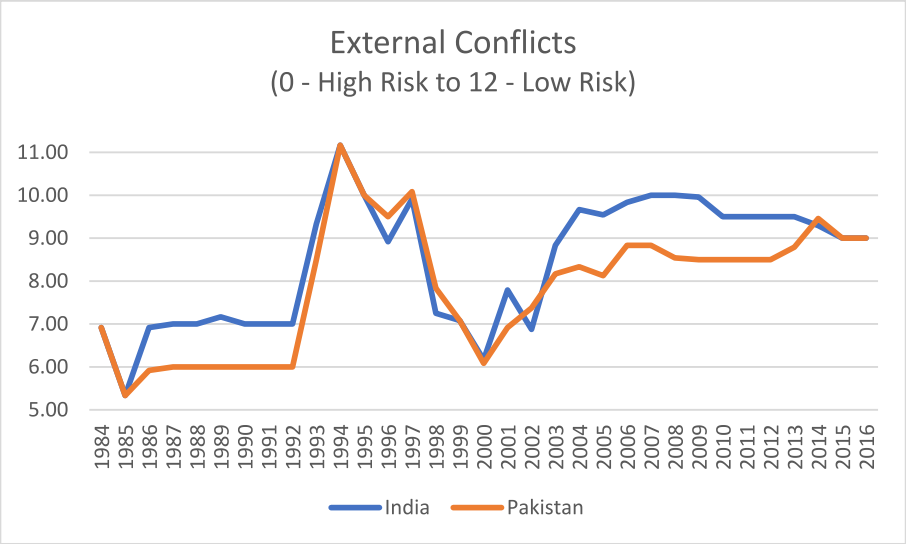

Fig. 5. External Conflicts in Pakistan and India. Source: Author self-construction using ICRG data.

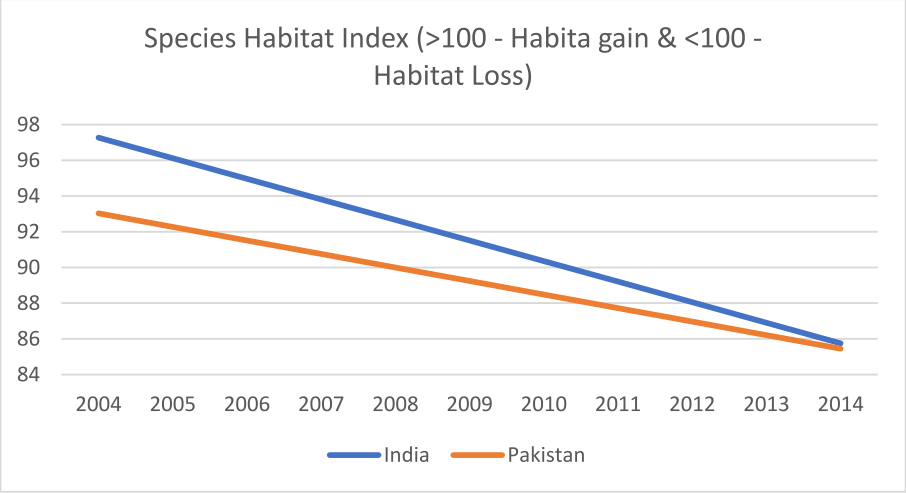

Fig. 6. Destruction in Species Habitat in India and Pakistan. Source: Author self-construction using Map of Life Indicators data.

water conflict. The government has implemented policies to improve water management in India such as establishing catchment area treatment and river basin management schemes. The Pakistani government has established the Indus Basin Development Authority (IBDA) to oversee water resource management and conservation efforts.

The water conflict also prompted the development of multilateral agreements on water management and storage, for example the Indus Water Commission, development of major dams in Pakistan, and cross river linking canal system to support the agrarian economy. Both governments have implemented policies and initiatives to improve water management and conserve water resources while also working together to develop multilateral agreements on water management.

5. Discussions

The dependence of life on water is a well-established fact (Turk, 2013). This is particularly evident in South Asia where some of the world's poorest populations reside. The water issues in this region are complex and arise from various factors such as population growth, unequal distribution, developmental needs, climate change, water mismanagement, and environmental concerns (Adhikari, 2014; Kraska, 2003). Furthermore, the seasonal heavy rainfall in South Asia leads to recurring floods and droughts, exacerbating the freshwater problem and making the region one of the most water-stressed areas globally (Kraska, 2003; Wirsingh, 2011).

There is a common belief that since water is essential for maintaining human life, future conflicts will be fought over water rather than oil. The basic argument is that disputes over environmental issues and natural resources could worsen and impact regional security. Conflicts inside and between nations may occur due to population growth's severe impact on scarce resources. The unavoidable fact is that the amount of water any nation can economically exploit over the long run remains finite. Additionally, many industrial and other waste products from human activity are dumped into the environment untreated, negatively impacting the quality of accessible water resources. Some scholars and practitioners have expressed the humanitarian concept that water might be shared (Sadoff, 2008), and the notion that water does not belong to anyone is the foundation for such a sharing. However, while the value of sharing water has long been recognized, understanding the practical effectiveness of agreements involving transboundary rivers has lagged. Water issues can sometimes become the most important aspect and significantly impact the whole political relationship (Iyer, 1999). A perfect example is the rivalry between India and Pakistan, particularly in the shared Indus River Basin (IRB). The escalating conflict over the

shared IRB is within the broader and deeper geopolitical tensions between India and Pakistan due to competition over nuclear power (as reported by Council on Strategic Risks, Washington DC), a shared land border, a bitter territorial dispute, a history of warfare under the shadow of nuclear weapons, and the ready spark of terrorism (Shidore, 2020, p1). With these premises, and in line with the water wars idea, India and Pakistan could (and should) have fought over control of the Indus River as all the required components were on hand. War, however, was avoided in favor of IWT negotiations. This shows that environmental management calls for cooperative management of shared natural resources rather than competitive competition over limited resources. It calls for policies of consensus and cooperation. More recently, the peaceful Indus Waters Treaty has been challenged because of the increasing population in both India and Pakistan as well as more severe climate change impacts (Krishnan et al., 2019).

According to the Intergovernmental Panel on Climate Change's (IPCC) fifth assessment report, IRB flows receive a significant contribution from glacier melt. The IRB's analysis of glacier trends predicts steady glacier mass for the majority of the century in relation to the (Pakistani-allocated) western rivers, particularly the Indus River, but significantly earlier glacier loss for the (Indian-allocated) eastern rivers (Muhammad et al., 2019). For the Sutlej, glacier melt runoffs will significantly decline after 2050 (Prasad et al., 2019). The eastern rivers' mean annual flows will not decrease due to the retreating glaciers (in fact, they will likely increase in the short term). However, they will become considerably more cyclical and unequal. Intensifying extreme rainfall and glacial lake eruption downpours will worsen this heightened volatility. Additionally, snowmelt will occur earlier in the year and, for the eastern rivers, glacier melt will first increase and then decline (Hasson et al., 2017; Jeelani et al., 2013). The western rivers' glacier-melt flow is projected to increase until 2070 (or thereabouts) at which point it will start to gradually decline. Due to the Karakoram anomaly, net flow for the Indus River in particular is projected to be fairly constant or growing until late in the 21st century but recent studies are focusing on the mixed nature of glaciers in the Karakoram region for its implications in the water flow downstream (Sivalingam et al., 2023). Khan (2022) used IPCC 6th assessment emission scenarios and concluded that in the upper Indus basin and Tarbela dam there will be availability of water, along with water scarcity, demanding for proper management of water.

Climate change will worsen glacial lake outburst floods (GLOF) and other occurrences. These floods are brought on by a lake that formed inside a glacier, collapsing and releasing water all at once. Such lakes are more prone to collapse due to glaciers that are melting more quickly. India, with a population of three million, and Pakistan, with a population of two million, have the highest number of people at risk of GLOF, accounting for 1/3rd of global population (Taylor et al., 2023a; UNDP, 2021). Of the 7000 initial glaciers in Pakistan, 3044 have already formed glacial lakes (Bhatti, 2022; Khan, 2021). According to recent data, approximately 2000 out of these 3044 glacial lakes are situated near 9 million people (Reuters, 2023) and consequently five million people in India and Pakistan are vulnerable to lake outbursts (India Today Web Desk, 2023). About 0.8 million people in Pakistan reside within 15 km of the vulnerable lakes (Sarwar and Mahmood, 2023; Taylor et al., 2023a).

Several such lakes in the Himalayan region have been at risk of collapsing (Chauhan et al., 2023) which led to 100 people being killed in India in 2022 (Reuters, 2023) while in Pakistan, glacial floods in 2020 swept away six houses, injuring several people (Khan, 2021). India and Pakistan also have highest normalized exposure to GLOF scores of 1.000 and 0.701 in 2022 respectively (Taylor et al., 2023a) which has increased 45% and 67% since 2000 (Taylor et al., 2023b).

The conclusion is that average flows in the IRB's rivers will continue to rise through at least the middle of the century. However, notably in the three eastern rivers allotted to India, these flows will become much more erratic and seasonal. As a result, there will probably be more flooding incidents in the IRB. The worst scenario that Pakistan can imagine is that India may alter dam storage levels to amplify downstream floods and severely harming Pakistani agriculture although any such actions by India will also have a negative impact on people who live downstream of the dams in Kashmir which is under Indian control. On the other hand, India is concerned that Pakistan may falsely accuse India of water tampering to gain geopolitical advantage using the floods brought on in part by climate change. Under these conditions, water management techniques must be much more effective to guarantee a continuous adequate water supply for present and future requirements. Professionals in water management face a difficult task in the 21st century (Gupta, 2001).

What is important to notice is that the main issue in South Asia is not merely the scarcity of water, nor the glacial lake outburst due to climate changes, but rather the broader concept of the metabolic rift which encompasses the social, economic, and ecological consequences of the unsustainable use and exploitation of water resources. This rift is particularly evident in South Asia where the region's growing population, uneven distribution of water, developmental needs, climate change, water mismanagement, and environmental concerns have led to a profound disconnect between human society and the natural water cycles (Kraska, 2003; Adhikari, 2014). In this context, the need-based approach emerges as a potential solution to address the metabolic rift and restore a sustainable relationship with water resources (Qureshi et al., 2010). This approach recognizes that water is a fundamental human right and emphasizes the fulfillment of basic needs for all individuals including access to safe drinking water, sanitation facilities, and water for livelihoods and agriculture. By prioritizing the satisfaction of these essential needs, the need-based approach aims to bridge the metabolic rift by promoting equitable distribution, efficient use, and responsible management of water resources.

More specifically, the need-based approach aligns with the principles of cooperative management and shared responsibility. It highlights the importance of collaboration among nations and stakeholders to effectively manage transboundary water resources. By fostering dialogue, understanding, and cooperation, this approach seeks to transcend political tensions and prioritize the collective well-being of communities and ecosystems reliant on shared water bodies (Alam, 2002; Greiber et al., 2008). Additionally, it recognizes the interdependence between human societies and the natural environment, emphasizing the need for sustainable water use practices that do not disrupt the ecological balance.

Implementing the need-based approach requires robust water governance frameworks, policy reforms, and investment in infrastructure and technology. It involves integrating social, economic, and environmental considerations into decision-making processes, fostering participatory approaches, and empowering local communities to actively engage in water resource management (Gupta, 2001). Furthermore, the need-based approach calls for a shift in societal values and behavior, encouraging individuals to adopt water conservation practices, promote ecological sustainability, and recognize the intrinsic value of water beyond its economic utility.

6. Conclusion

The critical importance of freshwater for human survival and the growing demand for water resources is a well-known fact. However, water availability is limited and the quality of accessible water is deteriorating due to factors such as increasing population, untreated waste, and climate change, leading to geopolitical tensions. With these premises, the rivalry between India and Pakistan over water resources in the Indus River Basin (IRB) is one of the most crucial examples across the world. While the overall precipitation in the IRB is unlikely to decline in the long run, the distribution and availability of water will become more erratic and seasonal, especially due to heightened volatility and risk of flooding incidents. This situation creates a challenging scenario for

water management professionals in both countries who must develop effective strategies to ensure a continuous and adequate water supply for both present and future needs. The study applies the metabolic rift theory, revealing the consequences of industrial capitalism on the delicate balance between humans and nature in the context of water resources. To address these challenges, a need-based approach that prioritizes essential human and ecological water needs over industrial and agricultural demands is proposed. Promoting sustainability and addressing the metabolic rift conflicts over water resources can be reduced, leading to more equitable and sustainable outcomes. Improved environmental policies, sustainable water management practices, and international cooperation are crucial to tackle the ecological, environmental, and geopolitical issues associated with water resources in the region. Implementing these measures can mitigate the negative impacts of the India-Pakistan water conflict, foster peace-building efforts, and secure a sustainable water future for both nations.

7. Policy implications

Three main kinds of activities are defined in the water sector. Water conservation and control includes works for drainage, water level control, flood control, water quality control, and water treatment. Water resource development includes intake works, dams, wells, canals, and weirs. Two of them deal with the construction of the hydraulic infrastructure as well as its use and upkeep. The third category, water resource management, is quite distinct. It demands a comprehensive view of the water. It comprises formulating policies as well as plans for regional and national development and management. It provides a balanced planning framework for the entire water sector to maximize water usage and management in time and space among present and future water users. It also comprises carrying out these plans by coordinating the building of hydraulic works and other institutional actions. There are four fundamental reasons why water resource management is frequently necessary. The first is the importance of fairly distributing (limited) water among users. Many external support agencies' development aid initiatives heavily rely on this equity premise. The second aspect is how important it is to optimize water use economically now and in the future, for instance, by deciding whether to utilize water for agriculture or power generation. These allocation challenges must frequently be addressed internationally and nationally in various parts of the world. The third element is the mitigation of risks and other detrimental environmental effects. Numerous case studies' findings indicate that if society does not take immediate effective management action it will pay dearly in the medium to long term. Of course, the fourth consideration is the necessity for the long-term sustainability of water resources and water supply infrastructure. This particular element is commonly disregarded when creating groundwater systems even though storage depletion, seawater intrusion, and increasing pollution could permanently lose essential resources. The challenges the professionals managing water resources face are clearly shown by thoroughly examining the water supply and demand for a specific river basin, beginning with a regional perspective on water and development. Technological intervention, potential institutional reforms, water policy, and legal frameworks enable a systematic approach to managing water resources, focusing on prudent and efficient water use.

Water policy has historically been connected to particular issues like flooding, water scarcity, and water pollution. Technology advancements and building water supply and flood defense systems were generally tied to a small number of specific interests. The development of water resources for a single purpose has given way over time to goals for multipurpose development. The old idea of water resources development, which places a strong emphasis on exploiting water resources systems, should be changed to water resource management which places a stronger emphasis on allocation concerns. Additionally, it is crucial to stress water conservation to maintain the environment's health. Recent publications have discussed the idea of sustainable development and the measures that must be taken in order to apply the idea to water management systems (Falkenmark, 1997; Gupta and Onta, 1997; Kundzewicz, 1997; Loucks, 2000). Jiaqi and Jun (1999) discussed the topic of managing China's water resources and recommended a variety of workable solutions. Most of the South Asian countries' existing methods for managing their water resources are not environmentally or economically viable. The following elements aggravate the shortcomings of present management techniques. Environmental concerns are becoming a crucial part of project design for the development of water resources (Gupta, 2001).

There are many concerns between the conservation and development organizations that still need to be resolved at this time. These worries include, among other things, a specific definition of sustainable development and the acceptance of trade-offs between project benefits and environmental losses. In practice, the participatory approach presents the most challenging process because it calls for involving all stakeholders. In many instances, the process becomes a stage for conflict between project-supporting and -opposing parties with the help of nongovernmental organizations. Case studies should be conducted to create valuable recommendations for environmental factors. A more practical strategy might then address the environmental problems caused by the growth of water resources.

Unquestionably, integrated water resource management requires a rigorous approach. Governance, economic performance, environmental quality, and the requirement for fair water distribution among the stakeholders provide the most significant challenges in managing water resources. The management of water resources will necessarily include trade-offs between many objectives in a multidisciplinary decision-making process. With little coordinated effort put into basin-wide planning and administration, several departments and agencies manage the development of water resources according to their respective needs under the current institutional structure. The long-term effects of this practice include unfavorable development outcomes and inefficient water utilization. The notion of managing water resources should also consider wastewater management, treatment, and reuse because these actions impact both the quality and availability of freshwater. In order to effectively regulate and control this, it is necessary to have the necessary technical and administrative skills, appropriate legislation and enforcement procedures, and regional consultation.

8. Future research directions and limitations

Future research on the water conflict between Pakistan and India and its impact on environmental management should focus on understanding the current dynamics of the conflict, identifying potential solutions for cooperation and negotiating water-sharing agreements, and examining the potential effect of climate change on the region's water resources. Research should examine the potential environmental, economic, and social impacts of the conflict and investigate how the water conflict affects the management of shared water resources. Additionally, research should explore how different stakeholders and institutions within India and Pakistan interact in the conflict and how these interactions influence the management of water resources. Finally, research should assess the potential for water-sharing agreements and other forms of cooperation between India and Pakistan and how such agreements might impact the management of shared water resources. Overall, research should focus on understanding the current dynamics of the water conflict between Pakistan and India and identifying potential cooperative solutions to ensure the sustainable management of shared water resources in the region.

Despite a detailed assessment, this study could only focus on governmental and policy perspectives. This study has overlooked the business outlook of the countries and indigenous knowledge and solutions to water management. The UNDP (2021) reports that there is a lack of research in the northern region of Pakistan on the threats of GLOF which could be explored in terms of its implication in Pakistan and

India.

Credit author statement

Conceptualization; Shajara Ul-Durar, Muzammel Shah, Noman Arshed and Marco De Sisto; Data curation; Shajara Ul-Durar and Noman Arshed; Formal analysis; Shajara Ul-Durar, Noman Arshed and Marco De Sisto; Funding acquisition; No funding associated; Investigation; Shajara Ul-Durar, Noman Arshed and Marco De Sisto; Methodology; Shajara Ul-Durar and Noman Arshed; Project administration; Shajara Ul-Durar and Marco De Sisto; Supervision; Shajara Ul-Durar; Writing - original draft; Shajara Ul-Durar, Muzammel Shah, Noman Arshed and Marco De Sisto; Writing - review & editing; Shajara Ul-Durar, Noman Arshed and Marco De Sisto.

Ethical approval

The entire research process is in line with our institutional research ethics policy. We declare that all ethical standards are met and complied with in true letter and spirit.

Informed consent

All participants in this study volunteered themselves during the entire research process, and their consent was taken at inception.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Only secondary data with free access has been utilised

Appendices.

Figure A1 provides the snapshot of each country based on Sustainable Development Goal no 6 parameters in comparable units. This SDG6 information is taken from the United Nations UN Water website and separate links for India and Pakistan are provided below. Further, the 2020 Voluntary National Review showed that 96% of Indians have access to an improved source of drinking water.[1]

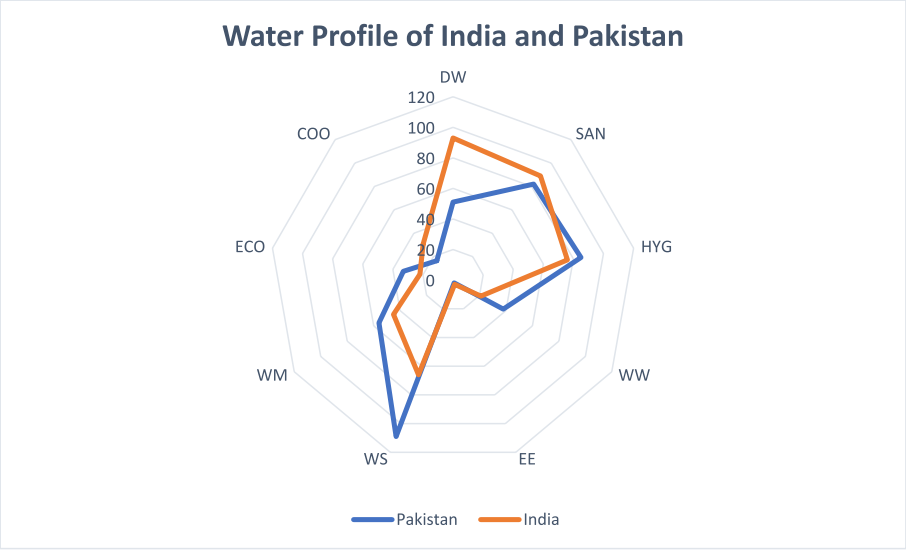

Fig. A1. Water Profile of India and Pakistan. Source: Author self-construction. Description and Source: DW = Proportion of population using a safely managed drinking water service (%); SAN = Proportion of population using an improved sanitation facility (%); HYG = Proportion of population with a handwashing facility with soap and water at home (%); WW = Percentage of domestic water safely treated (%); EE = Value added form use of water by people and the economy ($/m^3); WS = Percentage of renewable water resources that are being withdrawn, after taking into account environmental flow requirements (%); WM = The degree of implementation of integrated water resources management (%); ECO = Percentage of water basin that are experiencing rapid changes in the area covered by surface waters (%); COO = Amount of water and sanitation related official development assistance received (10m $). Data Taken From https://www.sdg6data.org/en/country-or-area/Pakistan and https://www.sdg6data.org/en/country-or-area/India.

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[1] https://www.sdg6data.org/en/country-or-area/Pakistan and https://www.sdg6data.org/en/country-or-area/India.

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