

Hydrology, Ecology, And Geopolitics Of Kashmir's Rivers, Bharath

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Abstract - This paper presents a comprehensive study on the rivers of Kashmir, which are vital lifelines for the region's environmental integrity, socio-economic development, and geopolitical stability. The intricate network of rivers in Kashmir, including the Jhelum, Sind, Lidder, Chenab, Veshaw, Neelum, Zanskar, Shyok, and Indus, originates primarily from the glaciers of the Himalayas and the Pir Panjal ranges. These rivers exhibit diverse hydrological and geomorphological characteristics, shaping the valley's agriculture, energy production, and ecological balance. The study delves into the seasonal dynamics of river discharge, the impact of climate change on glacial sources, and the geomorphological variations along river courses. It also highlights the rich aquatic biodiversity supported by these rivers, while raising concerns about ecological degradation due to sand mining, pollution, and deforestation. Furthermore, the paper analyzes the crucial role of rivers in human livelihood through irrigation, hydropower generation, and historical navigation routes. Special attention is given to the strategic importance of these rivers in the context of the Indus Waters Treaty between India and Pakistan, exploring recent geopolitical developments that threaten regional water security. The compounded effects of climate change and human intervention necessitate an integrated approach to river basin management, conservation policies, and transboundary cooperation. This paper, supported by scholarly references and case studies, provides a holistic understanding of the challenges and opportunities linked to the rivers of Kashmir, offering recommendations for sustainable management and future research directions.

Keywords - Rivers of Kashmir, Hydrology, Geomorphology, Climate Change, Aquatic Biodiversity, Indus Waters Treaty, Water Security, Sustainable Management

1. INTRODUCTION

Kashmir, often referred to as "Paradise on Earth," is not only renowned for its scenic beauty but also for its rich and complex river systems that sustain life, agriculture, and ecosystems in the region. Situated in the northwestern Himalayas, the Kashmir Valley is a geographical basin surrounded by high mountain ranges, including the Pir Panjal and the Greater Himalayas. The rivers that crisscross this valley originate primarily from glaciers, snowmelt, and natural springs, making them perennial water sources crucial to both India and Pakistan.

The major rivers of Kashmir such as the Jhelum, Chenab, Sind, Lidder, Neelum, and Veshaw, along with their numerous tributaries, form an intricate hydrological network that influences the valley's climate, soil fertility, biodiversity, and economic activities. These rivers not only support agriculture and fisheries but also generate hydroelectric power essential for the region's energy needs. Historically, rivers like the Jhelum served as important navigation and trade routes.

However, these vital waterways face increasing stress due to anthropogenic pressures such as urbanization, unregulated sand and gravel mining, deforestation, and pollution. Moreover, climate change has emerged as a significant threat, with shrinking glaciers and erratic rainfall patterns leading to altered river flows and increased flood risk. The political significance of these rivers is equally important, as they are central to the longstanding Indus Waters Treaty between India and Pakistan, a cornerstone of transboundary water sharing in South Asia. The following sections of this paper provide an in-depth exploration of Kashmir's key rivers, their hydrological patterns, ecological importance, human uses, and the pressing challenges they face, with the aim of highlighting the need for integrated and sustainable water resource management in the region



Figure 1 : Location of Kashmir's Rivers

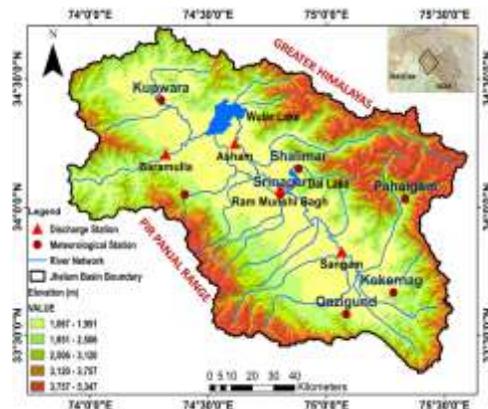


Figure 2 : Topography of Kashmir's Rivers

MAJOR RIVERS OF KASHMIR

1.1 Jhelum River (Vitasta):-

The Jhelum River, known locally as Vyeth, is the lifeline of the Kashmir Valley. Originating from the pristine Verinag Spring at the foothills of the Pir Panjal range in Anantnag district, the river meanders through the picturesque landscapes of South Kashmir, flowing northwards through Srinagar—the summer capital of Jammu & Kashmir—before entering the Wular Lake, one of the largest freshwater lakes in Asia. The river is approximately 725 kilometers long, with around 177 kilometers traversing through Indian-administered Kashmir. The Jhelum plays a pivotal role in the socio-economic life of Kashmiris, supporting agriculture, drinking water needs, and transportation. It eventually crosses into Pakistan, where it joins the Chenab River. Significant tributaries feeding the Jhelum include the Lidder, Sind, Vishav, and Neelum rivers, each contributing to its volume and vitality.



Figure3 : Location of River



Figure4 : view of River

1.2. Sind River:-

The Sind River begins its journey from the Machoi Glacier near Drass and Amarnath in central Kashmir. The river travels approximately 108 kilometers, flowing through Sonamarg—famed for its meadows—and the Ganderbal district before merging with the Jhelum at Shadipora. The Sind is a vital water source for irrigation and drinking purposes in central Kashmir and is also known for white-water rafting and tourism. The river is crucial in preserving aquatic life and providing hydroelectric energy through small-scale power plants.

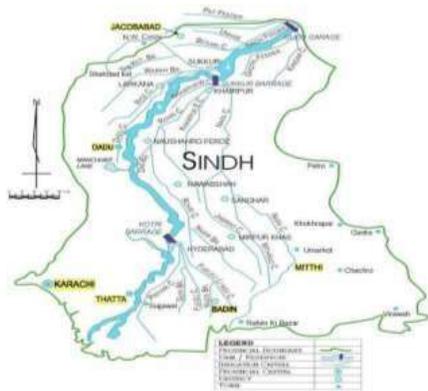


Figure5 : Location of River



Figure 6: View of River

1.3. Lidder River:-

The Lidder River, one of the major tributaries of the Jhelum, originates from the Kolahoi Glacier near Pahalgam. Flowing for about 73 kilometers, the Lidder is renowned for its crystal-clear waters, trout fishing, and as a hub for adventure tourism such as white-water rafting and trekking. The river flows through the famous tourist destinations of Aru, Betaab Valley, and Pahalgam before merging with the Jhelum near Anantnag. The Lidder plays a significant role in irrigating the surrounding fertile lands and sustaining the livelihoods of numerous communities. The Lidder River, emerging from the Kolhoi Glacier, flows through the famous Pahalgam region, contributing significantly to the Jhelum's flow and supporting local tourism and fisheries

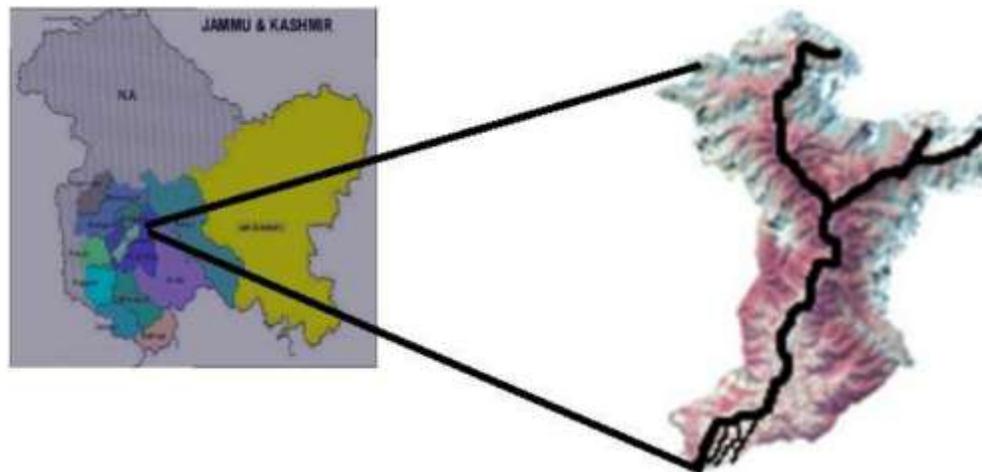


Figure7 : Location of River

1.4. Veshaw River:-

The Veshaw River, also known locally as Veshav Nallah, is one of the prominent tributaries of the Jhelum River in South Kashmir. It originates from the Kausar Nag Lake, a beautiful high-altitude glacial lake situated at an elevation of approximately 3,962 meters (13,000 feet) in the Pir Panjal mountain range in the Kulgam district of Jammu & Kashmir. The river's source, Kausar Nag, is not only geographically significant but also holds deep mythological and cultural importance, being revered by local Hindus as a sacred lake associated with ancient legends. From its glacial origins, the Veshaw River descends rapidly through steep mountainous terrain, carving its way through narrow valleys and lush meadows. The river flows in a northwesterly direction through Devsar, Qazigund, and several rural settlements in the Kulgam district before it finally merges with the Jhelum River near the town of Anantnag (also known as Islamabad). Along its course, the Veshaw is

joined by smaller streams and mountain rivulets, which contribute to its flow, especially during the spring and early summer months when snowmelt is at its peak.

1.5. Chenab River and Tributaries:-

The Chenab River, one of the five great rivers of the Punjab region, originates from the confluence of two rivers—Chandra and Bhaga—at Tandi in Himachal Pradesh. It enters Jammu & Kashmir through the Paddar Valley in Kishtwar district, flowing through the rugged terrains of Doda, Ramban, and Reasi before making its way into Pakistan. With an approximate length of 960 kilometers, the Chenab is essential for hydropower development in the region. The river is home to several major hydroelectric projects, including the Dul Hasti, Baglihar, Salal, and the under-construction Ratle Dam. It is a crucial river under the Indus Waters Treaty and has strategic geopolitical significance. Its major tributaries in J&K include the Marusudar River and the Tawi River.

1.6. Neelum (Kishanganga) River:-

The Neelum River, known as the Kishanganga in India, originates from the Krishansar Lake near Sonamarg in the Ganderbal district. The river traverses the scenic Gurez Valley before crossing the Line of Control into Pakistan-administered Kashmir. Spanning approximately 245 kilometers, the Neelum River is both strategically and ecologically significant. The Kishanganga Hydroelectric Project, a key infrastructure along its banks, harnesses its hydroelectric potential while also raising geopolitical debates between India and Pakistan. The river is surrounded by pristine forests, alpine meadows, and rich biodiversity, making it a vital ecological corridor.



Figure 8:location of river



Figure 9: view of river

1.7. Zaskar, Shyok, and Indus Rivers:

The Zaskar River is one of the most important rivers in the Union Territory of Ladakh, serving as a major tributary of the Indus River. It originates from the Ropshu plateau in the southeastern part of Ladakh and is primarily formed by the confluence of two significant rivers—the Doda River, which rises near the Pensi La pass, and the Tsarap Chu River, which emerges from the Zaskar valley near Sarchu. The Zaskar River traverses through some of the most rugged terrains in the Himalayas, including deep gorges, high mountains, and barren landscapes.

The river flows through the Zaskar Valley, home to remote villages, Buddhist monasteries, and adventure enthusiasts. During the summer months, the Zaskar is popular for white-water rafting, attracting tourists from around the globe. However, in the winter, the river freezes completely, creating the famous Chadar Trek, one of the world's most challenging winter treks, where adventurers walk over the frozen river. The river eventually meets the Indus River near Nimu, just outside Leh.

Ecologically, the Zaskar supports limited but vital agriculture in isolated villages where locals grow barley and peas. It also sustains rare high-altitude wildlife such as snow leopards, blue sheep (bharal), and Himalayan ibex. The river's untouched beauty and extreme climatic conditions make it a symbol of Ladakh's resilience and natural grandeur.

The Shyok River is another key river of Ladakh and an important tributary of the Indus River. The name "Shyok" translates to "The River of Death", a title earned due to the unpredictable and often dangerous nature of its flow through high-altitude, narrow gorges. The river originates from the Rimo Glacier, located in the Karakoram Range near the Siachen Glacier, which is the highest battleground on Earth.

The Shyok flows through Daulat Beg Oldie, Galwan Valley, Hot Springs, and enters the Nubra Valley, where it is joined by its major tributary—the Nubra River, which originates from the Siachen Glacier. This confluence creates the breathtaking Shyok–Nubra Valley, famous for its stark desert landscapes, sand dunes, and the rare double-humped Bactrian camels.

After flowing through the Nubra region, the Shyok River continues towards Turtuk, one of India's northernmost villages, and eventually crosses into Pakistan where it joins the Indus River near Skardu. The Shyok River basin is ecologically sensitive and supports unique cold desert flora and fauna. In addition to its strategic importance in terms of defense (due to its proximity to the Line of Actual Control), the river also plays a crucial role in local agriculture, supporting small communities that practice terrace farming along its banks.

The Indus River, known as the Sindhu in ancient Sanskrit texts, is not only the longest river in Pakistan but also one of the most important rivers in Asia and one of the oldest cradles of civilization—the Indus Valley Civilization—developed along its banks. The river originates from the Bokhar Chu or Sengge Zangbo stream near Lake Mansarovar and Mount Kailash in Tibet. It enters India through the Demchok sector in southeastern Ladakh, flowing northwest through the Ladakh region before entering Gilgit-Baltistan and then Pakistan.

In India, the Indus River is the lifeline of Ladakh, a cold desert with limited precipitation. Despite the harsh climate, the river allows small-scale agriculture in villages like Leh, Shey, Nimoo, and Basgo. The river is also joined by several important tributaries in Ladakh, including the Zaskar River, Shyok River, Suru River, and Shingo River. The Indus Valley in Ladakh is dotted with ancient Buddhist monasteries such as Hemis, Thiksey, and Alchi, showcasing the deep spiritual connection the people have with this river.

Further downstream, the Indus plays a central role in the Indus Waters Treaty between India and Pakistan. It is crucial for hydroelectric power generation, including the Nimoo-Bazgo Hydroelectric Plant and the Alchi Hydroelectric Project. Ecologically, the Indus supports rare species such as the Indus River dolphin (in Pakistan) and numerous migratory birds in Ladakh's wetlands. It is both a cultural icon and an environmental treasure, essential for sustaining life in one of the harshest climates on the planet.

2. OTHERS MINORS RIVER

2.1. The Sandran River:-

The Sandran River is a beautiful yet lesser-known river in South Kashmir. It originates from the lofty mountains of the Pir Panjal range near the Sarbal Pass in the Anantnag district. The river flows through scenic meadows and pine forests before joining the Jhelum River at Khanabal, near Anantnag town. The Sandran supports small-scale irrigation, trout fishing, and provides water for the settlements along its banks. Its waters remain pristine and cold, fed by snowmelt and rainfall, making it ecologically significant for aquatic biodiversity and agriculture.

2.2. The Rambhara River:-

The Rambhara River rises from the Pir Panjal mountains, specifically from springs and glaciers located near the Shopian district of South Kashmir. It is one of the key tributaries of the Jhelum River, joining it in the Bijbehara area. Flowing through the apple orchards and rice fields of Shopian and Pulwama, the Rambhara nourishes fertile farmlands and supports numerous villages. The river is vital for local agriculture and is also used for small hydroelectric schemes. Its scenic surroundings attract tourists, especially during the spring and summer months.

2.3. The Dudhganga River:-

The Dudhganga River originates from the slopes of the Pir Panjal range near Yusmarg, a picturesque meadow in Budgam district. Known for its milky-white frothy waters (hence the name "Dudh" meaning milk), the

river winds its way through Chadoora and Batamaloo before merging with the Jhelum River in Srinagar. The Dudhganga plays a significant role in irrigation, particularly for rice cultivation, which is a staple in the valley. It is also cherished for its beauty, as it enhances the charm of the surrounding meadows and pine forests, making it a favored destination for trekkers and nature lovers.

2.4. *The Poonch River:-*

The Poonch River, also called the Suran River in its upper reaches, originates from the lofty mountains of the Pir Panjal range near the Neelkanth Gali Pass in the Poonch district of Jammu & Kashmir. Flowing southwest, it passes through towns such as Poonch and Rawalakot before entering Pakistan-administered territory, where it eventually merges with the Jhelum River. The river is vital for agriculture, hydroelectric generation, and is the principal water source for the Poonch Valley. The Poonch River is prone to flash floods during monsoons, highlighting its importance in regional disaster management and ecological balance.

2.5. *The Suru River:-*

The Suru River is one of the primary rivers of the Kargil district in Ladakh. Originating from the Panzella Glacier near the Penzi La Pass in the Zaskar range, the river flows northward through the Suru Valley, nourishing the dry trans-Himalayan landscape before joining the Indus River near Nurla. The Suru River supports agriculture in the high-altitude desert by feeding irrigation canals and providing water for the cultivation of barley, wheat, and peas. The picturesque Suru Valley, enriched by this river, is popular for trekking and mountaineering, with stunning views of peaks like Nun-Kun.

2.6. *The Zaskar River:-*

The Zaskar River, famous for the Chadar Trek during the frozen winter months, is a major tributary of the Indus River in Ladakh. It originates from the Ropshu area of southeast Ladakh and is formed by the confluence of two main tributaries: the Doda and the Tsarap rivers. The Zaskar carves deep gorges through the Zaskar mountains, offering not only stunning natural beauty but also some of the most challenging river rafting routes in the world. The river is lifeline to the remote Zaskar Valley, supplying water for both domestic use and agriculture in the harsh high-altitude climate.

2.7. *The Ujh River:-*

The Ujh River originates in the Kailash Kund region of Bhaderwah and flows through the Kathua district of Jammu & Kashmir. It is a tributary of the Ravi River, eventually joining it near Madhopur. The Ujh River is particularly significant for the irrigation needs of the lower plains of Kathua and is also an important resource for sand mining and timber transportation. The Indian government has planned the Ujh Multipurpose Project on this river to harness its potential for hydroelectricity, flood control, and irrigation.

2.8. *The Shyok River:-*

The Shyok River, known as the "River of Death" due to its turbulent nature, originates from the Rimo Glacier in the Karakoram range. It flows through the remote and barren regions of Ladakh, including the Nubra Valley, where it is joined by the Nubra River. The Shyok eventually merges with the Indus River in Pakistan. The river is crucial for sustaining fragile desert ecosystems in the cold deserts of Ladakh and also holds strategic significance given its proximity to the Line of Actual Control (LAC).

2.9. *The Tso Moriri and Tsarap Rivers:-*

The Tsarap River, originating near the Tso Moriri Lake in southeastern Ladakh, is a key tributary of the Zaskar River. These high-altitude rivers, along with other glacial-fed streams, form a unique hydrological system in the Changthang region of Ladakh. They are extremely important for migratory birds, including the endangered black-necked crane, and support rare wetland ecosystems in an otherwise barren landscape.

3. Hydrology and Geomorphology:

The rivers of Kashmir are predominantly snow-fed, leading to seasonal discharge variations with peaks during spring and summer (Frontiers in Water, 2022). Rivers like Rambhara and Doodhganga show varied geomorphological patterns along their courses

The rivers of Kashmir, primarily the River Jhelum and its tributaries, exhibit distinct hydrological and geomorphological characteristics shaped by the region's unique topography and climatic conditions. Hydrologically, these rivers are mainly fed by snowmelt from surrounding mountain ranges and springs, with water chemistry predominantly influenced by rock weathering processes involving limestone, dolomite, and carbonate minerals. Most of the spring waters are fresh and alkaline, suitable for drinking and irrigation, with water types mainly being Ca-Mg-HCO₃ and Ca-Mg-SO₄. Geomorphologically, Kashmir's rivers flow through a valley that is essentially a floodplain with an oval shape framed by mountain ranges like the Pir Panjal and the Greater Himalayas. The rivers exhibit complex meandering and varied widths and depths, with their drainage patterns strongly influenced by geological structures and past glacial and fluvial activities, giving the valley a dynamic surface morphology shaped by ongoing deposition and erosion processes.

4. Ecological Significance and Challenges:

Rivers in Kashmir support diverse aquatic life, including native fish species such as Schizothorax. However, excessive extraction of sand and gravel, pollution, and deforestation have led to ecological degradation.

The rivers of Kashmir hold immense ecological significance as they support diverse flora and fauna, maintain regional biodiversity, and sustain livelihoods. These rivers and their associated wetlands provide critical habitats for various bird species, mammals, fish, and amphibians, contributing to the rich biodiversity of the region. The rivers also play a key role in regulating local climate by maintaining moisture levels and temperature, and they support agriculture by irrigating fertile lands that produce crops like rice, wheat, and horticultural fruits.

However, these rivers face significant ecological challenges. Increasing anthropogenic pressures such as pollution from urban sewage, unchecked dredging for sand and gravel, and habitat destruction threaten aquatic life and the overall health of river ecosystems. Pollution has led to declines in fish populations, while dredging disrupts breeding grounds for unique species like the Ibis Bill bird. Additionally, climate change impacts and unsustainable tourism further exacerbate the vulnerability of Kashmir's river ecosystems, affecting their ability to provide essential ecological services and support biodiversity.

5. Geopolitical and Climate Considerations:

The rivers of Kashmir are central to the Indus Waters Treaty between India and Pakistan. Recent developments, including India's suspension of portions of the treaty, highlight the geopolitical sensitivity of water-sharing (Financial Times, 2024). Climate change poses additional challenges, with glacial retreat impacting long-term water availability.

The rivers of Kashmir are of profound geopolitical significance due to their critical role as lifelines for both India and Pakistan. Originating mainly in the Indian-administered territory of Jammu and Kashmir, these rivers, including the Jhelum, Chenab, and Indus, provide essential water resources to millions of people downstream, particularly in Pakistan. The region's water resources are vital for agriculture, food security, hydroelectric power, and economic development in both countries. The 1960 Indus Water Treaty, which allocates waters between India and Pakistan, has been central to managing these shared water resources, but tensions persist due to ongoing conflicts and territorial disputes in Kashmir. Control over these rivers influences national security and regional stability, as any attempts to alter their flow can be seen as provocations, heightening geopolitical tensions between the two nuclear-armed neighbors.

Climate considerations further complicate the scenario. The Himalayan glaciers feeding these rivers are sensitive to climate change, impacting water flow regimes, seasonal availability, and the risk of floods and droughts. Climate-induced variability threatens both the ecological balance of the river systems and the human populations relying on them, exacerbating water stress and potentially amplifying regional conflicts. Thus, Kashmir's rivers are central not only to geopolitical strategies but also to climate resilience challenges in South Asia.

6. Benefits of Kashmir's Rivers

6.1 Irrigation and agriculture:-

Irrigated area (Jammu & Kashmir): Net irrigated area for J&K is on the order of ~3.5–3.6 lakh hectares ($\approx 355,000$ ha) (~40–45% of sown area in recent state digests). Canal irrigation supplies the majority of irrigated area in the valley; rice occupies a major share of irrigated cropping.

Key canal systems: Ranbir Canal (Jammu) originally designed for ~16,460 ha (gross/culturable command area figures vary by source) and remains central for the Jammu plains; other local distributaries irrigate rice paddies and orchards. Canal closure or damage significantly affects local productivity (case studies: Ranbir Canal impacts).

Economic role: Agriculture (rice, maize, orchards) remains the primary livelihood in many districts; river water is the dependable water source for paddy cultivation and orchard irrigation – thus river flows directly impact food security and rural incomes.

6.2 Hydroelectric power (clean energy):-

Selected operational/planned projects (summary table and figure below): capacities are shown for major projects in the Chenab/Jhelum/Indus basins within Ladakh/J&K. (Data sources: NHPC, project pages, government press releases and technical summaries).

Selected capacities (installed / planned, MW) – operational vs planned noted:

- Baglihar (Chenab) – 900 MW (total from stages).
- Salal (Chenab) – 690 MW (operational).
- Dul Hasti (Chenab) – 390 MW (operational; Stage-II planned).
- Uri-I (Jhelum) – 480 MW (operational) and Uri-II staged at 240 MW (planned/under construction).
- Ratle (Chenab) – ~850 MW (project revived/planned).
- Nimoo-Bazgo (Indus) – 45 MW (operational small run-of-river).

Regional potential & harnessing: Jammu & Kashmir's total technically feasible hydropower potential is often cited around ~18,000 MW (state estimates), with the Chenab basin providing a substantial share (e.g., >11,000 MW in some government summaries). Current harnessing remains a fraction of that potential (recent press reports cite harnessing at $\approx 24\%$ in one summary).

6.3 Drinking water and municipal supply:-

Many urban and rural settlements (including Srinagar) draw the majority of municipal and domestic water from river abstractions and connected springs and tributaries. Water quality studies (Rather et al., 2023) show seasonal microbial contamination risks – highlighting the need for treatment and watershed protection.

6.4 Fisheries, tourism and cultural services:-

Rivers such as Lidder and Sind support trout fisheries (both livelihood and sport/tourism) and attract white-water rafting, trekking and other nature tourism which contribute seasonally to local incomes. Wetlands connected to river systems (Wular lake) are important for migratory birds and local fisheries. (See ecology section and Rather et al., 2023).

6.5 Navigation and historical uses:-

Historically the Jhelum served navigation and timber transport. Channel morphology and sedimentation (and modern anthropogenic changes) have reduced navigation utility; there is discussion in policy circles about selective revival for inland transport and tourism, but this requires environmental and engineering assessment.

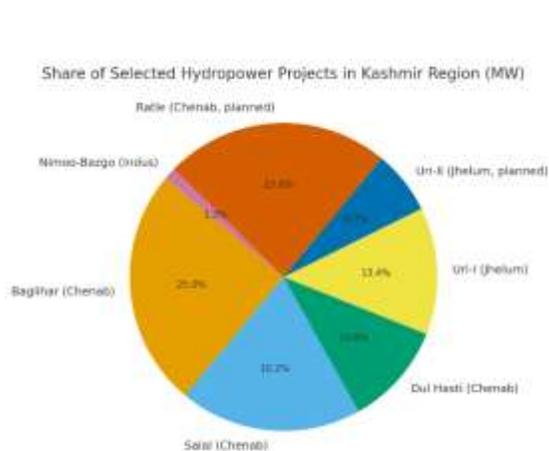


Figure 8: Pie chart of hydropower project irrigated cropping pattern

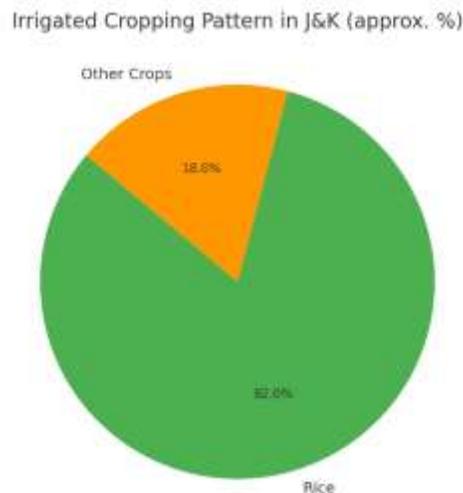


Figure 9: pie chart of irrigated cropping pattern

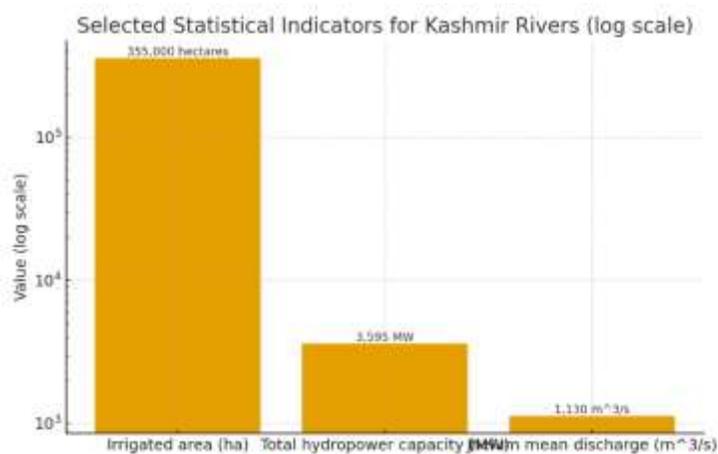


Figure 10 : statical data of indicators of rivers

7. CONCLUSION

Kashmir's rivers are indispensable natural assets that sustain irrigation, provide renewable hydropower, support fisheries and tourism, and form the ecological foundation of local livelihoods. With an energy potential of several terawatt-hours annually and existing projects such as Baglihar, Salal, Dul Hasti, Uri, and Nimoo-Bazgo, these rivers already contribute significantly to regional development. However, their benefits are under growing threat from glacial retreat, altered hydrological regimes, pollution, deforestation, unregulated mining, and land-use change.

Recent studies highlight increasing flood vulnerability, unstable river channels, and microbial contamination, indicating that the ecological resilience and socio-economic contributions of Kashmir's rivers are no longer assured. To safeguard these systems, an integrated basin-wide strategy is essential. This must combine sediment-sensitive hydropower operations, canal modernization, and efficient irrigation with ecological safeguards such as riparian restoration, catchment afforestation, and regulation of extraction. Equally vital are community engagement and transboundary cooperation under the Indus Waters Treaty.

By strengthening monitoring, data sharing, and policy frameworks that account for ecological costs, Kashmir can secure its rivers as multi-functional resources. Such an approach ensures sustainable food and energy

security, protects biodiversity, and promotes diplomatic stability in one of the world's most sensitive transboundary basins.

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