Hydrology, Habitat, and Humanity: A Case of Kabartal, Asia's Largest Freshwater Oxbow Lake

Total word count: 7558

Number of figures-48

Hydrology, Habitat, and Humanity: A Case of Kabartal, Asia's Largest Freshwater Oxbow Lake

Aditya Bharadwaj, Bachelor of Planning, Amity School of Architecture & Planning, Amity University (Noida)

Ar. Sandeep Kumar, Associate Professor, Amity School of Architecture & Planning, Amity University (Noida)

Mr. Lovlesh Sharma, Senior Water and Urban Infrastructure Expert, National Institute of Urban Affairs (NIUA)

Abstract

Jheel, Beel, Talab, Kayal ach term whispers the profound bond between the community and the wetlands that shape their ecosystem and the outer world surrounding it. Wetlands, an omnipresent ecosystem, found in every corner of the world, are a vital yet often misunderstood of all ecosystems. Among them lies Kanwar Lake, also known as Kabartal Wetland, is a Ramsar Site and Asia's largest freshwater oxbow lake, formed by the meandering Gandak River, a tributary of the Ganga. Its rich ecosystem services make it vital for local livelihoods. Once a haven for migratory birds, the wetland is now deteriorating due to anthropogenic pressures—habitat loss, pollution, and overexploitation—leading to changes in its natural hydrological regime. The lake's degradation has increased the livelihood vulnerability of thousands of people who depend on it, also creating conflicts amongst them. This research focuses on restoring Kabartal's hydrological regime through the *Taal Se Taal Mila* strategy, aiming to revive its natural inundation patterns. It further seeks to develop an integrated wetland conservation and livelihood enhancement strategies by examining the lake's ecological components and the socio-economic realities of its dependent communities, ensuring long-term ecological and economic sustainability.

Keywords

Wetlands, Degradation, Dependent Community, Conservation, Hydrological Regime.

1. Introduction

According to the Ramsar Convention (1971), wetlands are dynamic ecosystems, including marshes, mangroves, peatlands, and shallow marine areas, whether natural or artificial, permanent or temporary. Despite covering only 6% of the Earth's surface, they support 40% of all plant and animal species and over a billion people globally. However, wetlands are disappearing three times faster than forests, potentially contributing to a 1.6°C rise in global temperatures. Historically misclassified as wastelands, wetlands have been degraded due to uncoordinated development across sectors like water resources, fisheries, and tourism, often overlooking local communities' dependence on them.

Effective restoration must consider ecological, hydrological, socio-economic, and institutional factors through a basin-level, stakeholder-inclusive approach. Wetlands must be integrated into broader strategies for water management, agriculture, and disaster risk reduction. The Supreme Court's suo motu PIL further underscores the need for monitoring and sustainable management of Ramsar sites.

Kanwar Lake (Kabartal Wetland), Asia's largest freshwater oxbow lake in Bihar, spans 14 subdistricts and plays a vital role in hydrological regulation, biodiversity conservation, and sustaining agrarian and fishing livelihoods. Despite being designated as a protected zone (1986), bird sanctuary (1989), and Ramsar site (2020), its area shrank from 6,786 ha (1984) to 2,620 ha (2012), disrupting ecological balance and affecting over 15,000 fishers. The shift to permanent agriculture, infrastructure development, and pollution has further degraded the ecosystem. This project aims to integrate conservation with livelihood enhancement by evaluating ecological changes and proposing strategies for sustainable wetland use and biodiversity protection.

2. Literature review

2.1. Current Wetland Trends

The global extent of inland and coastal wetlands is estimated to exceed 1.21 billion hectares. The global value of services provided by wetlands is estimated at around US$4.9 trillion annually, contributing significantly to the estimated US$33 trillion value provided by all ecosystems. Since **1900, approximately 64%** of the world's wetlands have been lost, with Asia experiencing significant annual losses mainly due to conversion of this vital ecosystem

for other use. (Ramsar Convention Secretariat, 2016). The National Wetlands Atlas states that there are approximately **7,57,060 wetlands** in India, covering **15.98 million hectares,** Which is **4.86%** of India's total area. Of this total, inland wetlands comprise **74.1%** (11.85 million hectares). The United Nations reports that since 1970, 35% of the world's wetlands have been lost due to factors such as drainage for agriculture, pollution, overfishing, invasive species, and climate change.

India is endowed with a rich diversity of wetlands shaped by its varied climate, topography, and hydrology. The National Wetlands Atlas reveals that there are approximately **7,57,060 wetlands** in India, covering **15.2 million hectares,** Which is **4.2%** of India's total area. Of this total, inland wetlands comprise **74.1%** (11.85 million hectares). India comprises of total 89 Ramsar Site, highlighting their international importance.

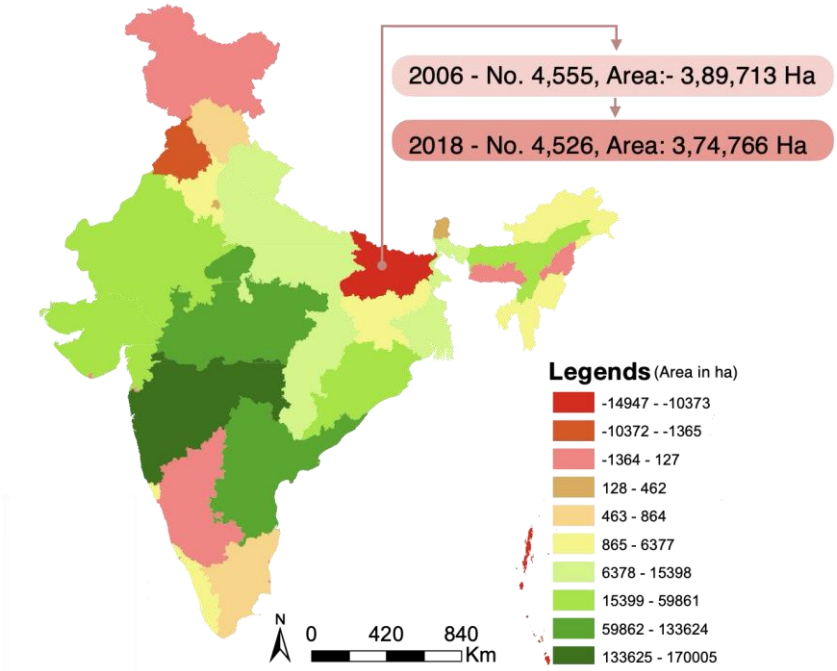


Figure 1: Decadal Changes in Wetland Area in India (2006 - 2018) (Source: Gupta et., 2021)

There has been a steady increase in both the number and extent of wetlands in many of Indian states. However, Figure 2 highlights Significant decadal wetland losses, particularly in Bihar, Punjab, and the Andaman & Nicobar Islands has contributed to decrease in the groundwater storage capacity, water scarcity, heightened flood risks.

3. Study Area Context

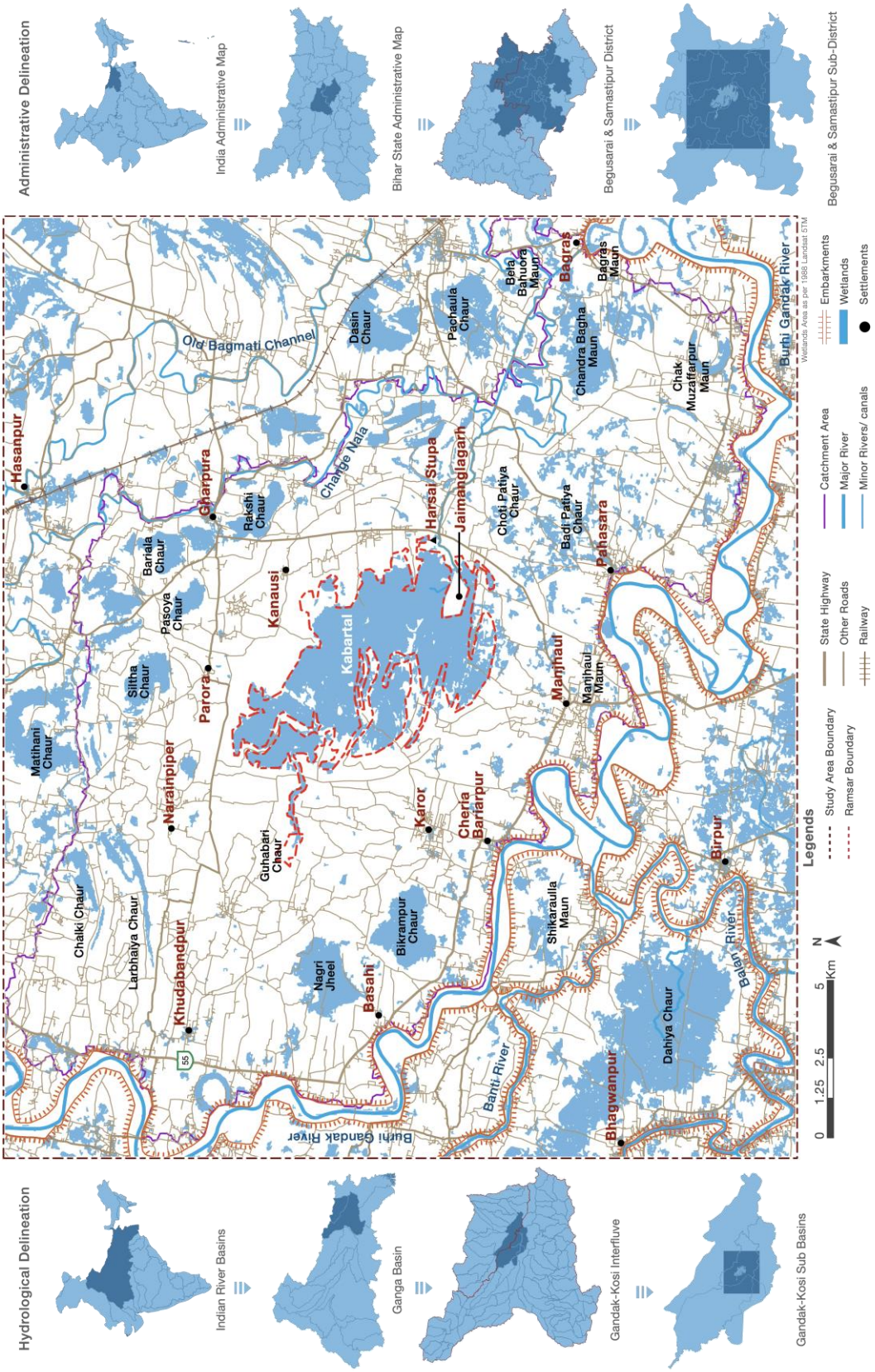


Figure 2: Hydrological and Administrative Delineation of kabartal Wetland Complex (Source: Bharadwaj et al., 2025)

The Kabartal Wetland is a floodplain wetland located in the Burhi Gandak sub-basin of the Ganga Basin in Bihar, India. It comprises various Mauns (oxbow lakes) and Chaurs (seasonally inundated floodplains) formed by the meandering of the Burhi Gandak, Chandrabhaga, and Bagmati rivers within the Gandak-Kosi interfluve. Covering a study area of 658 km², the wetland includes a Ramsar-designated area of 26.2 km² and spans across Begusarai and Samastipur districts. It encompasses 313 villages with a total population of 12,63,014 (as per the 2011 Census) and an average household size of 4.9. The region experiences an average temperature of 25.4°C and receives an annual rainfall of 1,285 mm. Situated at an elevation of 41 meters above mean sea level (AMSL), Kabartal is classified as a floodplain wetland within the Eastern Plain Hot Sub-Humid Agro-Ecological Sub-Region (AESR).

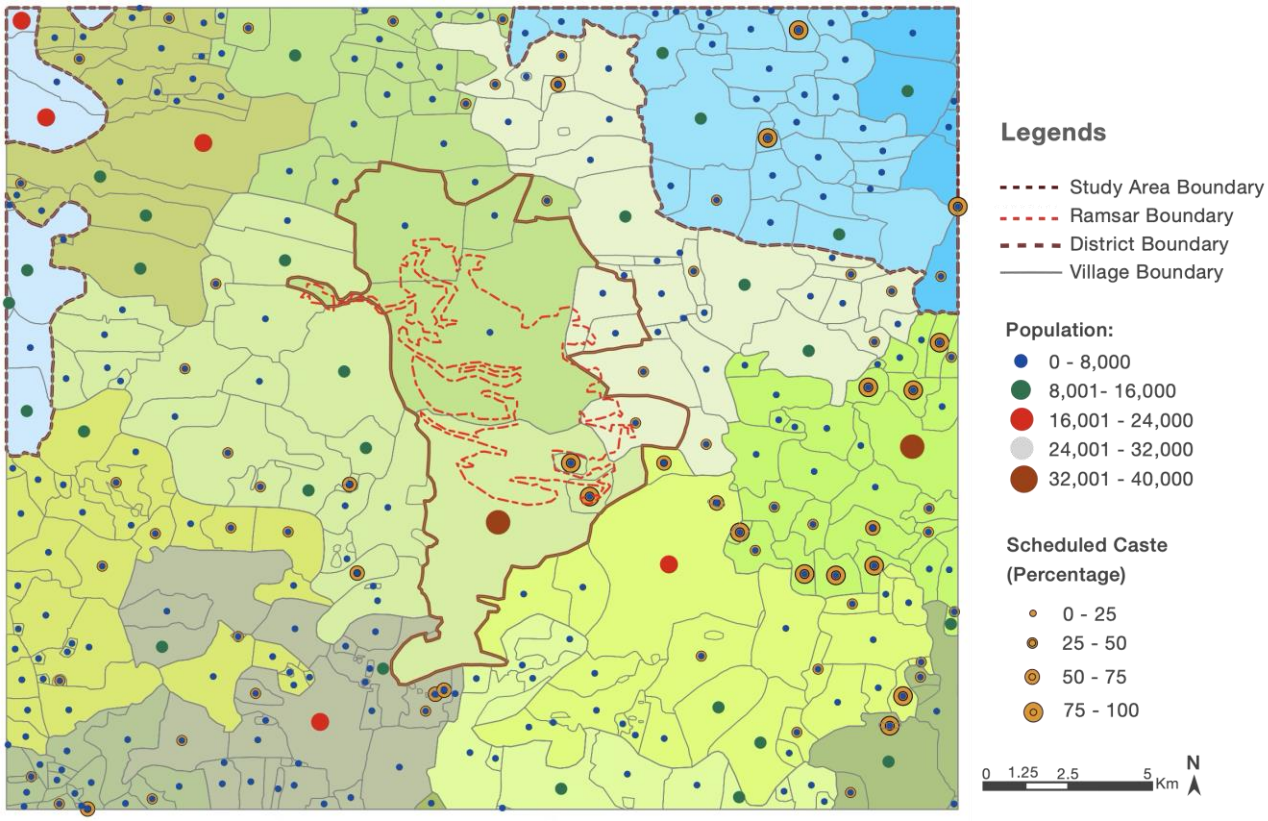


Figure 3: Administrative Boundary Within the Wetland Complex (Source: Bharadwaj et al., 2025)

The Kabartal Wetland Complex spans over **14 subdistricts** with a population of 29,04,252 (projected for 2025), with 3 located in **Samastipur** and 11 in **Begusarai**. The subdistricts included in this complex are Bakhri, Barauni, Begusarai, Bhagwanpur, Bibhutpur, Birpur, Bithan, Cheria Bariarpur, Chhorahi, Dandari, Garhpura, Hasanpur, Khudabandpur, Naokothi, and Teghra.

3.1. Kanwar Lake: A Sanctuary Only on Paper

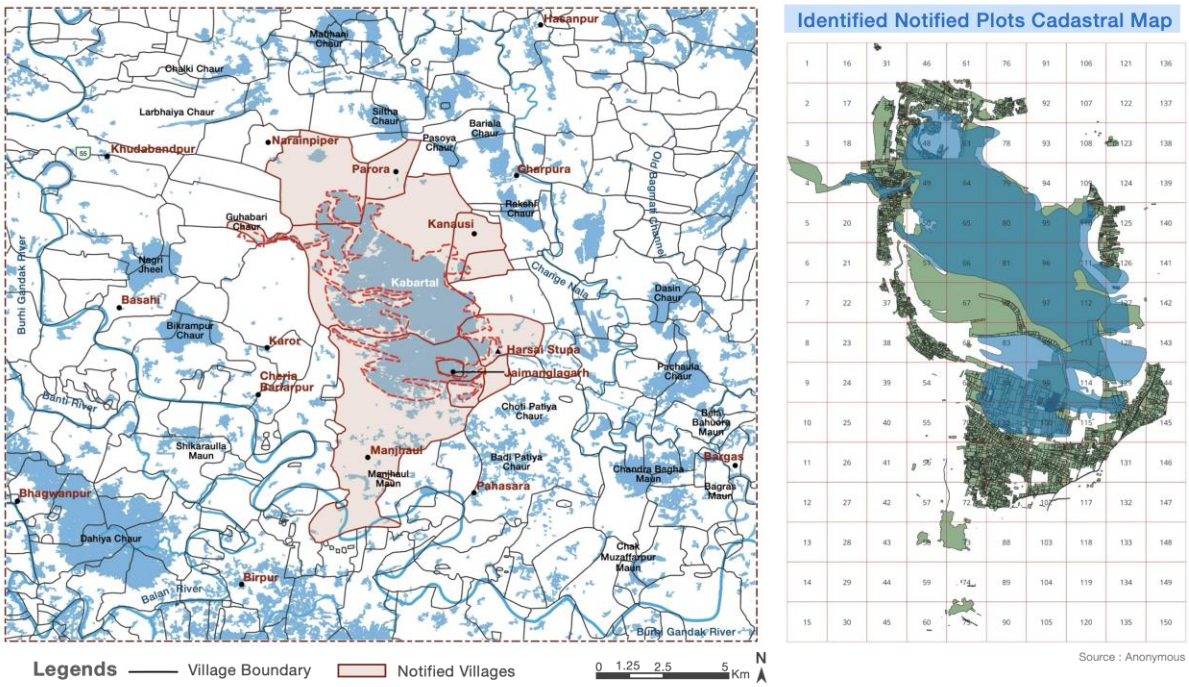
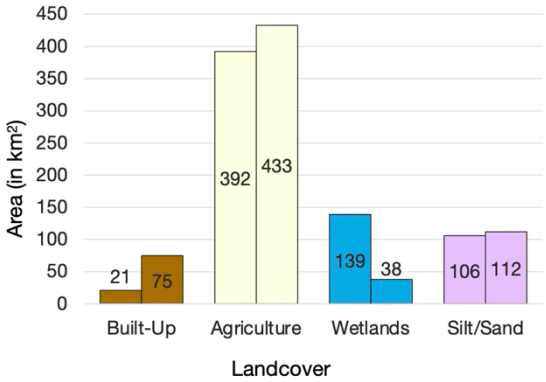


Figure 4: Sub-Districts Notified as Bird Sanctury in 1989 (Source: Bharadwaj et al., 2025)

Kabartal Wetland, notified as a sanctuary under the Wildlife Protection Act, 1972, spans 63.11 km², including significant private land. Due to errors in the 2012 notification—such as incorrect area and plot numbers—around 20 km² and 90 plots remain untraceable. Despite major private ownership, it was declared a sanctuary instead of a community reserve (Section 36C), without a proper land rights survey. This has left nearly 50% of the area under unresolved private ownership, causing long-standing disputes and restrictions on land use. For over 35 years, the community has faced legal uncertainty, disrupting livelihoods and preventing land transactions essential for social and economic needs, underscoring the urgent need for a balanced resolution.

Figure 5: Land Use Land Cover Change From 1988 to 2024 (Source: Bharadwaj et al., 2025)



Wetland area have declined from **139 km² to 38 km²**, while built-up areas have increased from **21 km² to 75 km²**. Agricultural land has expanded from **392 km² to 433 km²**, and silt/sand deposits have slightly increased from **106 km² to 112 km²**.

Figure 6: Graph Showing Change in Land Cover Pattern (1988-2024)

Rising human settlements near wetlands, with houses built on **public land** on Jaimanglagarh Island under **Indira Awas Yojna.**

Figure 7: Jaimanglagarh Island (Source: Bharadwaj et al., 2025)

The wetlands now remain inundated only in their lower ranges locally known as **'Khai,' throughout the year,** and have submerged macrophytes in the entire region.

Figure 8: Mahalya Deepest Area of The Kabartal (Source: Bharadwaj et al., 2025)

Once a thriving wetland, the **66% of the area** is now dominated by intensive farming, leaving only small patches of water-inundated land.

Figure 9: Wetland Area Used for Agriculture (Source: Bharadwaj et al., 2025)

Harsai Stupa, a site of historical significance with ties to Buddhist scholars, was cleared to make way for agricultural expansion, leading to the loss of heritage.

Figure 10: Harsai Stupa (Source: Google Earth, 2025)

4. Hydrology

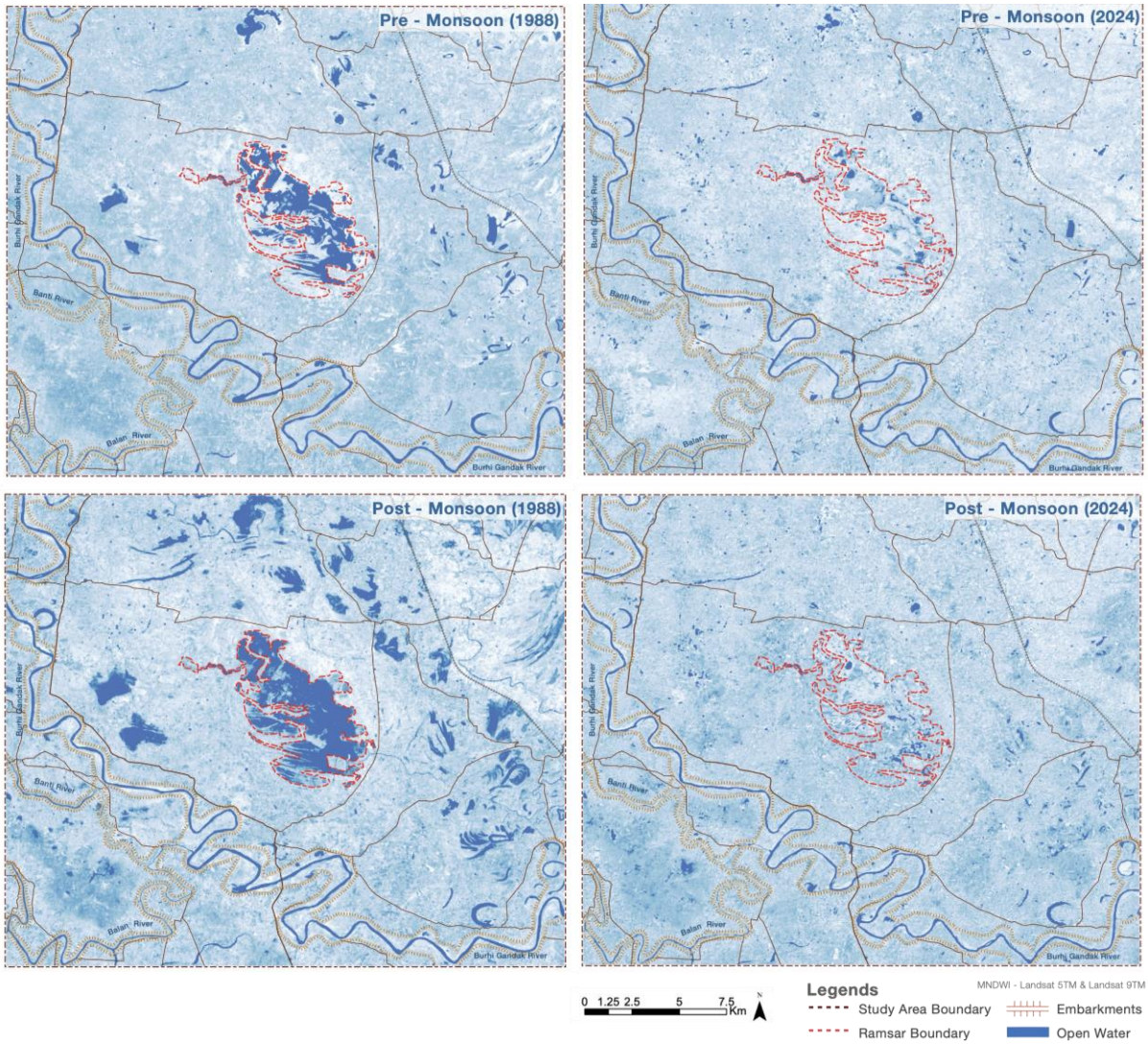


Figure 11: Trends in Water Inundation of Wetlands in Kabartal Complex (1988 and 2024) (Source: Bharadwaj et al., 2025)

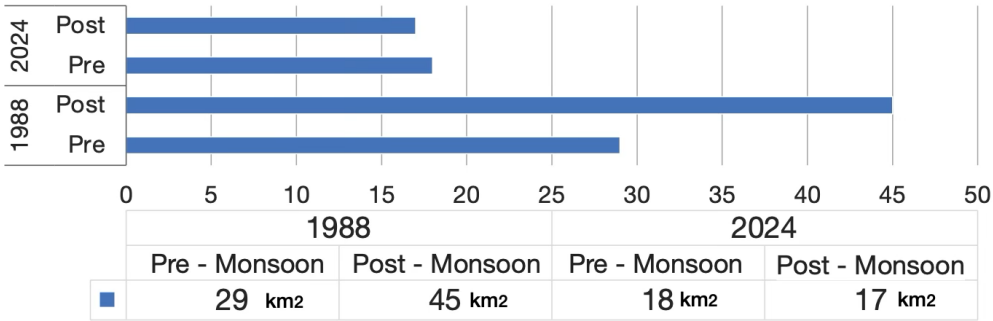


Figure 12: Graph Showing the Variation in Water Inundated Area For two Year 1988 & 2024 (Pre and Post-Monsoon) (Source: Bharadwaj et al., 2025)

Water inundation has decreased from **29 km² (1988 pre-monsoon) to 19 km² (2024 pre-monsoon)** and from **45 km² to 18 km² post-monsoon**. Climate change altered rainfall patterns, and intensive post-monsoon farming have contributed to this decline. Further factors affecting wetland loss will be discussed in the next section.

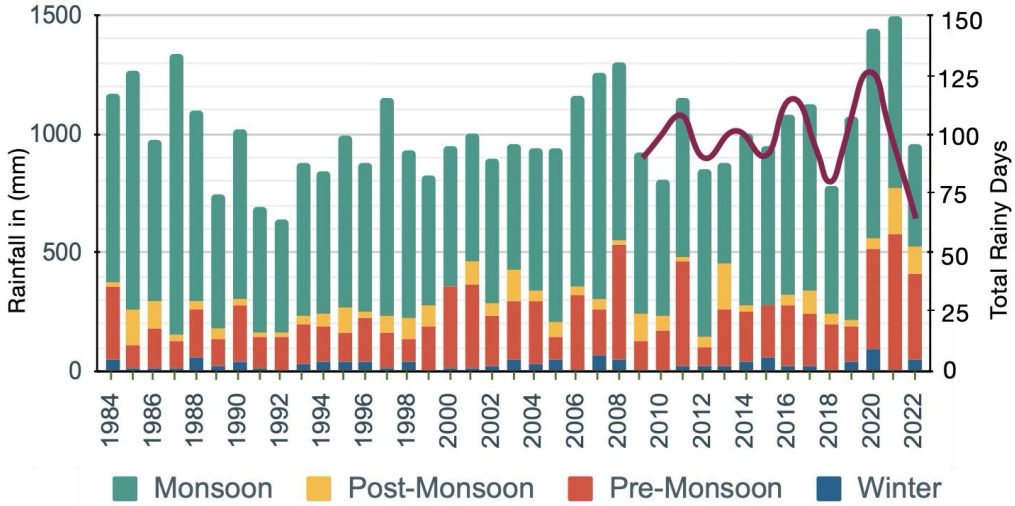


Figure 13: Graph Showing Trends in Rainfall Pattern and Total Number of Rainy Days over years (Source: NASA Langley Research Center, 2022; and Worldweatheronline, 2025)

4.1. Key Factors Behind Wetland Loss and Habitat Disruption

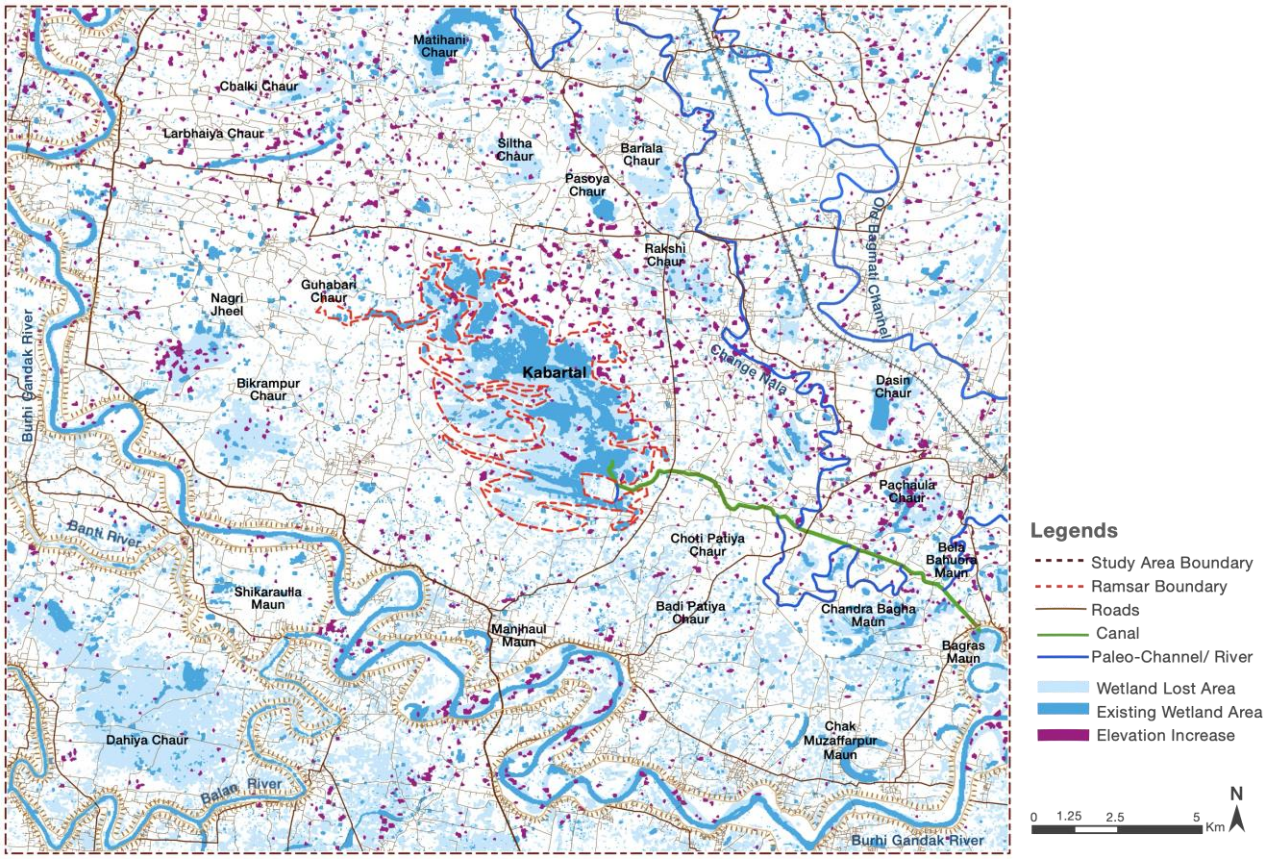


Figure 14: Loss in Wetland Area Over 3.5 Decades (Source: Bharadwaj et al., 2025)

4.1.1. Flood Embankments & Kabar-Bagras Canal

Figure 15: Flood Embarkment, Bagras Sulice Gate, and Kabar Bagras Canal (Source: Bharadwaj et al., 2025)

The construction of embankments along the Burhi Gandak River (1951–1956) disrupted Kanwar Wetland's natural connectivity with river systems, blocking the flow of water, fish, and sediment. In 1956, a 12 km canal was constructed to divert water from Kabartal to Bagras and drain it into the Burhi Gandak, reducing sediment distribution and increasing silt accumulation in the wetland. By the 1980s, land reclamation for agriculture intensified, further altering the hydrology and accelerating ecological degradation.

4.1.2. Habitat Fragmentation & Chandra Bahaga River Alteration

Figure 16: Elevated Embarkment Roads Disrupts The Natural Flow of Water Leading to Dry Areas And Fragmented Wetlands. (Source: Bharadwaj et al., 2025)

The Elevated embankment roads with inadequate water flow provisions have disrupted Kabartal's natural drainage, fragmented water channels, and impaired ecosystem function. Floods in 1987 and 2007 worsened habitat fragmentation by depositing silt and burying streams like Fudiya Nala. The Chandra Bahaga River has also been encroached upon, reduced to the silted and seasonally dry Chanha Nala.

4.1.3. Waste Dumping

Figure 17: Use of Maun for Waste Dumping by Locals Which Include Household as Well as Construction Wastes (Source: Bharadwaj et al., 2025)

Unregulated disposal of construction debris, brick kiln waste, and household garbage is significantly degrading wetland ecosystems, leading to habitat destruction and pollution. Indiscriminate waste dumping accelerates the deterioration of wetlands by altering natural water flow, clogging channels, and reducing water quality. This disruption affects aquatic life, diminishes biodiversity, and weakens the wetland's ability to provide essential ecosystem services such as flood control and water purification.

4.1.4. Soil Dumping & Land Conversion

Figure 18: Land Reclamation for Agriculture Expansion (Source: Bharadwaj et al., 2025)

Farmers often reclaim land by filling in wetlands and natural streams with soil to expand their agricultural fields. While this may temporarily increase cultivable land, it significantly disrupts the wetland’s natural hydrology. The alteration of water flow patterns and drainage systems accelerates habitat loss, reduces biodiversity, and weakens the ecological functions that wetlands provide, such as flood control and groundwater recharge.

4.1.5. Water Pumping & Macrophyte Spread

Figure 19: Use of Pumps to Dry Out The Wetland Areas, and Growth of Invasive Macrophyte (Source: Bharadwaj et al., 2025)

The practice of pumping out water to reclaim submerged areas of the wetland for farming has become increasingly common, significantly altering the natural water retention capacity of the ecosystem. Additionally, the unchecked expansion of invasive macrophytes contributes to rapid siltation, blocking the natural flow of water and making navigation within the wetland increasingly difficult. These combined pressures are gradually transforming the wetland's structure and undermining its ecological stability.

5. Humanity

5.1. Community: The Core Stakeholder

The community around the wetland complex consists of diverse ethnic groups with distinct livelihoods: the **Bhumihar**, who are farmers; the **Mallah**, with subgroups like Sahnis who traditional fishers are; and the **Mushar**, who work as wage laborers.

5.1.1. Occupation Profile and Shift in last Decades

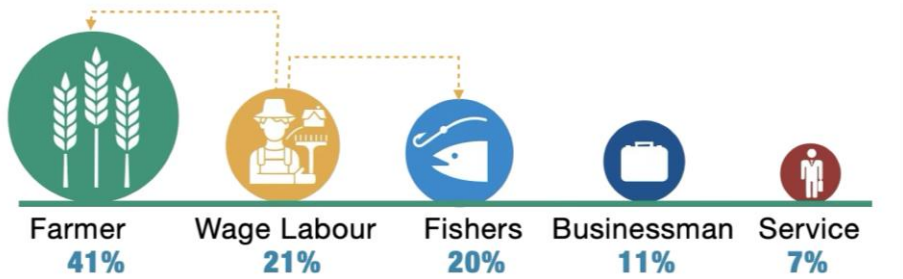


Figure 20: Occupational Profile of the People living around kabartal Wetland (Source: WISA ,2016)

Farming is the dominant occupation due to extensive land holdings, while wage laborers, who rely on seasonal employment, engage in farming, fishing, and various labor activities, whereas businessmen, including shopkeepers and small business owners, contribute to the local economy through trade and commerce.

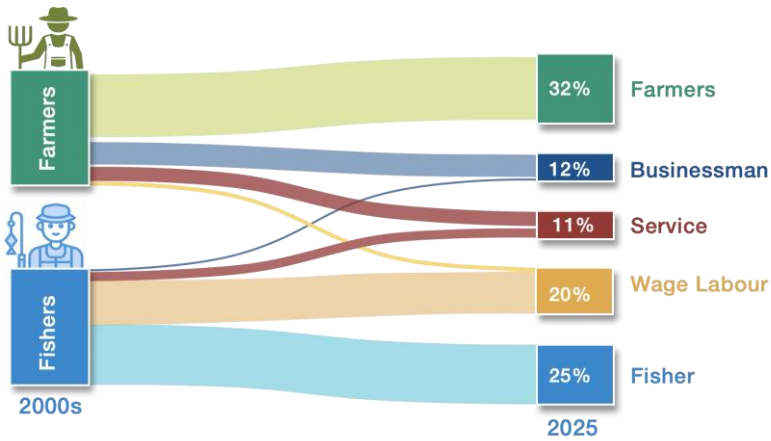


Figure 21: Occupational Shift Over 2 Decades (Source: Bharadwaj et al., 2025)

Farmers, due to low land productivity, lease land to wage laborers, while both fishers and farmers seek external job opportunities.

Declining water levels reduced fisheries-based livelihoods, pushing fishers toward culture fisheries and wage labor. Kabartal Wetland now faces increasing pressure from competing agricultural and fisheries demands and thus increasing livelihood vulnerability.

5.1.2. Indigenous Knowledge and Seasonal Migration

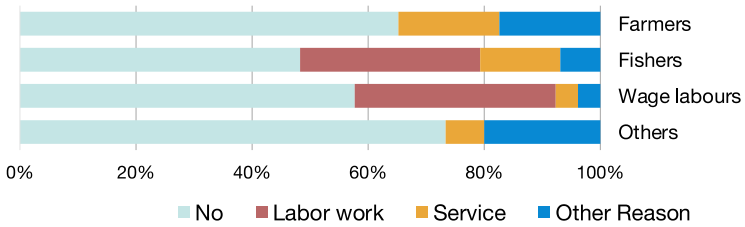


Figure 21: Migration Pattern Based on Occupational Profile (Source: Bharadwaj et al., 2025)

Migration trends are closely linked to changing land use and wetland productivity and are seasonal. Due to economic needs, fishers migrate to states like West Bengal, Odisha, Jharkhand, Andhra Pradesh, Kerala, etc for seasonal fishing, highlighting their reliance on water resources and the challenges of sustaining livelihoods in their native regions.

5.2. Changing Agricultural Landscape

Traditional agriculture in Kabartal relied on natural inundation, with cultivation limited to elevated areas (rahi) for one or two crops in prior to 1950. By the 1970s, irrigated farming expanded, introducing short-cycle rice, wheat, and double cropping, and today nearly the entire wetland is cultivated, supporting three or more crops.

5.2.1. Cropping Patterns

- **Kharif Season (June–November):** Rice is the dominant crop.
- **Rabi Season (December–April):** Wheat, sugarcane, and mustard are extensively grown. pea, pigeon pea, Red Lentil
- **Garma/ Zaid Season (April–June):** Maize cultivation.


Figure 22: Wetland Area Used for Intensive Agriculture Farming (Source: Bharadwaj et al., 2025)

Water regimes have been altered to support continuous agriculture, leading to the replacement of indigenous crops with water-intensive alternatives. Agricultural expansion and soil dumping have disrupted water flow, drying up parts of the area. This has degraded ecosystems and reduced crop quality, particularly sugarcane, impacting farmers' livelihoods. Although most studies indicate that menthol cultivation is still ongoing, but declining demand and productivity have led farmers to stop it.


Figure 23: Stubble Burning in Wetland Area is Raising Environmental Concern (Source: Bharadwaj et al., 2025)

Stubble burning and excessive use of fertilizers and pesticides are major threats to wetlands, leading to water pollution, eutrophication, and habitat disruption, and on the other hand chemical runoff harms aquatic life, while toxic exposure affects birds and wildlife, endangering biodiversity and ecological balance.

5.3. Declining Fisheries & Livelihood Challenges

5.3.1. Economic Impact of Wetland Species

In the Kabartal Wetland Complex 26 out of 36 species as per Zeological Survey of India have economic value, The Wetland Complex is rich in **edible molluscs and crabs**, supporting local economies and food security.

5.3.2. Government Support & Fishery Access:

The Kabartal Wetland primarily functions as an open-access capture fishery, whereas most of the adjacent *maun* and *chaur* wetlands are leased by fisher cooperatives from the state fisheries department for semi-intensive culture fishing. Fishers receive **₹1,500/month** for three months during monsoon when fishing is prohibited in the region.

Managed ponds in **maun areas** support controlled fish breeding, ensuring seed production and enhancing fisheries managed by the **matsaya jivi samiti** (Fishery cooperatives).

5.3.3. The Decline of Wetland Fisheries

Figure 24: Reduce in Fish Capture Over years (Source: Bharadwaj et al., 2025)

Reduced water coverage has led to a shift from high-value species (Indian Major Carps) to lower-value species, with a significant drop in average catch (from 10-12 kg/day to 1-3 kg/day). A 2008 assessment by CIFRI revealed that the existing production levels in the maun and chaur areas (265 kg/ha) were considerably lower than the potential yield of 1,500–2,000 kg/ha, assuming optimal ecological conditions are maintained.

5.3.4. Inequities in Cooperatives & Management Issues

Fishery cooperatives often favor wealthier individuals, limiting opportunities for smaller fishers and pushing them to the margins. This imbalance creates disparities in resource access and economic benefits, further widening the gap between large and small-scale fishers. Additionally, many Maun and Chaur areas face challenges such as encroachments and a lack of proper surveys, despite being leased for water body management. The absence of clear land demarcation and monitoring mechanisms allows unauthorized occupation, threatening both the livelihoods of local fishing communities and the ecological balance of these water bodies.

5.3.5. Ecological & Economic Shifts

Figure 25: Decreased Inundated Area is increasing Livelihood Vulnerability (Source: Bharadwaj et al., 2025)

Declining livelihood dependency on traditional water-based activities due to environmental degradation, reduced inundated areas, and socio-economic shifts. Some boats are intentionally submerged when people migrate, indicating changing livelihood patterns.

5.3.6. Secondary Livelihood Source

Figure 26: Secondary Livelihood Options for the Fishing Community (Source: Bharadwaj et al., 2025)

Beyond fishing, the wetland supports various livelihood activities that contribute to the economic well-being of local communities. It serves as a vital resource hub, providing essential materials for sustenance and income generation. Aquatic vegetation found in the wetland offers fuelwood, fodder, edible plants, and medicinal herbs, which are widely used by local households. Additionally, the wetland plays a crucial role in Makhana (fox nut) cultivation, a traditional practice that complements fishing and

provides an alternative source of income, promoting economic stability. Despite modernization, 72% of surveyed households still rely on fuelwood for cooking. Kabartal Wetland supports both domestic and international tourism, with local fishermen engaging in tourism-related activities to supplement their income. This underscores the wetland's vital role in daily life and livelihoods, highlighting the need to balance resource use with conservation for long-term sustainability.

5.4. Groundwater Depletion & Rising Dependence

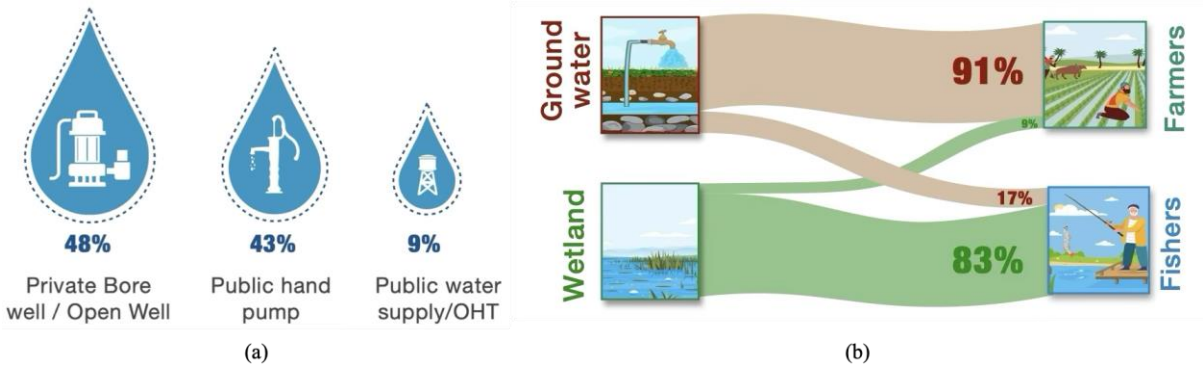


Figure 27: Source of Water for Household Activities (a) and Livelihood Activities (b) (Source: Bharadwaj et al., 2025)

Since the 1970s, groundwater levels in the region have dropped sharply—from 2–3 meters to 9–12 meters, with some borewells reaching over 75 meters. This decline is mainly due to intensified agriculture and fish farming, increasing dependence on groundwater. Currently, all households rely on it for domestic use, while 17% of fisheries and 9% of agriculture also depend on it. Rainfall variability and disrupted natural hydrology have further intensified this dependence, straining local water resources.

5.5. Livelihood Assets of two dominant Stakeholder

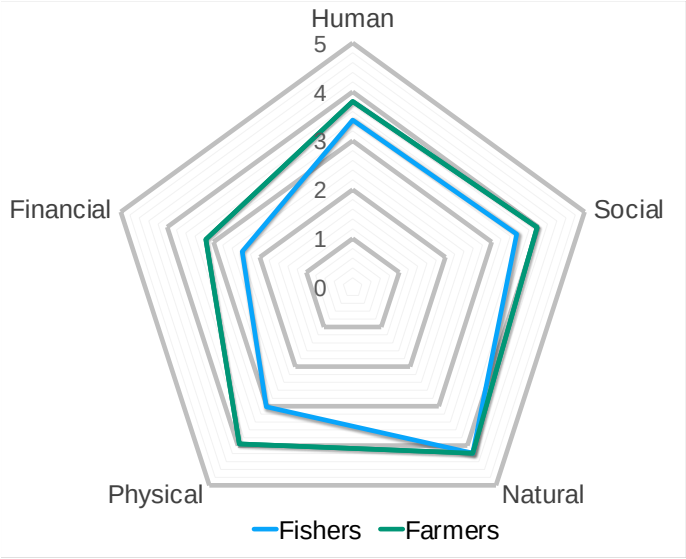


Figure 28: The Livelihoods Assets Pentagon of two dominant Stakeholder (Source: Bharadwaj et al., 2025)

Both stakeholders face significant financial constraints, with fishers having particularly low physical and financial capital. Additionally, limited cooperative support and lack of skill development hinder their progress. Restricted land ownership further limits access to formal credit, pushing both groups to rely on local moneylenders and deepening their financial vulnerability.

5.6. ESSVA and Human Well Being Assessment

The Ecosystem Services Shared Value Assessment (ESSVA) and Human Well-Being Assessment highlight the crucial role wetlands play in supporting both ecological functions and community livelihoods. Provisioning services such as fisheries and agriculture continue to sustain the local population, even as overall ecosystem services show signs of decline. Regulating services like groundwater recharge and flood prevention are vital for maintaining environmental stability and enhancing the area's resilience to climate-related risks. These functions underline the wetland's importance in supporting not just livelihoods but also long-term environmental health.

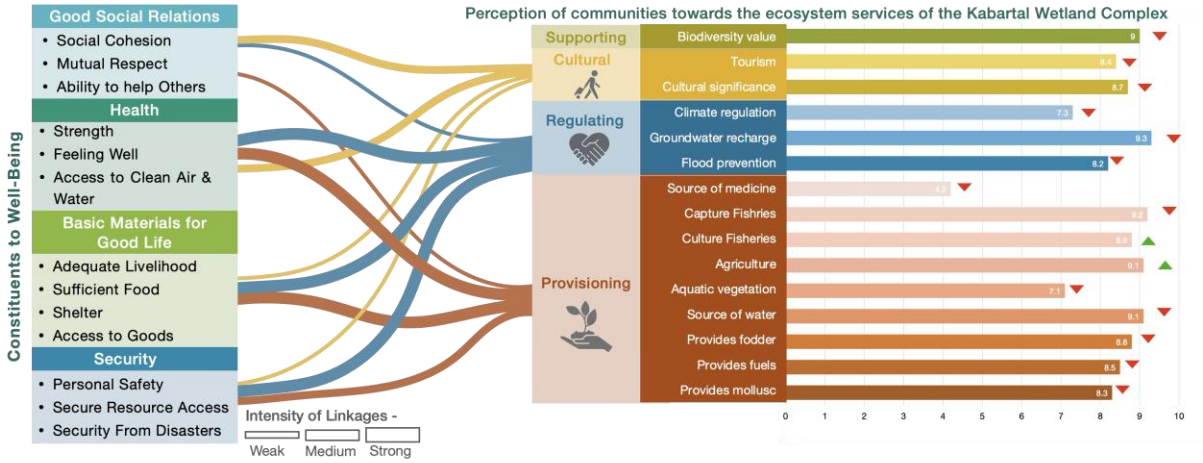


Figure 29: Ecosystem Services Shared Value Assessment (ESSVA) and Human Well Being Assessment (Source: Bharadwaj et al., 2025)

Cultural and tourism-related values remain strong, indicating a community that recognizes and cherishes the nonmaterial benefits of the wetland, such as spiritual and recreational connections. However, the degradation of supporting services—such as nutrient cycling and habitat maintenance—poses a growing threat to the sustainability of both ecosystem functions and human well-being. As reliance on the wetland intensifies, the loss of these services could undermine livelihoods, reduce climate resilience, and diminish the cultural identity tied to the landscape.

5.7. Economic Valuation

The Economics of Ecosystems and Biodiversity India Initiative (TII) assessed the trade-offs of land use changes in Kanwar Jheel across three scenarios: Business-As-Usual (2000–2014) with 50% inundation, SEM1 (1980s) with 60%, and SEM2 (1970s) when the wetland was fully inundated. The 1970s scenario showed the highest ecosystem service values—₹87 million from fisheries, ₹18.42 million from wetland agriculture, and ₹9.07 million from fuelwood annually. In contrast, converting wetlands to permanent agriculture yields only ₹12.67 million annually, while causing losses of ₹74.19 million in fisheries, ₹7.9 million in aquatic plants, and ₹9.66 million in groundwater recharge—demonstrating that agricultural expansion does not compensate for the lost ecosystem benefits.

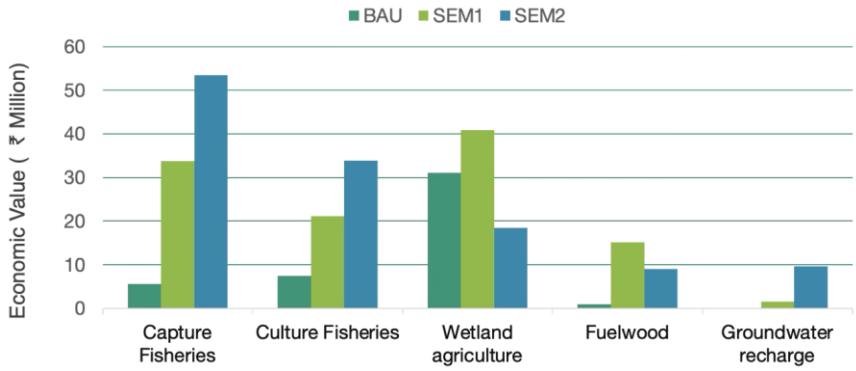


Figure 30: Economic Shift Since 1970s in 5 major Wetland Related Ecosystem Services (Source: Kumar et al., 2016)

Overall, the transformation of Kanwar Jheel from a multifunctional wetland to agricultural land results in Opportunity Cost outweighs the Realized Benefit 7.2 times, making continued conversion both ecologically and economically unsustainable.

6. Habitat

6.1. Significance of Kabartal as a Biodiversity Hotspot

Kabartal Wetland, also known as Kanwar Jheel, holds immense ecological significance due to its rich biodiversity and strategic location. It is designated as an Important Bird Area (IBA) and functions as a vital stopover site along the Central Asian Flyway, providing essential resting and refueling opportunities for 58 migratory waterbird species. Additionally, the wetland supports a diverse ecosystem comprising 165 species of flora and 394 species of fauna, underscoring its role as a biodiversity hotspot of both national and international importance.

Critically endangered	Endangered	Vulnerable
Baer's Pochard, White-rumped Vulture, Indian Vulture, Red-headed Vulture, Sociable Lapwing	Common Pochard, Saker Falcon, Greater Adjutant, Pallas's Fish Eagle, Egyptian Vulture	Wallago catfish, Greater Spotted Eagle, Woolly-necked Stork, Lesser Adjutant

Figure 31: Species of global conservation significance Present in Kabartal (Source : Ramsar Sites of India Factsheets)

6.2. Declining Fish Habitats and Aquatic Ecosystem Disruptions

Kabartal's aquatic ecosystem faces severe stress from human-induced disturbances. Declining riverine connectivity has disrupted fish regeneration cycles, reducing biodiversity and productivity. Infrastructure like embankments and roads further fragments habitats, blocking fish and invertebrate movement. Since the 2007 flood, fish diversity and abundance have

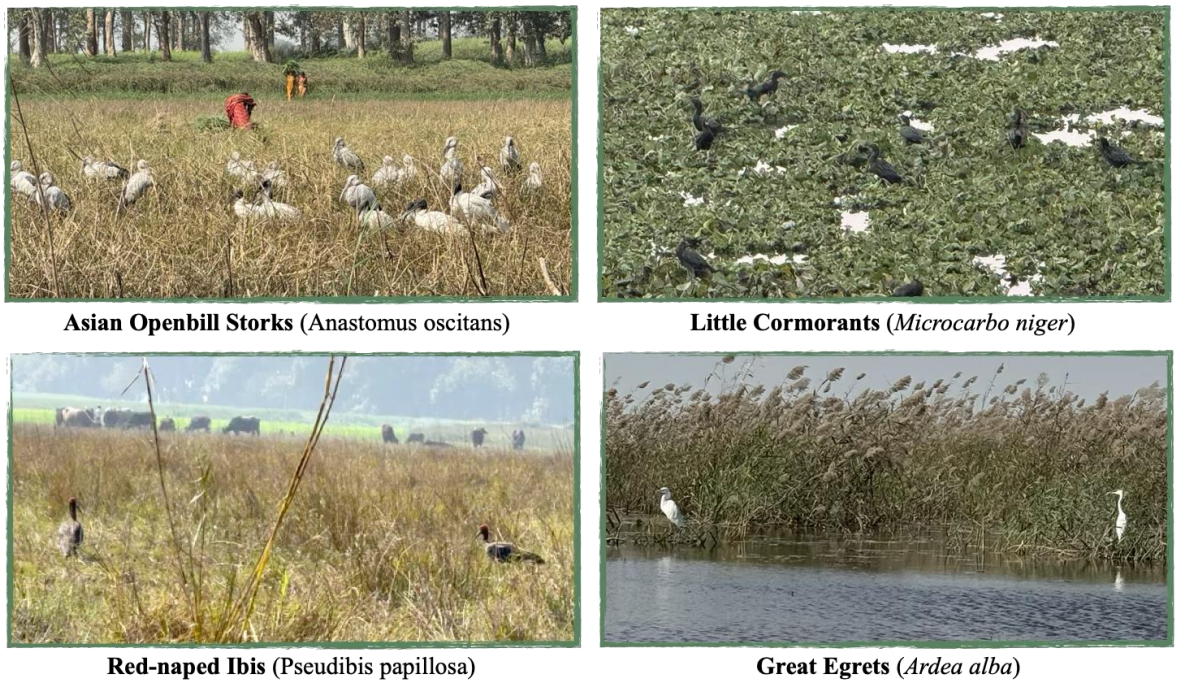
notably declined. Water quality is deteriorating due to nutrient-rich agricultural runoff, causing algal blooms that deplete oxygen and harm aquatic life. Invasive species like *Phragmites karka* and Tilapia outcompete native species, while unsustainable fishing practices, such as using small-mesh nets and box traps, further threaten ecological balance. These combined pressures endanger the wetland's health and sustainability.

Figure 32: Unsustainable Fishing Practices and Wetland Degradation (Source: Bharadwaj et al., 2025)

As seen in Figure 41, Local fishing communities, particularly the Mallah, rely on traditional handmade box traps to catch small fish in inundated areas, but large-scale installations of these traps across flooded waters have led to the depletion of fish stocks, impacting the wetland's biodiversity, while discarded mollusc shells contribute to water pollution, further harming the aquatic ecosystem, and in shallow waters, floating drums tied with fine nets are used to maximize fish catch, exacerbating the strain on fish populations and disrupting the ecological balance of the wetland.

6.3. The Impact of Wetland Changes on Bird Populations

The 2023 Asian Waterbird Census (AWC) recorded a total of 1,584 birds representing 51 species in the Kabartal wetland. Among these, 1,033 were waterbirds, 182 were wetland-dependent birds, and 369 were landbirds. This distribution reveals ongoing shifts in species abundance and habitat use, likely in response to changing ecological conditions. The once-thriving congregation of migratory birds is now dwindling, signaling a disruption in the wetland's ecological balance.



Asian Openbill Storks (Anastomus oscitans)

Little Cormorants (*Microcarbo niger*)

Red-naped Ibis (Pseudibis papillosa)

Great Egrets (*Ardea alba*)

Figure 33: Some Wetland Birds and Their Surroundings (Source: Bharadwaj et al., 2025)

One of the major drivers of this decline is the shrinking size of the wetland due to agricultural expansion, which has significantly reduced traditional bird congregation and feeding areas. As natural feeding grounds vanish, birds are increasingly deprived of essential food sources such as paddy grains, insects, frogs, mollusks, and tortoises. Overexploitation of wetland resources has compounded this issue, directly impacted the survival of migratory species and highlighting the urgent need for sustainable wetland management.

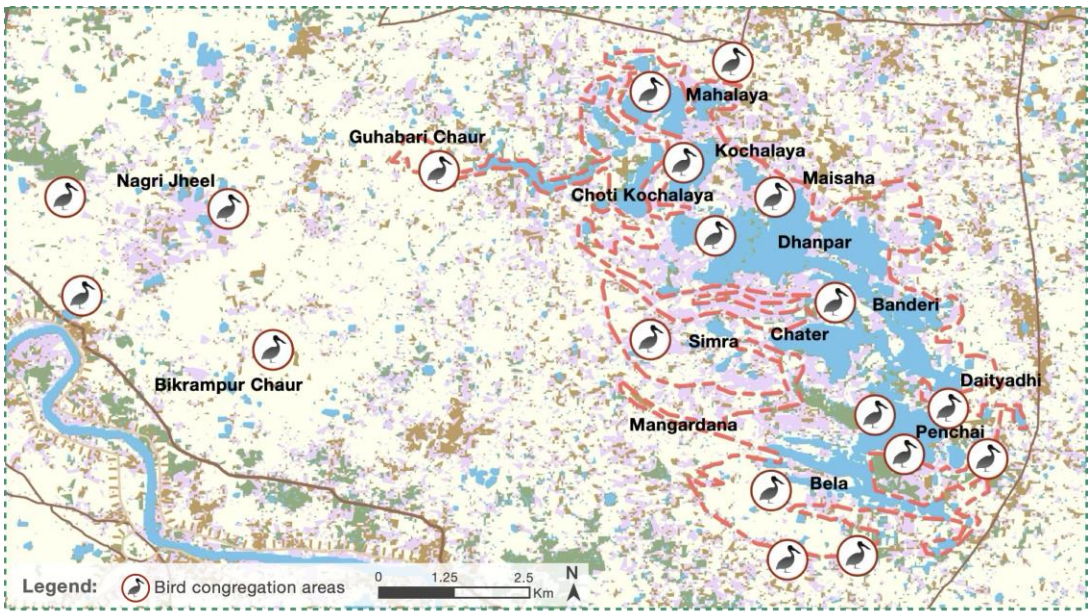


Figure 2: Bird congregation areas (Source: WISA ,2016)

While bird poaching has declined notably since 1989, it continues to be a threat to bird populations. Communities, particularly those involved in fishing, still trap species like the Red-crested Pochard (*Lalsa*) and Cotton Teal (*Sarayor*) using nets for local consumption and sale. These pressures, alongside habitat degradation, have created an ecological imbalance, underscoring the critical need for conservation efforts that balance livelihood needs with biodiversity protection to restore and sustain the avian diversity of Kabartal.

7. ताल से ताल मिला - Where Humanity Reunites to Restore Hydrology and Revive Habitat

Taal se Taal Mila will a community-driven initiative focused on reconnecting and restoring the hydrological **connectivity and inundation as of 1980s** of the Kabartal wetland complex. The project will integrate wetland conservation with active community participation, ensuring sustainable water management, biodiversity enhancement, and ecosystem resilience. By fostering partnerships among local stakeholders, it aims to balance ecological restoration with livelihood opportunities, promoting long-term stewardship of wetlands.

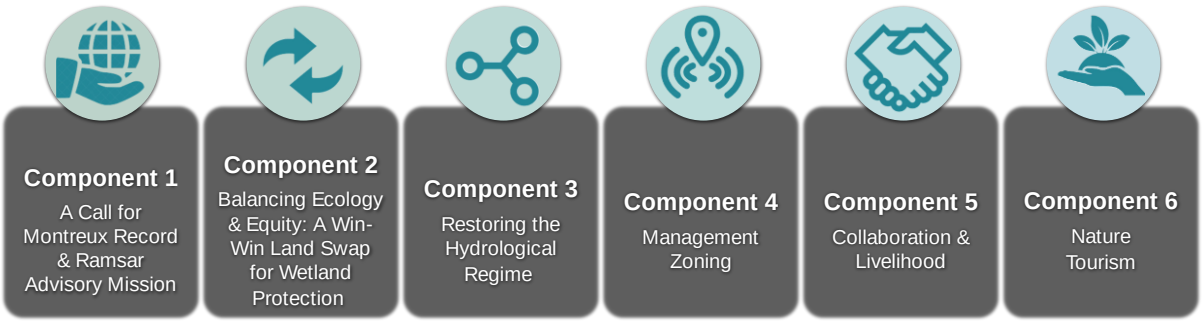


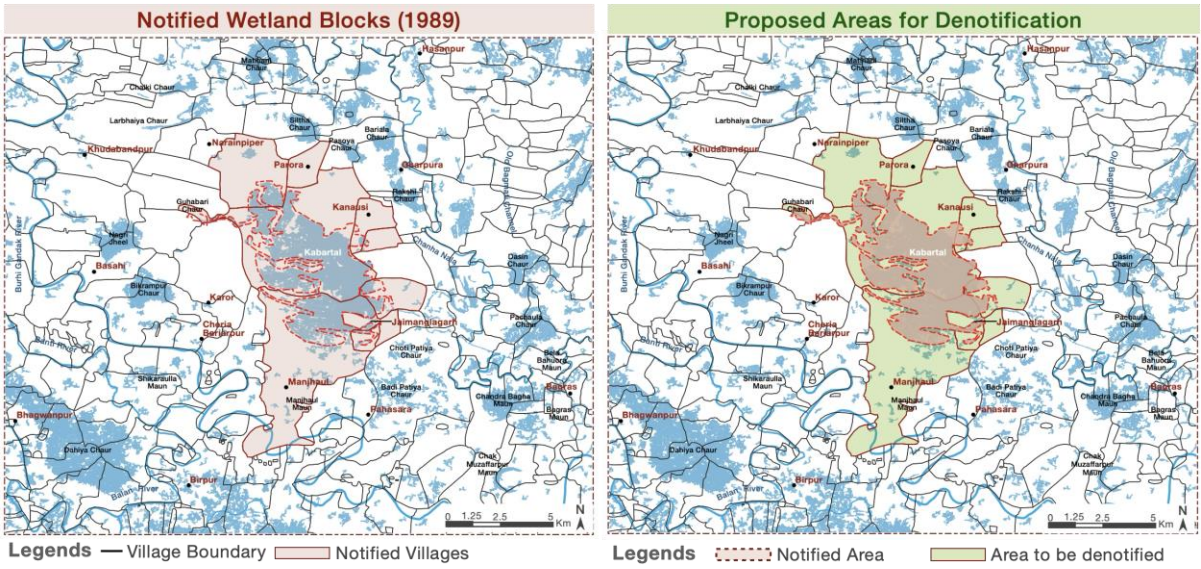
Figure 3: Six key Components of Taal Se Taal Mila (Source: Bharadwaj et al., 2025)

7.1. Component 1: A Call for Montreux Record & Ramsar Advisory Mission

The Montreux Record lists Ramsar wetlands facing or likely to face ecological degradation due to human activities, pollution, or technological developments. Under Article 3.2, member countries must report such changes and may seek technical support. Given the threats to Kabartal Wetland—habitat loss, pollution, and hydrological disruption—its inclusion in the Montreux Record would ensure global attention and facilitate a Ramsar Advisory Mission

(RAM). This expert-led initiative would help assess risks, guide restoration, and strengthen governance through international support and funding, safeguarding Kabartal's ecological health.

7.2. Component 2: Balancing Ecology & Equity: A Win-Win Land Swap for Wetland Protection



Extent & Coverage of Notified Areas		
Ownership	**1989 (Notified Sanctury)**	**Proposed Sanctury**
Government	31.42 km²	26.2 km²
Private	30.35 km²	0 km²

Figure 4: Map Depicting Existing and Proposed Notified Areas (Source: Bharadwaj et al., 2025)

The Kabartal wetland complex spans a notified area of 63.11 km², comprising 30.35 km² of private land, 25.09 km² of government land, and 6.33 km² of settled land as per 2012 records. When including settled land, the total government-owned land amounts to 31.42 km², leaving 1.34 km² unaccounted for. To facilitate effective wetland conservation and equitable land distribution, a structured approach is proposed, focusing on establishing clear land ownership, implementing a land swap for wetland protection, and streamlining protected area boundaries.

7.2.1. Establishing Land Ownership through Svamitva Scheme

Since clear land ownership records are unavailable, the Svamitva Scheme will be utilized to identify and map both private and government land parcels. This initiative will ensure transparency in land ownership, enabling a structured land reallocation process. Villagers will

receive property cards, which will formalize their land ownership and facilitate an equitable exchange where necessary.

7.2.2. Land Swap for Wetland Protection

Once land ownership is clarified, efforts will be made to bring the 26.2 km² Ramsar-designated wetland fully under government ownership for conservation. To achieve this, a land swap mechanism will be implemented, wherein private landowners inside the Ramsar boundary will be relocated. In exchange, they will receive equivalent government land outside the wetland area, ensuring their property rights while prioritizing wetland conservation.

7.2.3. Streamlining Protected Area Boundaries

To improve land-use planning while maintaining wetland conservation, the remaining land of 36.91 km² outside the Ramsar boundary will be denotified from the bird sanctuary. This adjustment will create a more structured and manageable conservation framework. With 31.42 km² of government land available, this strategy provides a cost-effective and balanced solution, safeguarding both ecological conservation and equitable land distribution without notifying it as a Community Reserve.

7.3. Component 3: Restoring the Hydrological Regime

Restoring the hydrological regime will involve multiple interventions to ensure sustained wetland recharge and ecological balance. This includes enhancing river inflow to maintain a steady supply of water, regulating outflow to stabilize water levels, and reconnecting fragmented wetland areas to promote ecological continuity. Additionally, desilting of canals and wetland zones will be carried out to improve water flow and retention capacity, ensuring long-term hydrological sustainability.

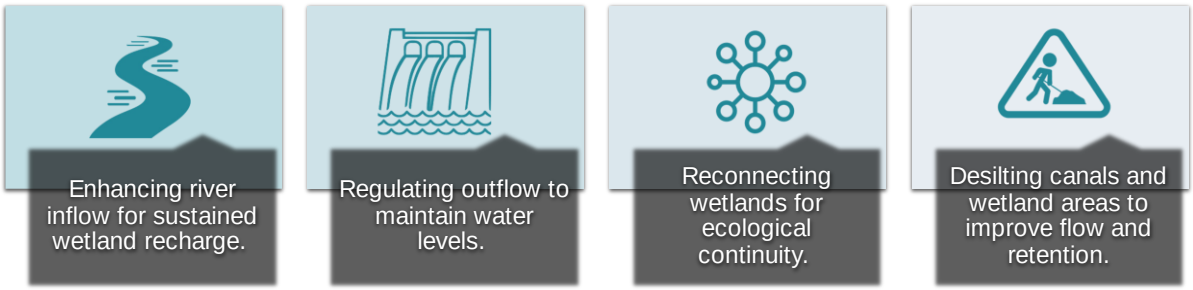


Figure 5: Key Intervention for Hydrological Regime Restoration (Source: Bharadwaj et al., 2025)

7.3.1. Restoration Blueprint: Natural Streams and Dredging Interventions

Figure 6: Restoration Blueprint: Natural Streams and Dredging Interventions (Source: Bharadwaj et al., 2025)

As part of efforts to restore the hydrological regime of the Kabartal wetland complex, extensive dredging and stream restoration interventions have been proposed. Two major wetlands - Nagri Jheel and Bikrampur Chaur, will undergo dredging up to a depth of 1.5 meters, covering areas of 308 hectares and 281 hectares respectively.

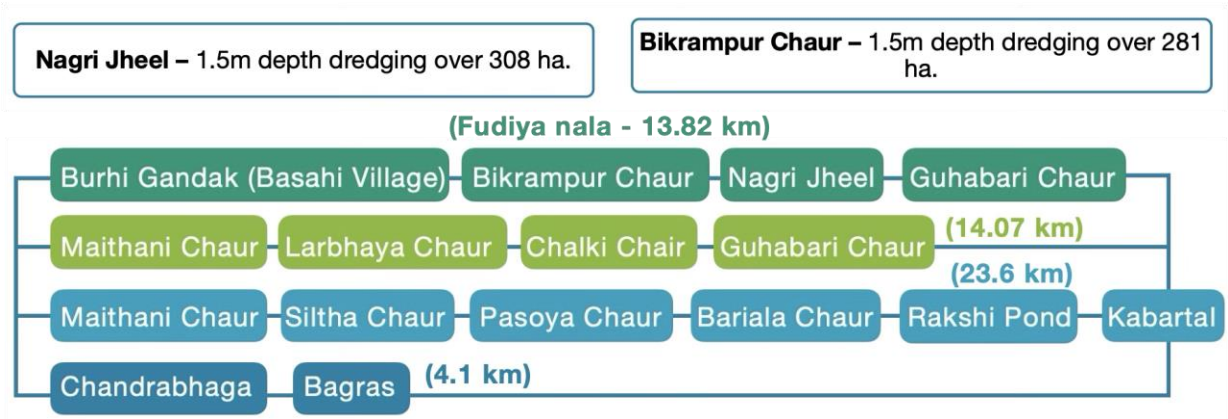


Figure 7: Dredging Interventions & Natural Stream Restoration Connecting 16 Wetlands (Source: Bharadwaj et al., 2025)

To enhance ecological continuity, a network of natural streams will be restored, including: Fudiya Nala to Burhi Gandak via Basahi Village to Nagri Jheel and Guhabari Chaur (7.56 km), Fudiya Nala to Bikrampur Chaur and back (6.26 km), Maithani Chaur to Guhabari Chaur (14.07 km), Maithani Chaur to Kabartal (23.6 km), and Chandrabhaga to Bagras (4.1 km). These canals will interlink 16 wetlands which includes Nagri Jheel, Bikrampur Chaur, Siltha Chaur, Larbhaya Chaur, Chalki Chaur, Maithani Chaur, Pasoya Chaur, Barial Chaur, Bairala Chaur, Guhabari Chaur, Rakshi Chaur, Chandra Bhaga Maun, Bagras Maun, and Kabartal thus restoring the natural flow pathways and reestablishing vital riverine connectivity across the wetland complex.

7.3.2. Interventions

a) **Gated Spillways** will be installed at key points (e.g., SH 55 Bridge, Harsainpul, Manjhaul) to regulate inflow/outflow and maintain an optimal water level (~37m AMSL), ensuring 60–70% inundation to support wetland habitats and reduce flood risks.
b) **Check Dams** in canals will slow water flow, reduce erosion, and enhance groundwater recharge, supporting both wetland hydration and agriculture.
c) **Reed Beds** along channels will trap sediments, filter pollutants, and enhance aquatic biodiversity, improving water quality.
d) **Water Canal** will restore wetland-river connectivity and provide irrigation support, balancing ecological restoration with community needs.

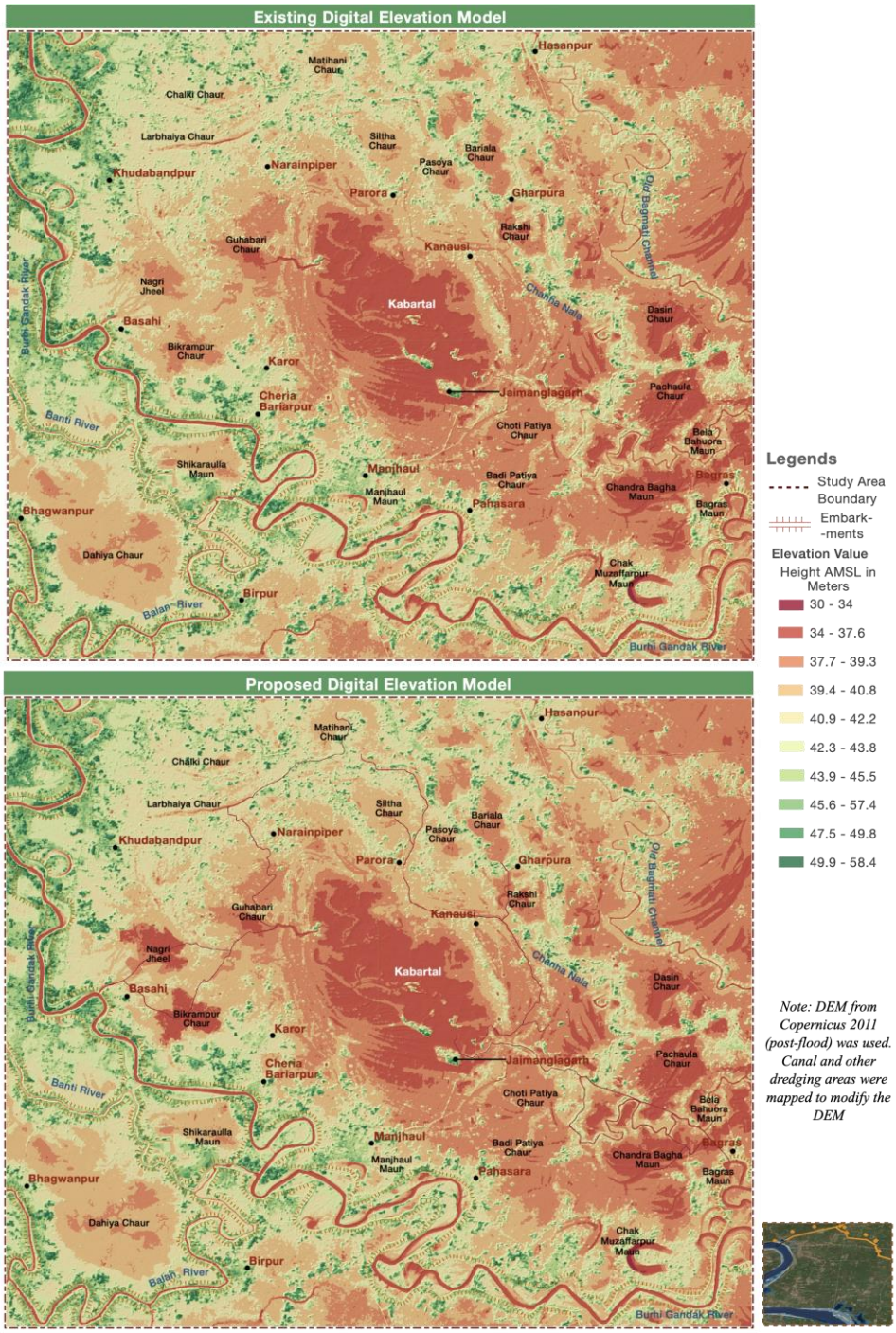


Figure 38: Existing and Proposed Digital Elevation Model (Source: Bharadwaj et al., 2025)

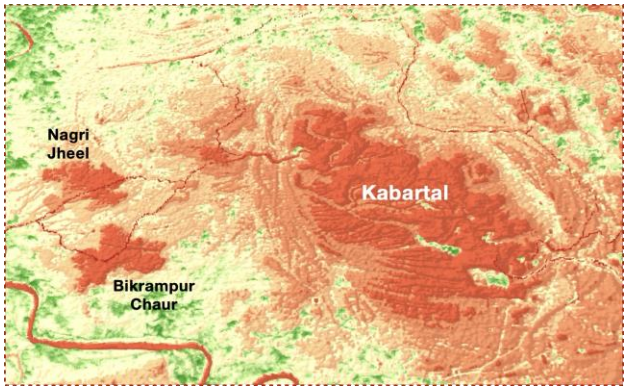
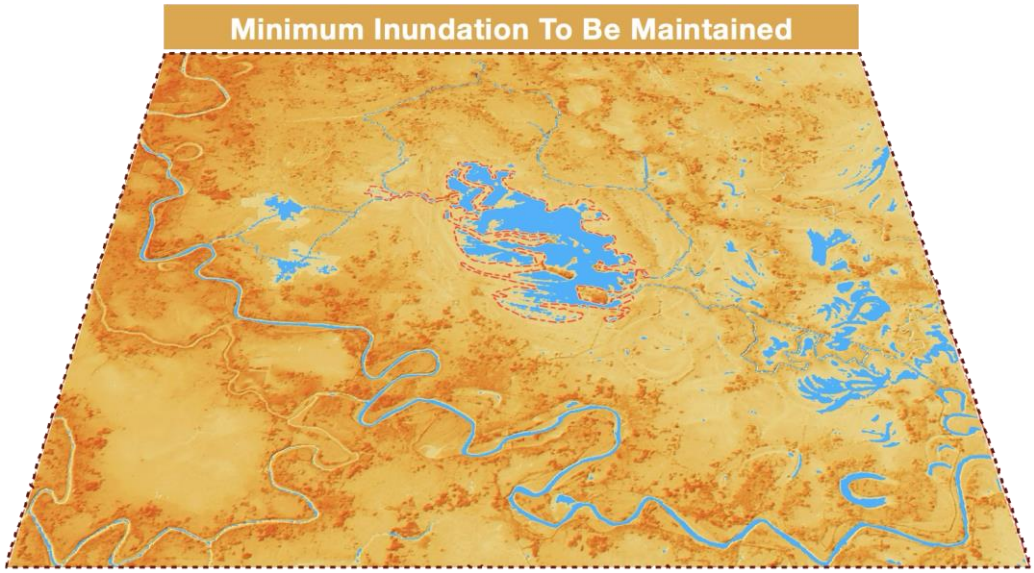
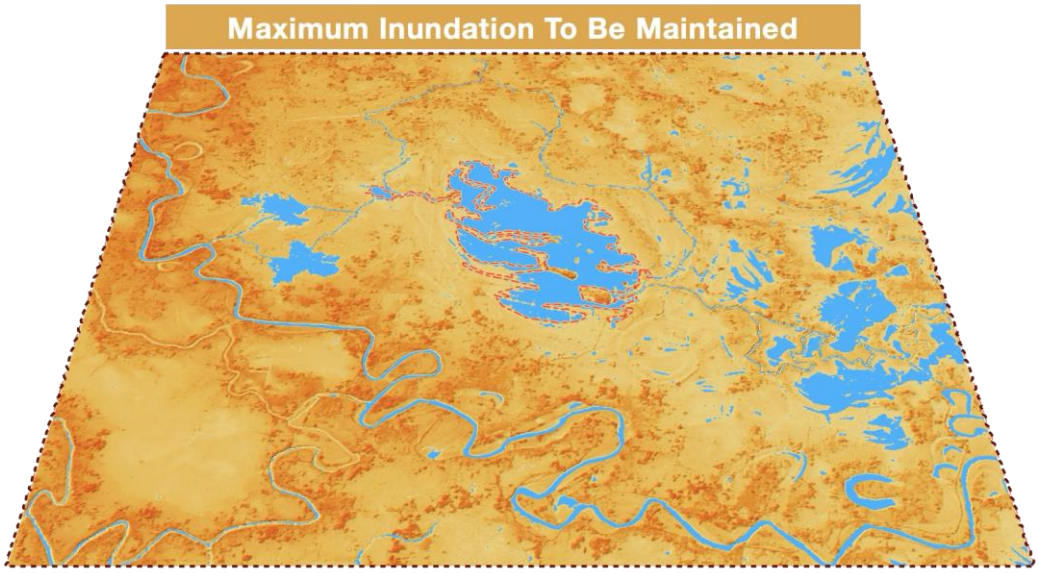


Figure 9: 3D View of the Areas Proposed to be Dredged (Source: Bharadwaj et al., 2025)



Minimum Water Level **(37m AMSL): Ensuring 60% Wetland Inundation** Year-Round (1980s Benchmark)



Maximum Water level **(37.6 m AMSL): Ensuring Full Ramsar Site** Inundation During Monsoon.

Figure 10:3D Modelling of Minimum and Maximum Water Level to be Maintained (Source: Bharadwaj et al., 2025)

The hydrological balance of the Kabartal wetland is to be restored and maintained by ensuring a **minimum water level of 37 meters AMSL**, allowing **60% inundation year-round**, in alignment with the **1980s benchmark**. During the monsoon season, the water level is to be regulated at a maximum of **37.6 meters AMSL**, ensuring **full inundation of the Ramsar site** to support its ecological functions. To achieve precise hydrological assessments, **high-resolution DEM from LiDAR sensing** is to be utilized for verifying elevation levels and optimizing water management strategies for sustainable wetland conservation.

7.3.3. Direct Benefits from Hydrological Restoration

Restoring Kabartal's hydrological regime offers multiple benefits: it reestablishes riverine connectivity, enhances aquatic ecosystems, and supports native biodiversity. Regulated water levels maintain seasonal inundation, essential for wetland health. Improved water availability boosts agriculture and fisheries, aids groundwater recharge, and revives bird habitats—promoting both conservation and eco-tourism opportunities.

7.3.4. Implementation & Monitoring Framework

Water Resources Department (WRD), Bihar will oversee implementation, monitoring, and periodic assessment of the restoration, including surveys to identify dredging areas. Pani Panchayats (community groups) will be formed for local water management, maintenance, and sustainable resource use. Funding will be sourced from NAFCC, MNREGA, and PMKSY to support long-term restoration. Local Employment through MNREGA will provide wage-based jobs for canal construction, dredging, and wetland upkeep.

7.4. Component 4: Management Zoning

The management zoning strategy, aligned with the Wetlands (Conservation and Management) Rules, 2017, aims to ensure protection and sustainable use of the ecosystem. The Core Area (26.2 km^2) will be strictly protected to preserve biodiversity, while the Zone of Influence (292.9 km^2), covering the catchment, will be monitored to prevent ecological harm. Strict regulatory compliance will be enforced, with violations penalized under the Environment (Protection) Act, 1986, and Wildlife Protection Act, 1972.

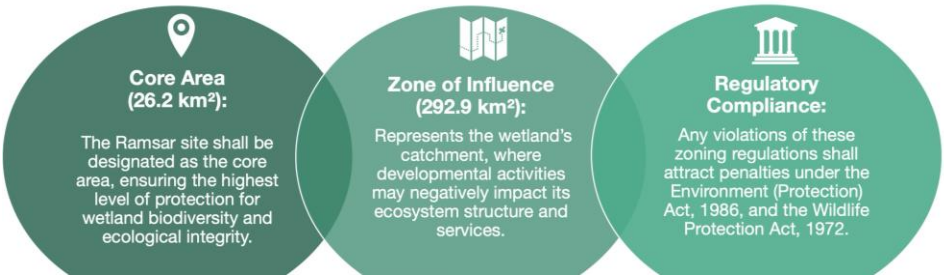


Figure 11: Wetland Zoning and regulation

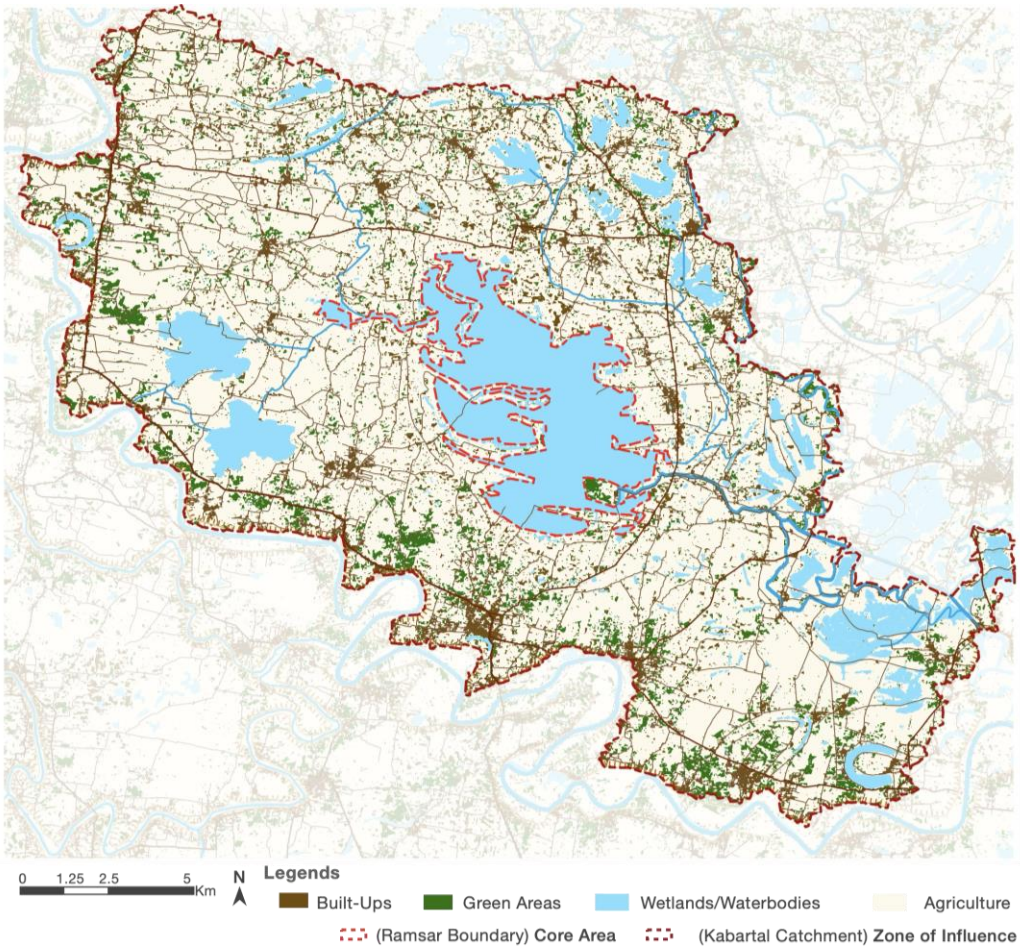


Figure 12: Proposed Management Zoning Map (Source: Bharadwaj et al., 2025)

7.4.1. Core Area Regulations

i. **Legal Protection -** All regulations under the Wildlife Protection Act, 1972 shall be strictly enforced, as the area is designated as a sanctuary.

ii. **Sustainable Agriculture -** Seasonal collective farming shall be permitted on 40% of the core area that remains dry, utilizing fish-rice farming techniques and other eco-friendly and economically viable practices. Leasing shall be managed by the Divisional Forest Officer (DFO) to ensure responsible land use.

iii. **Regulation on Biomass Harvesting -** Biomass harvesting in the shall be limited to non-invasive species and shall adhere to guidelines set by local authorities, ensuring no disruption to hydrology, biodiversity, or habitat integrity.

7.4.2. Zone of Influence Regulations

i. **Regulation on Sinking Borewells -** Sinking of borewells in the wetland zone of influence shall be restricted to a sustainable depth, ensuring groundwater conservation and preventing ecological disruption

ii. **Regulation on Biomass Harvesting -** Biomass harvesting in the shall be limited to non-invasive species and shall adhere to guidelines set by local authorities, ensuring no disruption to hydrology, biodiversity, or habitat integrity.

iii. **Fishing Regulations -** There shall be a prohibition on fishing in rivers from 15th June to 15th August to protect fish spawning. The use of nets with a mesh size smaller than 4 cm and the construction of obstructions restricting fish movement in canals and wetlands shall be prohibited to sustain fish populations and maintain hydrological flows. These regulations shall be enforced in accordance with the Bihar Fish Jalkar Management Act, 2006, ensuring ecological balance and sustainable fisheries.

   a. Fishing in intermittently inundated areas shall be allowed solely for the fishing community based on a social contract, as per the 1895 verdict.

iv. **Land Use and Construction Restrictions -** Permanent agriculture and land use alteration shall be prohibited in intermittently inundated areas, including Chaur regions, where water accumulates during peak inundation, to protect the wetland ecosystem.

v. **Strict Prohibition on Topographical Disruptions -** Any alteration of natural topography, including soil filling, cutting, or land modification, is strictly prohibited to safeguard wetland integrity and prevent ecological degradation.

   All road infrastructure within the wetland zone of influence shall be designed to ensure uninterrupted natural water flow by incorporating elevated structures (stilts/pillars) instead of embankments where feasible. Roads are to be equipped with adequate culverts, bridges, or sluice gates to maintain hydrological connectivity. A comprehensive drainage plan shall be mandatory before construction approval to prevent waterlogging, habitat fragmentation, and disruption of wetland ecology.

Desilting shall be allowed only where siltation affects wetland inflow regimes and water-holding capacity, while deepening activities shall be strictly prohibited to preserve the natural wetland structure.

vi. **Agricultural Restrictions -** Groundwater extraction shall be strictly prohibited within a 1 km buffer zone from canals to maintain hydrological balance. Stubble burning and the use of chemical fertilizers shall be restricted to prevent soil and water contamination. Sustainable native cropping systems suited to regional agro-climatic conditions shall be encouraged, with Krishi Vigyan Kendra facilitating the transition through capacity-building and support programs.

vii. **Wildlife Protection -** Poaching shall be strictly banned to safeguard wetland biodiversity and protect native species.

viii. **Waste Management -** Dumping of solid waste and discharge of wastewater into wetlands and canals shall be strictly prohibited to prevent pollution and preserve water quality.

7.5. Component 5: Collaboration & Livelihood

7.5.1. Establishing the Taal Se Taal Mila Samiti

Taal The Taal Se Taal Mila Samiti will be a sub-committee established under the District Wetland Committee (DWC) to manage specific tasks at the Site level.

The Taal Se Taal Mila Samiti will operate as a multi-stakeholder committee, involving local communities, NGOs, government agencies, and private sector representatives in collaborative wetland management.

This committee will help formation of Wetland Mitra Network and collaborate with them to implement conservation initiatives and ensure equitable decision-making.

Major functions of the committee include the followings:

i. **Conflict Resolution & Data-Driven Decision-Making**
    a. Develop a structured mediation mechanism within the Samiti to resolve land-use conflicts and disputes over wetland resource distribution.
    b. Implement transparent leasing systems for fisheries and sustainable agriculture.

c. Promote data-driven decision-making, integrating scientific assessments, remote sensing, and community inputs for wetland planning.
d. Advocate for policy reforms and regulatory frameworks to protect wetland-dependent communities.

ii. Strengthening Community Participation

a. Empower Wetland Mitras as key community representatives within the Taal Se Taal Mila Samiti for on-ground wetland monitoring.
b. Establish the Bal Mitras (Youth Wetland Friends) Program to engage local schools in conservation activities.
c. Collaborate with Krishi Vigyan Kendra to introduce climate-smart and wetland-compatible agricultural practices.

iii. Wetland Health Monitoring & Biodiversity Conservation

a. Conduct Asian Waterbird Census through community-led monitoring programs.
b. Integrate People's Biodiversity Registers (PBRs) to document flora, fauna, and traditional wetland knowledge.
c. Develop a Community-Based Wetland Health Index to regularly assess ecosystem conditions.

The Taal Se Taal Mila Samiti, in collaboration with Wetland Mitras, will serve as a community-driven, scientifically guided, and policy-backed platform to restore, conserve, and sustainably manage wetlands, ensuring ecological resilience and economic prosperity.

7.5.1.1. Structure of Functional Cells Under Taal Se Taal Mila Samiti

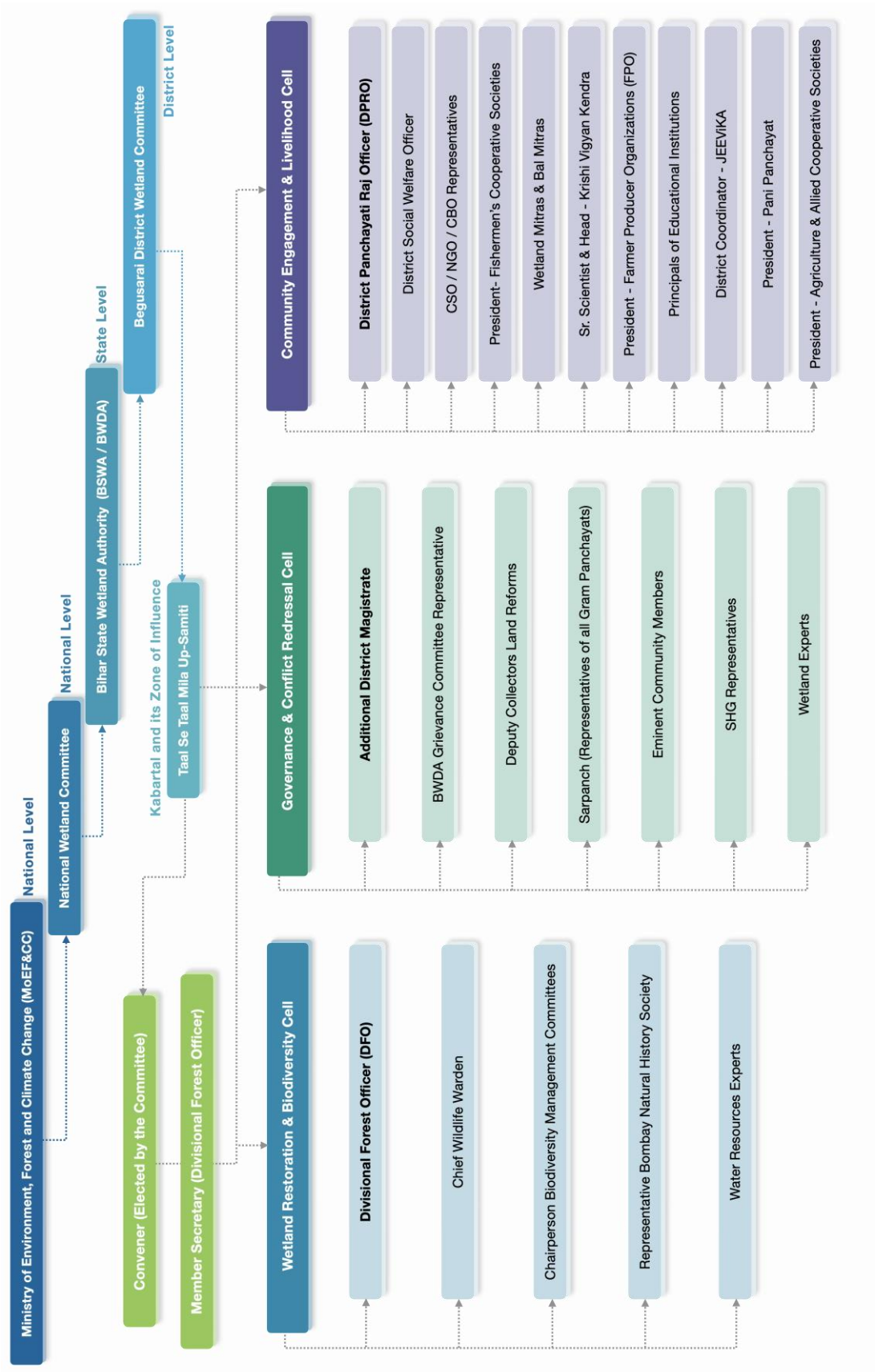


Figure 13: Structure of Functional Cells Under Taal Se Taal Mila Samiti (Source: Bharadwaj et al., 2025)

7.5.2. Empowering Fisher Cooperatives through PMMSY

A proper survey of wetlands should be conducted to ensure accurate mapping and classification, which will facilitate structured leasing by fisher cooperatives in accordance with the Jalkar Management Act.

Additionally, through the support of the *Pradhan Mantri Matsya Sampada* Yojana (PMMSY), activities such as the stocking of fingerlings can be promoted to enhance fish production and improve the livelihoods of local fisher communities.

7.5.3. Integrated Fish Farming

Integrated fish farming should be promoted to improve income generation through polyculture systems, community-run hatcheries, and sustainable aquaculture practices. Enhancing market access and training fisher communities will ensure economic stability while maintaining ecological balance.

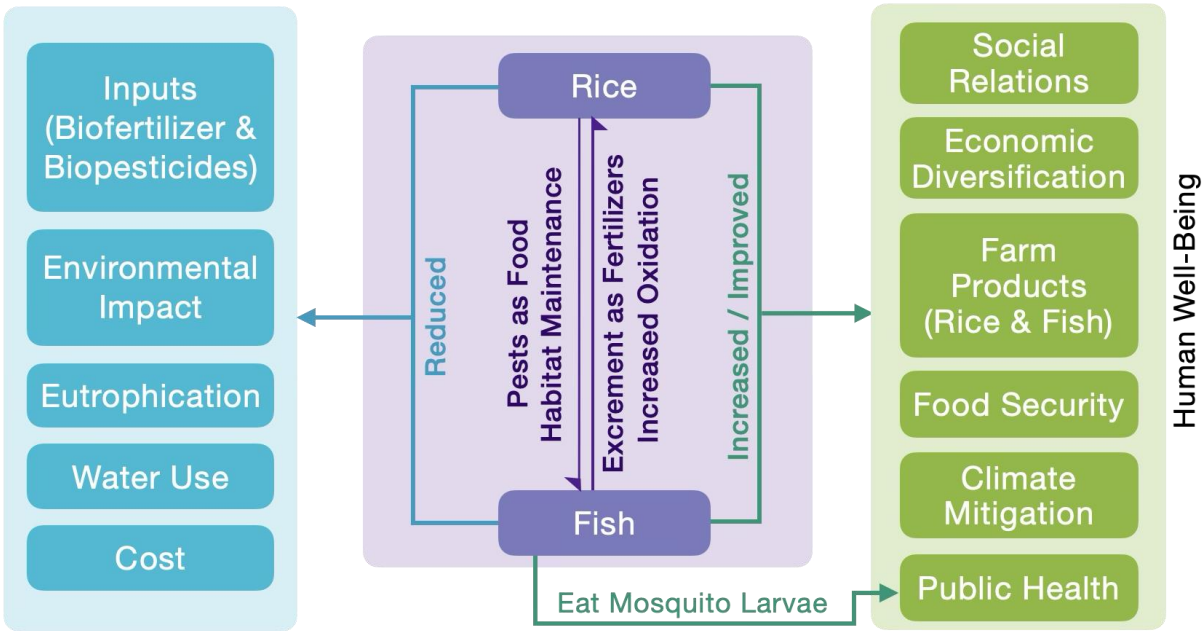


Figure 14: A flow Diagram showing Integrated fish farming's Benefits (Source: Bharadwaj et al., 2025)

7.5.4. (Fox-Nut) Makhana-cum-fish farming system

Perennially inundated areas should be sustainably utilized for makhana-cum-fish farming, ensuring continuous production and natural fish flow while supporting livelihoods through structured leasing and will receive additional backing from the proposed Makhana Board in Bihar, as announced in the Union Budget 2025–26.

7.5.5. System of Rice Intensification (SRI)

The System of Rice Intensification (SRI) utilizes alternate wetting and drying (AWD) instead of continuous flooding, making it highly suitable for water-scarce regions. SRI enhances yields by 20-50% or more while significantly reducing inputs—seed by 90%, water by 30-50%, fertilizers by 20-100%, and often lowering pesticide use (Cornell University, 2015).

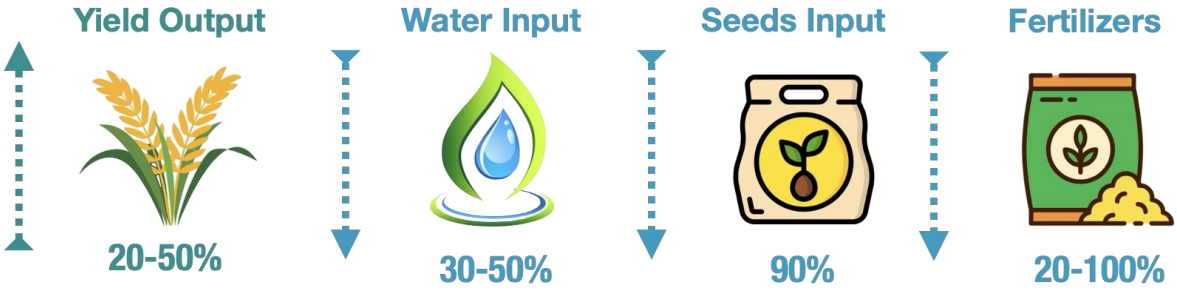


Figure 15: Benefits of System of Rice Intensification (Source : Cornell University, 2015)

7.5.6. Projected Economic Benefits from Taal Se Taal Mila Strategy

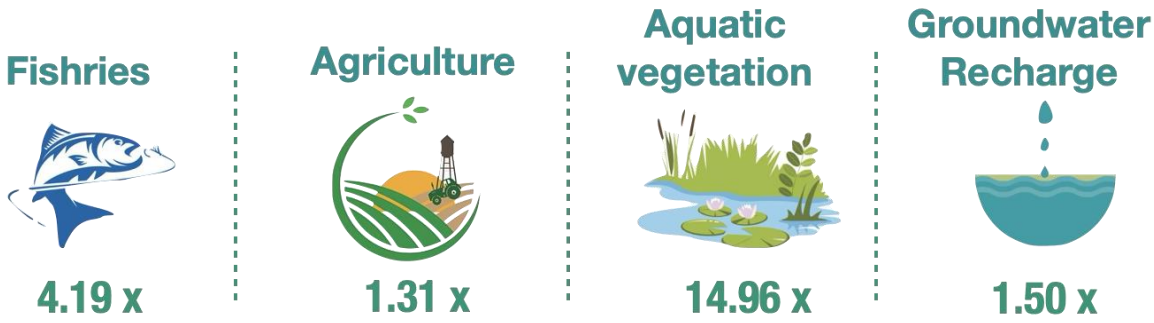


Figure 16: Approx. Economic Boost from Wetland Restoration (Source: Kumar et al., 2016)

The Taal Se Taal Mila initiative aims to restore Kabartal's 1980s hydrological regime, promoting both ecological and economic sustainability. Aligned with the TEEB-India Initiative, this restoration is expected to increase the economic outcome of fisheries by **4.19 times**, wetland agriculture by **1.31 times**, aquatic vegetation by **14.96 times**, and groundwater recharge by **1.50 times**. By reviving natural water flows, the initiative reinforces wetlands as vital ecological and socio-economic assets.

7.6. Component 6: Nature Tourism

7.6.1. Heritage Village Designation

In accordance with Component 2: Nature Tourism of the Amrit Dharohar Scheme, the villages of Jaimangal Garh, Cheria Bariarpur, and Sakra (Gharpura) in Begusarai district, Bihar, are to

be designated as Heritage Villages. This initiative aims to highlight and promote the unique conservation values of the Kabartal Ramsar Site, fostering community-based ecotourism while preserving the ecological and cultural heritage of the region

1) **Jaimangal Garh -** Jaimangal Garh is home to the Jaimangla Garh Temple, an ancient Hindu temple dedicated to Goddess Chandi Mangla Devi, situated on an island within Kabartal. The temple has high archaeological and cultural significance, with excavations dating back to the prehistoric and Mughal periods. It is also believed to have been a site for Buddhist scholars during the time of Gautam Buddha. The island, often called "Monkey Island", is known for its large population of monkeys and remains a center for year-round festivities and cultural celebrations.

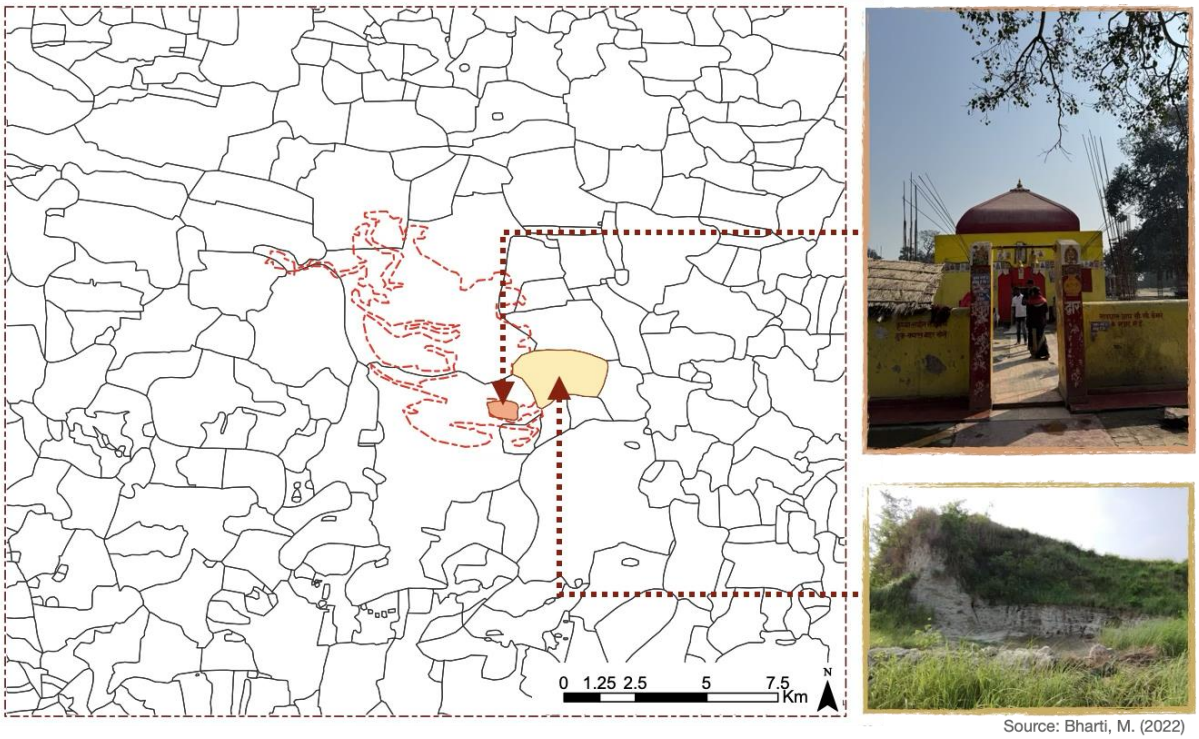


Figure 17: Location Map of Two Heritage Villages (Source: Bharadwaj et al., 2025)

2) **Sakra Village -** Sakra is home to four stupas, with the largest at the center and three equidistant smaller stupas to the west, north, and south. These stupas, entirely made of clay with a hardened outer layer of brick dust (surkhi), belong to the Bajralepit architectural style. The Mahavansh texts mention such stupas, making this an important archaeological site. The discovery of these stupas is significant in the historical context of Buddha's visit to Anguttarap, as referenced in the Majjhima Nikaya.

7.6.2. Signature Souvenir

The Narkat (reed) art piece, such as a pencil, flute, will be designated as the signature souvenir of the Ramsar Site. This will highlight the region's biodiversity, ecological significance, and traditional craftsmanship. The design and specifications will be carefully identified to showcase local artistry while promoting sustainable practices.

7.6.3. Taal Se Taal Mila Kendra

The Kabartal Wetland Interpretation Centre is proposed at Jaimangal Garh as a hub for visitors to explore the rich biodiversity, cultural heritage, and ecological significance of the Kabartal Wetland Complex. The centre will feature a resting area, boating facilities, a birdwatching tower, an exhibition on local history and culture, an artisan market showcasing Narkat crafts and regional products, nature trails, interactive learning spaces, guided tours, and a sustainable café serving local delicacies. Additionally, a dedicated meeting hall will be established for all stakeholders to facilitate activities, discussions, and management efforts, ensuring community ownership and participation in the conservation and sustainable development of the wetland.

8. Conclusion

The degradation of Kabartal Wetland reflects the broader challenges faced by wetlands globally—undervaluation, fragmented management, and increasing anthropogenic pressures. Through the *Taal Se Taal Mila* approach, this research emphasizes the need to restore the wetland's natural hydrological regime while integrating the socio-economic realities of dependent communities. Sustainable conservation can only be achieved by aligning ecological restoration with livelihood enhancement, basin-level planning, and inclusive governance. Reviving Kabartal is not just an environmental imperative but also a socio-economic necessity, ensuring that this vital ecosystem continues to support biodiversity, mitigate climate risks, and sustain thousands of lives for generations to come.

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