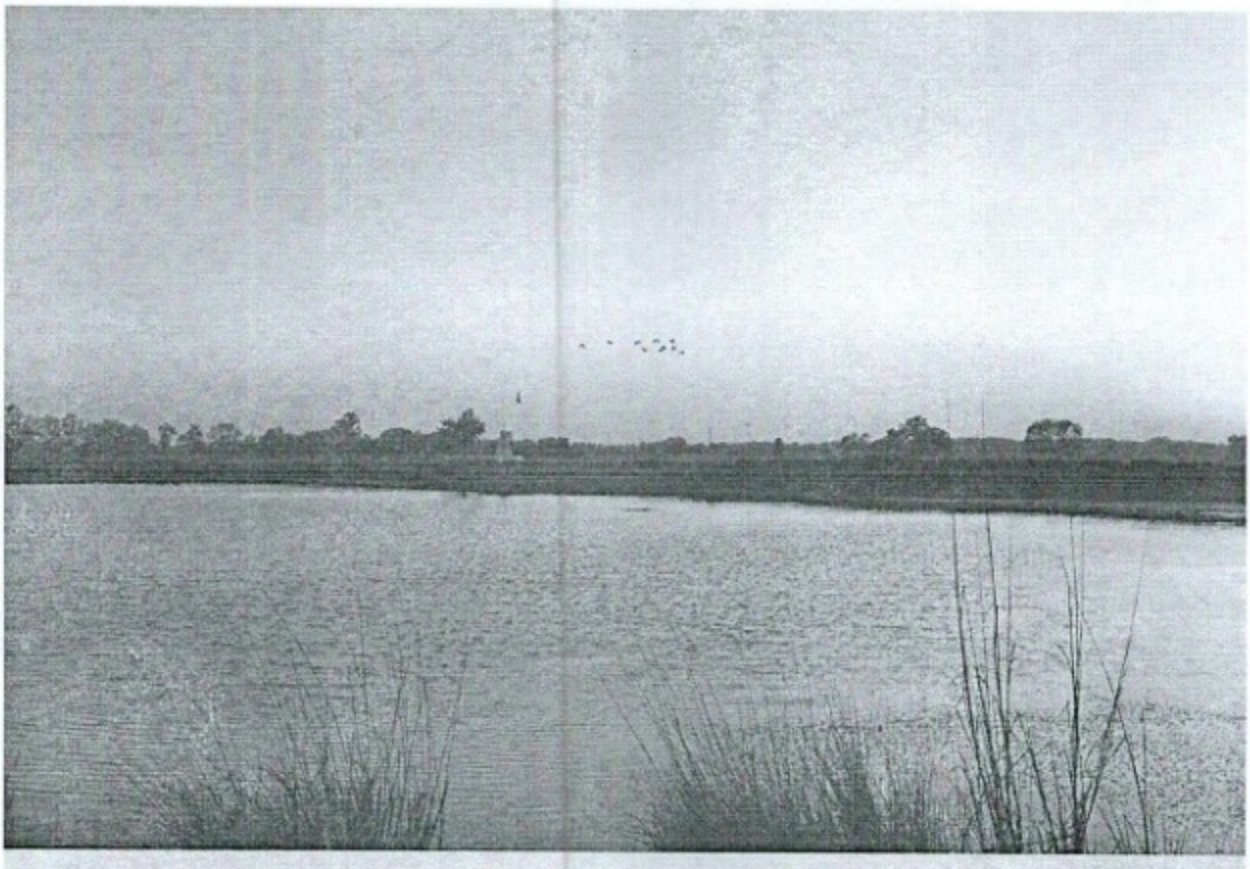


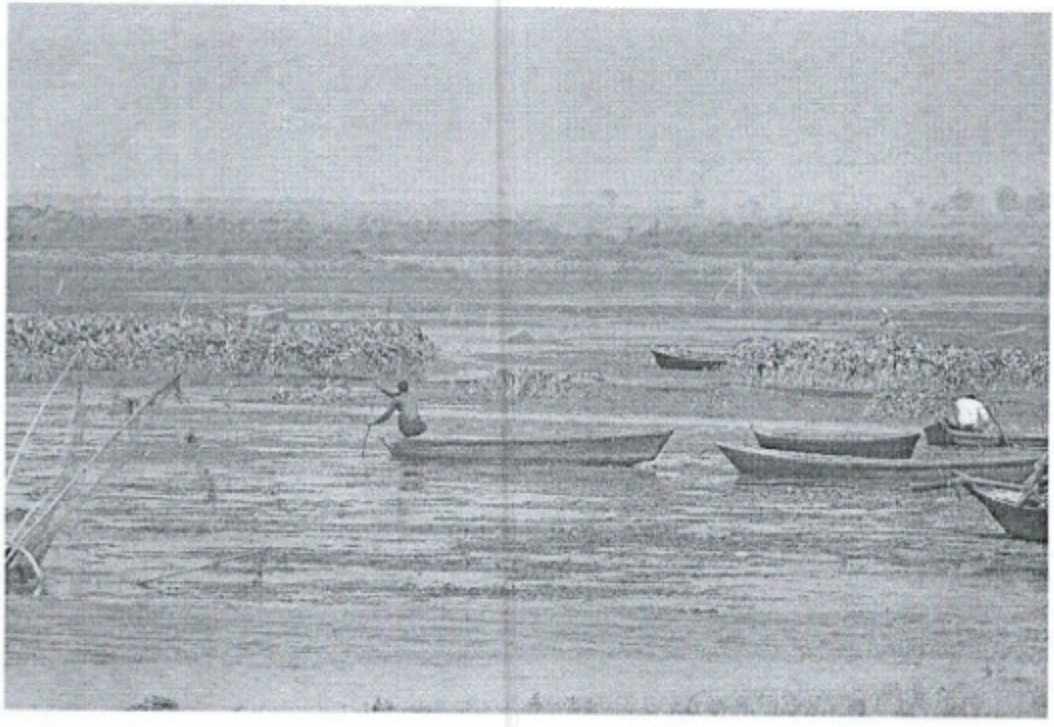
Conserving and Sustainably Managing Gangetic Floodplain Wetlands of Bihar

Interim Technical Progress Report
2024

Department of Forest, Environment and Climate Change

NAMAMI GANGE

Conserving and Sustainably Managing Gangetic Floodplain Wetlands of Bihar



Department of Forest, Environment and Climate Change

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Acronyms

BNHS	Bombay Natural History Society
BSDMA	Bihar State Disaster Management Authority
BSI	Botanical Survey of India
BSWA	Bihar State Wetland Authority
BWDA	Bihar Wetland Development Authority
CIFRI	Central Inland Fisheries Research Institute
DDMA	District Disaster Management Authority
DFECC	Department of Forest, Environment and Climate Change
DWC	District Wetland Committees
ESI	Ecosystem Services Index
FS	Functional Score
HGM	Hydrogeomorphic classification system
IUCN	International Union for Conservation of Nature
RAWES	Rapid Assessment of Wetlands Ecosystem Services
RGB	River Ganga Basin
MEA	Millennium Ecosystem Assessment
METT	Management Effectiveness Tracking Tool
MoEFCC	Ministry of Environment, Forest and Climate Change
MoWR	Ministry of Water Resources
NDMA	National Disaster Management Authority
NGOs	Non-Government Organizations
NMCG	National Mission for Clean Ganga
NPCA	National Plan for Conservation of Aquatic Ecosystems
NWIA	National Wetland Inventory and Assessment
PA network	Protected Area network
PRI	Panchayati Raj institutions
SAC	Space Application Centre
SEEDS	Sustainable Environment and Ecological Development Society
WIAMS	Wetland Inventory, Assessment and Monitoring System
WISA	Wetland International South Asia
ZSI	Zoological Survey of India

1. Project Background and Rationale

River Ganga flows in the west–easterly direction criss-crossing 12 districts of Bihar and covering a distance of around 445km, from her entry point in Buxar District and exit at Katihar District. The complex fluvial geomorphology of River Ganga and her tributaries have over a period of time created a diverse wetland regime, which play a critical role in the ecological and economic security of the region. Known variously as *mauns, chaurs and taals*, these wetlands are a characteristic feature of the interfluvial regimes of Gangetic plains which are completely inundated during monsoon, shallow with a maximum depth of 1.5 m, and mostly dry by March - June. The floodplains flanking the main channel provide an ecological and hydrological continuum rendering vital ecosystem services and biodiversity habitats. Effective management of these wetlands is crucial for achieving river integrity, and food and water security for the dependent communities.

The 'Vision Ganga' of the National Mission on Clean Ganga is structured along four dimensions of river system, namely: a) Aviral Dhara (uninterrupted flow), b) Nirmal Dhara (unpolluted flow), c) Geological entity, and d) Ecological entity.

Within any basin, including the River Ganga Basin (RGB), management of hydrological regimes and linked ecosystem processes, services, and biodiversity values needs to be based on complementarity and interactions between lentic ecosystems (i.e., the wetlands) and lotic systems (i.e., the river). Floodplains, especially the active part, harbour significant riverine wetlands, which are unique, highly productive, and perform a wide range of functions such as flood control, water purification, carbon storage, groundwater recharge, and water storage. In terms of biodiversity, these wetlands provide refuges for fauna in times of flooding, are food reservoirs and breeding sites, and participate in the dispersion of plant and animal species. Owing to the variability of the geomorphological, physicochemical, and hydrogeological contexts in which they are created, riverine wetlands offer a unique diversity of ecological situations that has no equivalent in other wetlands on similar scales.

Conservation and wise use of wetlands based on the, recognition of their role and full range of, ecosystem services and biodiversity values are essential aspects of river basin planning and management. Degradation and loss of wetlands, and rapid changes in the river basins of which these wetlands are integral elements, lead to the disruption of natural hydrological cycles, often leading to enhanced frequency and severity of flooding, drought and pollution, and imposing significant economic and social losses and costs to the societies. Proper consideration of the role and importance of wetlands in river basin management can significantly assist in securing safe, reliable sources of water and meeting development objectives identified within the Ganga Vision.

The Environment, Climate Change & Wetlands Wing of the Department of Environment, Forest & Climate Change, Government of Bihar has been constituted as the nodal policy-making, regulation, and management organization for wetlands conservation at the state level. The NMCG, with an objective of supporting conservation and sustainable management of Gangetic wetlands of Bihar, has supported a technical assistance project to the Environment, Climate Change & Wetlands Wing of the Department of Environment, Forest & Climate Change, Bihar. The project has an overall objective of 'effective management of floodplain wetlands in River Ganga Districts' to ensure sustained provision of wide-ranging ecosystem services naturally provided by these ecosystems and securing diverse habitats. The specific objectives are to:

- Define and characterize floodplain wetlands regimes within the Ganga Districts.
- Put in place institutional arrangements for managing floodplain wetlands by notifying under Wetlands (Conservation and Management) Rules, 2017.
- Develop stakeholder-led integrated management plans for securing ecosystem services and biodiversity values.
- Design and implement a monitoring regime to enable periodic assessment of wetland ecosystem health and effectiveness of management.

- Creating and developing the available infrastructure, capacity building and generation of awareness of the stakeholders.

Wetlands International South Asia is the technical partner to The Environment, Climate Change & wetlands Wing of the Department of Environment, Forest & Climate Change, Government of Bihar for implementation of this project. This report summarises the key results of project implementation, and recommendations for conservation and wise use of Gangetic floodplains of the state.

Training workshop for wetlands managers on Rapid Assessment of Wetlands conducted by Wetlands International South Asia, Patna, Bihar

2. Approach and Method

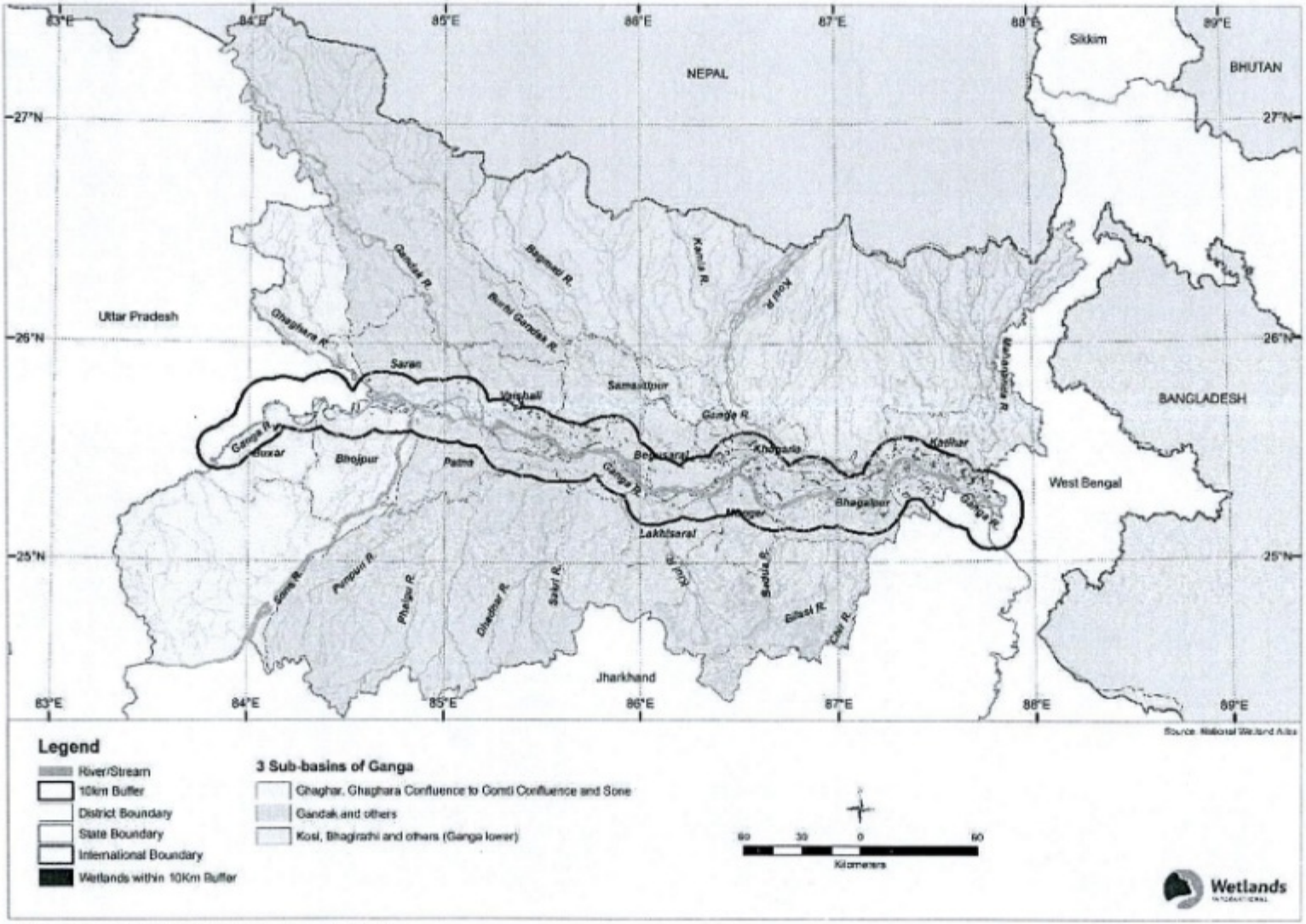
The Gangetic floodplain wetlands in Bihar fall within three sub-basins of the River Ganga: a) Ghaghar, Ghaghara Confluence to Gomti Confluence and Sone, b) Gandak and others and c) Kosi, Bhagirathi and others (Ganga Lower) (Map 1). Much of the region along the 10-kilometer buffer of the Ganga River channel is constituted by river floodplains. The uniqueness of floodplain ecosystems lies within their near-linear form, the high dynamism of their geomorphology, and the ability to process large fluxes of energy and material from upstream areas. Several conceptual models and frameworks have emphasized upstream-downstream linkages along the river corridor, the influence of river basin form and climate on downstream areas, their horizontal linkage across the floodplain between the river channel and the floodplain, the vertical interconnection within the floodplain between overbank flooding, groundwater, and rainfall. Amongst several factors, hydrological inputs to floodplains play a significant role through a) their influence on the arrangement of landforms and vegetation communities, and b) the impact of flooding regimes on the regeneration and turnover time of floodplain vegetation.

Wetlands under the Gangetic floodplains evolve and function within physical templates, characteristics of which are determined primarily by the interaction between water and sediments. The ecological components, processes, and services are influenced by land and water management practices within the immediate as well as indirect catchments of the wetland complex.

River floodplains are specific areas typical of grid dynamics of natural, especially fluvial processes co-existing within anthropogenic influences and intensive use. Floodplains apparently exist in two alternating phases. For most of the time, these ecosystems exist in a dry phase during which, at least superficially, is not substantively different from surrounding terrestrial ecosystems. However, during monsoons, these ecosystems are inundated wherein large, shallow floods driven by rainfall top up moisture in the soil, recharge the groundwater aquifers, and fill up depressions. This recharge provides the reservoir of water upon which the biota depends until the next flood event. These ecosystems have evolved to cope with these phase changes. Many aquatic plants have long-lived seeds that can withstand extended periods of drought. Similarly, many animals possess drought- resistant stages in the life-cycle or the physiological capacity for diapause or, like waterbirds, adopt highly mobile strategies in order to track scarce resources.

The gradients of flooding frequency, soil moisture, and vegetation create conducive environments for wetlands within these floodplains. Located at the interface of terrestrial and aquatic ecosystems, combining features of both, wetlands arise when inundation by water produces soils dominated by anaerobic processes, which in turn, forces the biota, particularly rooted plants to adapt to flooding. Ramsar Convention, an inter-governmental treaty defines wetlands broadly as 'areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tides does not exceed six metres.

The variable water regime in floodplains plays an important role in the structure and function of floodplain wetlands. Intermittent or seasonal floods transport organic matter and biota, triggering the life cycles of many aquatic and terrestrial organisms inhabiting wetlands. Wetting and drying are vital to the functioning of these ecosystems. During dry phases, eggs, and seeds of diapausing animals and plants remain in dry floodplain soils. Nutrients and energy to floodplain soils are also added by decomposing organic matter from leaf litter and stranded aquatic plants and animals. During floods, these organic reservoirs support emerging aquatic organisms and biota which colonise the newly inundated habitats. Heterotrophic organisms, in particular, assimilate these resources into the food webs, linking detritus to higher trophic levels. The temporal dynamics of water drive this complexity. Species like waterbirds and fishes depend on floodplain river connections to complete their life cycles.



Map 1: River Ganga and her three sub-basins in Bihar.

Conservation of floodplain wetlands needs to be based on maintaining the carbon and biotic balance through appropriate water regimes and land management practices. The concentration of carbon, organic matter, dissolved oxygen, density, and diversity of micro-invertebrates as well as recruitment in fish, plants, and water birds can serve as key indicators of floodplain wetland ecosystem health. Wise use of floodplain wetlands entails that the underpinning ecological and hydrological processes, particularly the flood pulse are maintained in line with natural regimes. From this perspective, the management of floodplain wetlands is closely interlinked with the management of river systems within their basin and linked developmental planning.

Conservation and sustainable development of floodplain wetlands of Ganga require integrated planning and resource management at the river basin level recognizing the interconnectedness of the wetland system with its catchments.

The methodology for management planning is based on the New Guidelines for Management Planning for Ramsar Sites and Other Wetlands as adopted by the Contracting Parties to the Ramsar Convention on Wetlands in 2002. These guidelines also form the basis of the wetlands management planning guidelines of the MoEFCC's National Plan for Conservation of Aquatic Ecosystems (NPCA). In 2022, the Ministry also notified the Sahbhagita Guidelines – wherein a participatory and inclusive framework for wetland management has been outlined clarifying roles and responsibilities at various levels of administration.

The NPCA guidelines recommend following a diagnostic approach – wherein the selection of management interventions is guided by knowledge of wetlands features and factors governing these features, and their relationship with broader societal conservation and development goals that wetland wise use is contributing to (Figure 1). Wetlands features are its ecological, social, and institutional attributes, which collectively characterize a wetland. Wetlands are dynamic systems, and thus their features undergo cyclical and temporal changes.

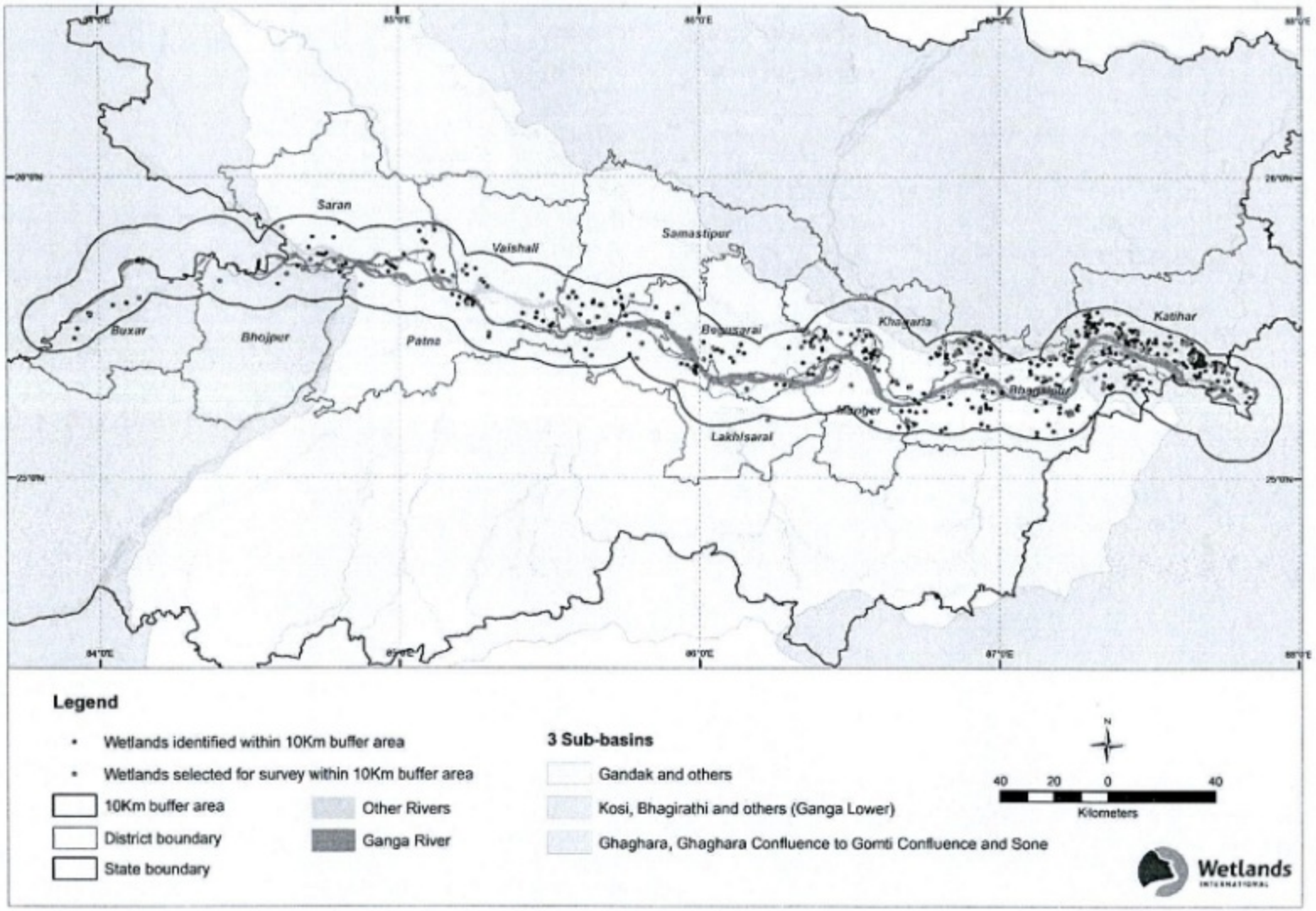
Figure 1: Framework for integrated management planning

Factors (natural as well as anthropogenic) cause the wetland to move along a specific trajectory. The aforementioned wetland management planning method was implemented in the following steps:

a) Mapping and inventory of wetlands within 10 km buffer along either side of the Ganga River channel: Inventory of 124 wetlands (of which 9 wetlands were in sub-basin 1, 66 in sub-basin 2 and 49 in sub-basin3) (Map 2)., identified on the basis of 2023 land use and land cover map of the 10-km buffer region was undertake with the help of a rapid assessment tool. For each wetland, the following information was generated:

Wetland settings: Official and vernacular names, geographical location, extent, wetland type, and features of the surrounding area.

Description of wetland features: Catchment, hydrology (topography, geology, geomorphology, soil, land use, and land cover, climate, major sources of water, number and status of inlets and outlets, water depth, connectivity, inundation regime, water flow direction, water permanence, and usage), Species and habitats (habitat types, availability of bird counts, invasive species status, macrophytes, fish, reptiles, birds, amphibians, and mammals), and Communities (permanent and temporary settlements present on the shoreline, population, and percentage of community dependence).



Map 2: Wetlands identified for ground truthing and data collection in the three sub-basins

Values and benefits: provisioning services (freshwater - drinking, washing & domestic use, agriculture and livestock; food – fish and edible aquatic plants; fuel; fibre and fodder; natural medicines; ornamental resources; clay, sand, and mineral harvesting), regulatory(air quality regulation, local climate regulation, water regulation, flood hazard regulation, water during droughts, pest regulation, disease regulation – human and livestock, erosion regulation, water purification, pollination, salinity regulation, fire regulation, and noise and visual buffering), supporting services (soil formation, primary production, nutrient cycling, water recycling, and provision of habitat), and cultural services(cultural heritage, recreation and tourism, aesthetic value, spiritual and religious value, inspiration value, social relations, educational and research, and transportation).

Threats: adverse changes faced in the ten years, major direct threats, and major indirect threats.

Management: Pattern of land ownership within the wetland, the pattern of land ownership in the area surrounding the wetland, and pre-existing rights and privileges in the wetland.

The inventory data of 124 wetlands have been prepared and are being uploaded onto an electronic database of the Environment, Climate Change & Wetlands Wing of the Department of Environment, Forest & Climate Change, Government of Bihar.

Preparation of wetlands health cards: For each wetland, the inventory information was used to develop an ecosystem health report card on the basis of nine indicators related to wetland extent, hydrology and catchments, biodiversity, ecosystem services, and governance.

Hydrogeomorphic classification and prioritization: Wetlands were prioritized on the basis of scores generated for threats, and a cumulative score of ecosystem service index and hydro-geomorphic function score.

A systematic classification of wetlands is a necessary step for their management and conservation. The hydrogeomorphic (HGM) classification of wetlands emphasizes the wetland hydrological processes and functions and their ecological significance within a generalized landscape context (Christine and Vic, 2018)[1]. The HGM classification renders the wetlands classes which have distinctive ecological character as they represent the hydrogeomorphic functions of wetlands. The classification system used in the project has been modified from those applied in Australia, South Africa and other countries and uses landform and water characteristics as the dominant features and wetland size and vegetation as descriptors.

Stakeholder Consultations: Significant data was generated based on preliminary consultations with relevant stakeholder groups, Government department(s), and/or agencies from varied relevant sectors for wetlands conservation and management planning. The varied sectors considered for consultation and their corresponding stakeholder groups included wetlands management (State Wetlands Authority, District Ganga Committees, Nodal departments entrusted for management of wetlands), Biodiversity conservation (State Biodiversity Board, Forest Department), Water resources (Water resources department, State Pollution Control Board), Agriculture (State Agriculture Department), Fisheries & Animal Husbandry (State Fisheries and Animal Husbandry Department), Climate Change (Science and Technology Council), Planning (Department of Planning), Disaster Management (State Disaster Management Authority, District administration), Culture & Tourism (Department of Culture & Tourism, Religious bodies present around wetlands, Tour Operators (public and private), Hoteliers and Hotel Associations), Research and Academia (College, Universities and research institutes conducting research & monitoring on wetlands), State governance (Elected political representatives, District Administration), Civil society (NGOs engaged in developmental and conservation activities around wetlands) and Resource users (Fishing communities and others which depend directly on wetlands) respectively.

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[1] Christine, Semeniuk and Semeniuk, Vic. 2018. Wetland Classification: Hydrogeomorphic System. In The Wetland Book: I: Structure and Function, Management, and Methods. pp.1483-148

3. Results

3.1 Component 1: Wetlands inventory and assessment

3.1.1.1 Wetlands extent and change

The study area was defined as the 10 km buffer area on either side of the river banks. Wetlands dynamics in the 10-km buffer was assessed using cloud-free post monsoon (October) Landsat images (30 m resolution) of 2008 and 2023. This spatial resolution is suitable for 1:50,000 scale mapping. Satellite images downloaded from USGS Earth Explorer were radiometrically and atmospherically corrected.

The 10 km buffer zone on either side of the Ganga River channel falls between 83.79 ° E and 87.86 ° E and 25.13° N to 25.87° N in 12 districts (Buxar, Bhojpur, Saran, Patna, Vaishali,Samastipur, Begusarai, Lakhisarai, Munger, Khagaria, Bhagalpur and Katihar) and spans ~1165164ha with ~138131ha of area falling in sub basin 1; ~837130ha in sub basin 2 and ~189902ha in sub basin 3 (Table 1 and Map 3, Map 4, Map 5, Map 6).

The Ganga River floodplain was delineated using the Global Surface Water data for 1984-2020 (Pekel et al., 2016[2]). The data provides occurrence, change, recurrence, transitions, seasonality for 32 years and maximum extent at 30m resolution. The maximum extent of inundation was used as the active floodplain boundary. This was digitized using visual interpretation, and rectified at a constant scale of 1:4000 to ensure accuracy in capturing the landscape details.

The active floodplain area in 2023 was assessed to span ~341682ha (16 % of the 10-km buffer area) after excluding areas fragmented by linear infrastructure and no longer part of active floodplains.

The wetland mapping method used in the project was adapted from National Wetland Atlas (SAC, 2017[3]) and Sinha et al., (2017)[4] and is presented in **Error! Reference source not found.**. Water-dominated areas (including wetlands, river channel, river bed, and aquatic vegetation) were extracted from the current LULC map (i.e., the Year 2023) in the GIS environment. Additional information pertaining to the wetland types mapped were derived from satellite imagery-based spectral indices including Normalized difference vegetation index (NDVI) (which indicates the extent of aquatic vegetation) and Normalized Difference Water Index (NDWI) (which depicts the open water extent within the wetland). Proximity to linear infrastructure was used to derive the current extent of active floodplains and to segregate human-made waterlogged areas.

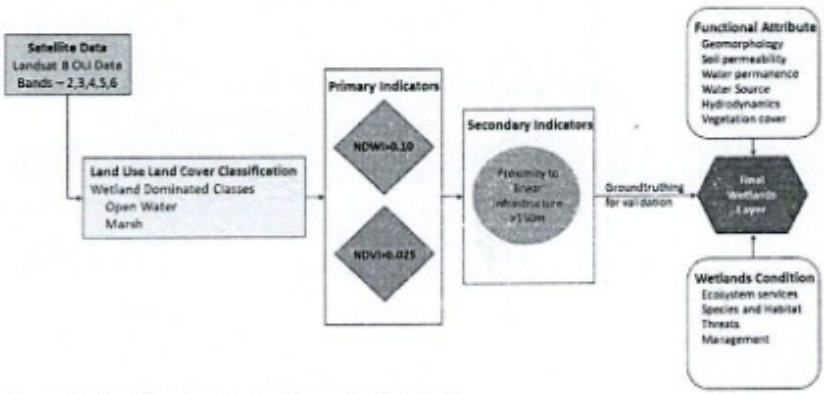


Figure 2: Classification approach used in the study

[2] Pekel, J.-F & Cottam, Andrew & Gorelick, Noel & Belward, Alan. (2016). High-resolution mapping of global surface water and its long-term changes. Nature. 540. 10.1038/nature20584

[3] SAC (2017) National Wetland Atlas

[4] Sinha, Rajiv, Shivika Saxena, and Manudeo Singh. "Protocols for Riverine Wetland Mapping and Classification Using Remote Sensing and GIS." Current Science 112, no. 7 (2017): 1544–52

In 2023, wetlands covered an area of 96323ha which formed 8.6 % of the 10 km buffer area. From 2008 - 2023, 4.1% or 4070ha of wetlands were transformed into different land use classes (Table 2).

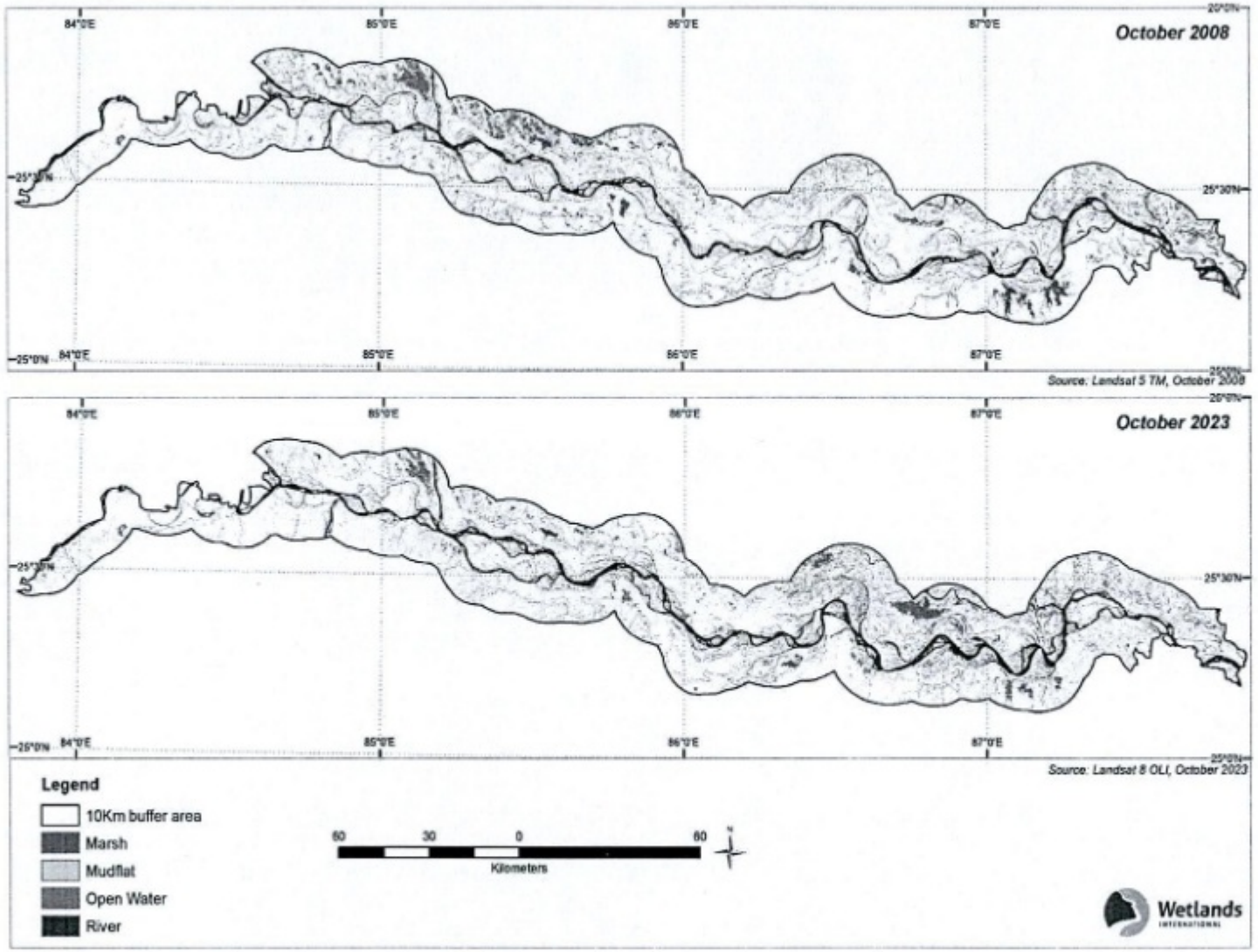
During 2008 – 2023 the wetland area in sub basin 1 was observed to have shrunk by 35% (a loss of 2837 ha). The conversion of wetlands in sub basin 1 may be related to the ephemerality of wetlands in response to changes in river hydrology and sedimentation processes. The wetlands have been subsequently transformed into agricultural areas. Sub-basin 2 exhibits an almost two and half fold increase in open water expanse. However, a concurrent decrease in marsh areas has been noted, leading to a slight 0.2% overall increase in wetland area. Given that open water areas typically dry up to form marshes, this expansion of open water is indicative of a wetter phase in the wetland's hydrograph, likely due to seasonal rainfall variations. Sub-basin 3 exhibits a 6.7% reduction in wetland area.

Table 1: Sub basin wise changes in land use and land cover from 2008 - 2023 in the Ganga basin in Bihar

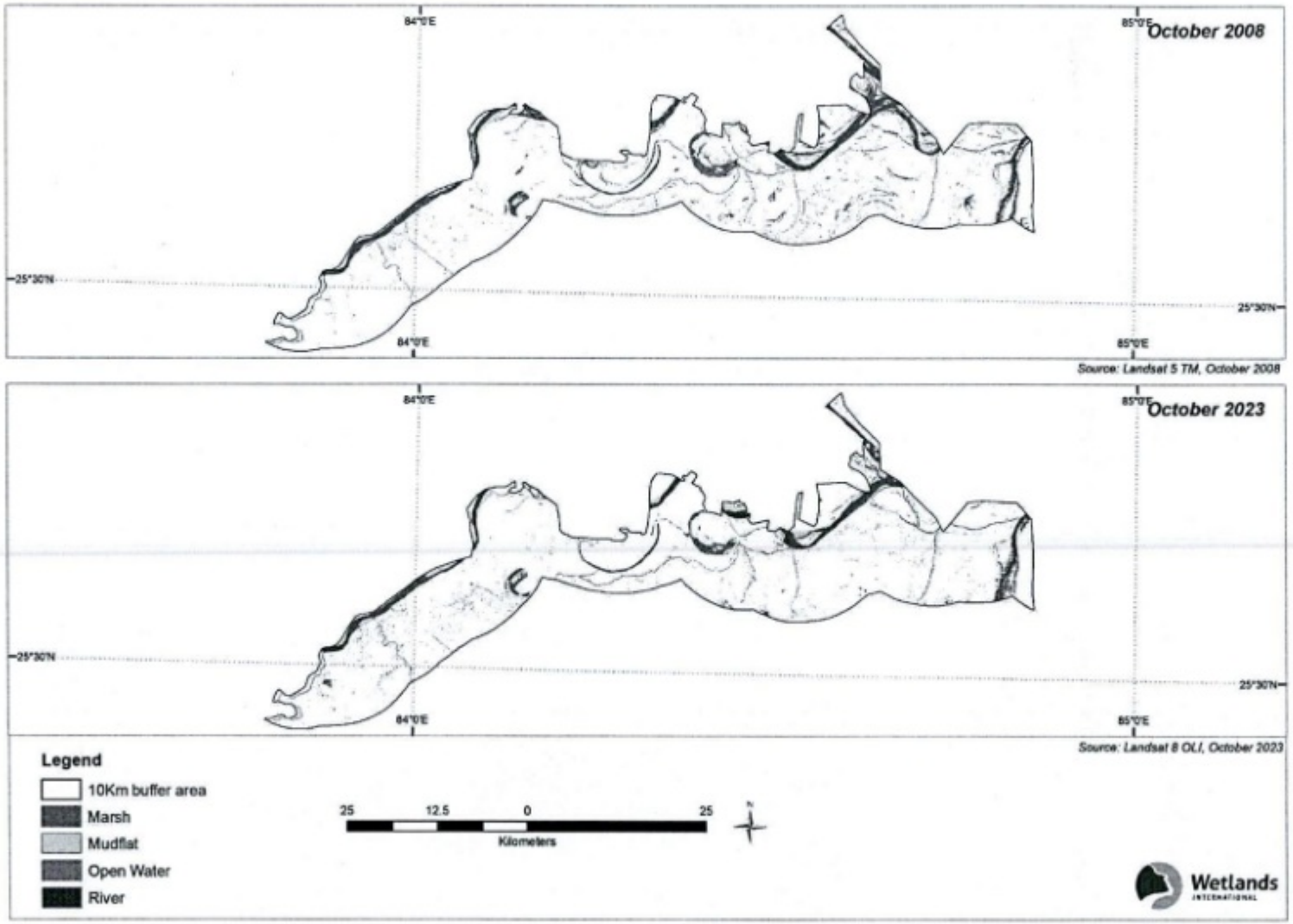
Class	Sub Basin 1			Sub Basin 2			Sub Basin 3			Total		
	Area(ha)		% change	Area(ha)		% change	Area(ha)		% change	Area(ha)		% change
	2008	**2023**		**2008**	**2023**		**2008**	**2023**		**2008**	**2023**	
Marsh	6582	4403	-33.11	62388	49610	-20.48	15986	12881	-19.42	84956	66894	-21.26
Open water	1619	961	-40.61	9236	22149	139.80	4582	6319	37.89	15437	29429	90.63
Sub total (Wetland)	**8201**	**5364**	**-34.59**	**71624**	**71759**	**0.19**	**20568**	**19200**	**-6.65**	**100394**	**96323**	**-4.05**
River	7191	6350	-11.70	55441	62398	12.55	14551	15111	3.85	77183	83859	8.65
Mudflat	1738	2771	59.41	22955	32481	41.50	6510	5083	-21.92	31203	40335	29.27
Sub Total	**17131**	**14486**		**150020**	**166638**		**41629**	**39393**		**208780**	**220517**	
Other classes	121001	123646		687111	670493		148273	150509		956384	944647	
Total		**138132**			**837131**			**189902**			**1165164**	

Table 2: Change in the land use and land cover from 2008 - 2023 in the Ganga basin in Bihar

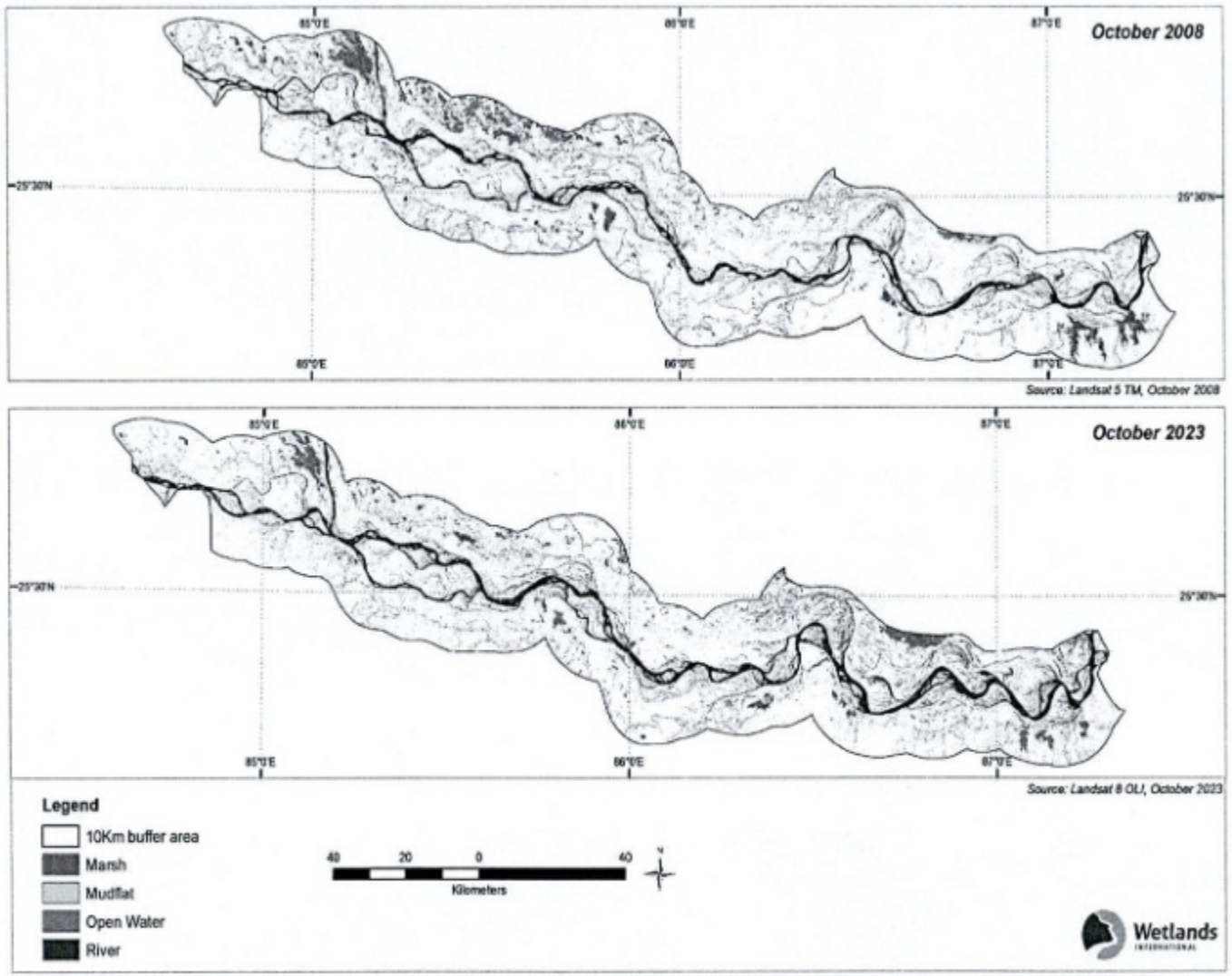
Class	Area(ha)		% change
	2008	2023	
Marsh	84956	66894	-21.3
Open water	15437	29429	90.6
Subtotal (Wetland)	**100393**	**96323**	**-4.1**
River	77183	83858	8.6
Mudflat	31202	40335	29.3
Sub Total	**208780**	**220516**	
Others	956347	944610	
Total		**1165127**	



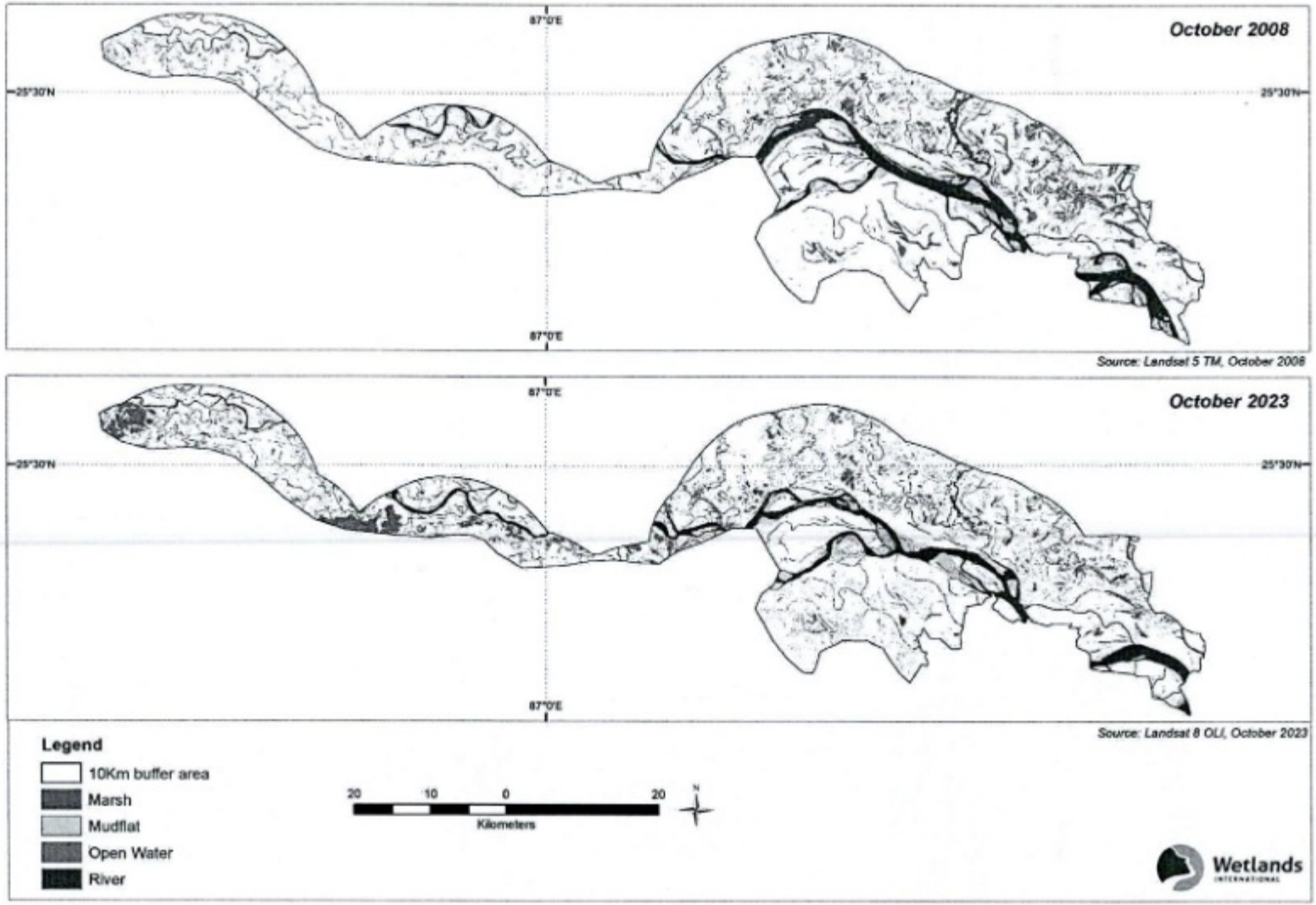
Map 3: Change in wetland extent in the 10km buffer zone on either side of the River Ganga from 2008 to 2023 in Bihar



Map 4: Wetland extent in the 10 km buffer zone in sub basin 1 on either side of the River Ganga during the years 2008 and 2023 in Bihar



Map 5: Wetland extent in the 10 km buffer zone in sub basin 2 on either side of the River Ganga during the years 2008 and 2023 in Bihar



Map 6: Wetland extent in the 10 km buffer zone in sub basin 3 on either side of the River Ganga during the years 2008 and 2023 in Bihar

3.1.1.2 Wetland Inventory

A total of 526 wetlands falling within the 10km buffer area were extracted using National Wetland Atlas (SAC 2017)[5]. Of these, 124 wetlands were selected from across the 12 districts for ground truthing and inventory. The selection of wetlands was done using a stratified random sampling, taking into consideration their spatial distribution, type, and size.

Wetlands were categorized into four size classes i.e. <5ha, 5-20ha, 20-50ha, and >50ha. For conducting surveys, 10% of wetlands of size class <5ha and 5-20ha were selected, likewise, 50% of wetlands of size class 20-50ha were selected, and all wetlands (i.e. 100%) having an area of >50ha were considered. In terms of typology, wetlands were classified as per their landscape setting viz. rural and urban. Important Bird Area, Key Biodiversity Area, wetlands > 50ha in size were given preference for selection. Wetlands <5ha in size situated in a rural setting are categorised as village ponds. The total number of wetlands selected in different size classes are:

Number of wetlands under class <5ha = 24
Number of wetlands under class 5-20ha = 33
Number of wetlands under class 20-50ha = 33
Number of wetlands under class >50ha = 35

Inventory of the 124 wetlands was undertaken with the help of a Rapid Assessment Tool (Annex 1). The data collected has been used in the subsequent sections for describing wetland features, assessing values and benefits, threats and management arrangements.

3.1.1.3 Wetland Ecosystem Services Assessment

An assessment of the ecosystem services of the 124 wetlands was undertaken using the Rapid Assessment of Wetland Ecosystem Services Tool (RAWES) (Ramsar 2018)[6]. RAWES has been developed to support ecosystem service assessment of wetlands recognizing practical time and resource limitations faced by operational staff, providing a simple, user-friendly, cost-effective approach supporting systemic assessment of the full range of wetland ecosystem services (McInnes and Everard 2017)[7]. RAWES addresses the four ecosystem service categories (provisioning, regulatory, cultural, and supporting services) defined by the Millennium Ecosystem Assessment (2005)[8].

Expert assessors interacted with numerous local stakeholders, community groups, government officials, and non-governmental organizations. Consent to use anonymised feedback from interviewees was sought prior to interviews and meetings.

Semi-quantitative importance of each service is scored on a scale from 'significantly positive' (++) through 'neutral' (0) to 'significantly negative' (−) or 'unknown' (?). Data captured in hand-written RAWES field assessment sheets were transposed into spreadsheet format, with some modification in dialogue amongst assessors and other experts where more information became available. Groups of ecosystem services (all 36 assessed services or within Millennium Assessment categories) were summed and divided by the number of services in that category (up to provisioning n=9, regulating n=14, cultural n=8, supporting n=5 but reduced where services were not relevant) to derive a single comparable ecosystem services index (ESI) (based on similar index methods by Butchart et al. (2010)[9], calculated using Equation.

$$ESI = \frac{\sum(n_{++} + n_{+-}) + \sum(n_{-+} + n_{--})}{\sum n_{total}}$$

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[5] SAC (2017) National Wetland Atlas
[6] Ramsar Convention on Wetlands. (2018). Global Wetland Outlook: State of the World's Wetlands and their services to people. Gland, Switzerland: Ramsar Convention Secretariat.
[7] McInnes and Everard 2017. Rapid Assessment of Wetland Ecosystem Services (RAWES): An example from Colombo, Sri Lanka. Ecosystem Services. Volume 25, June 2017, Pages 89-105.
[8] Millennium Ecosystem Assessment (2005). (Ed.): Rashid Hassan, Robert Scholes and Neville Ash. Published by Island Press, 1718 Connecticut Avenue, Suite 300, NW, Washington, DC 20009.
[9] Butchart, H. M. et. al. (+ 44 authors). (2010). Global Biodiversity: Indicators of Recent Declines. Science. Vol 328, Issue 5982. Pp. 1164-1168.

Interview with villagers during field assessment

The potential ESI range is from +1 to −1 when calculated for each of the four ecosystem service categories, though compound values for all services can exceed these limits where benefits are realized at multiple geographical scales.

Based on the range of ESI scores for each of the services, the Figure 3 below was constructed illustrating the combined ESI scores for all ecosystem services under each sub-basin i.e., a) Sub-basin 1: Ghaghar, Ghaghara Confluence to Gomti Confluence and Sone, b) Sub-basin 2: Gandak and others and c) Sub-basin 3: Kosi, Bhagirathi and others (Ganga Lower) for all 124 wetland sites with a breakdown of ESI for each service category (provisioning, regulating, cultural, supporting). As revealed from the data analysis (Figure 4), sub-basin 3 reported maximum ESI scores (mean: 0.66), followed by sub-basin 1 (mean: 0.64) and followed by sub-basin 2 (mean: 0.51).

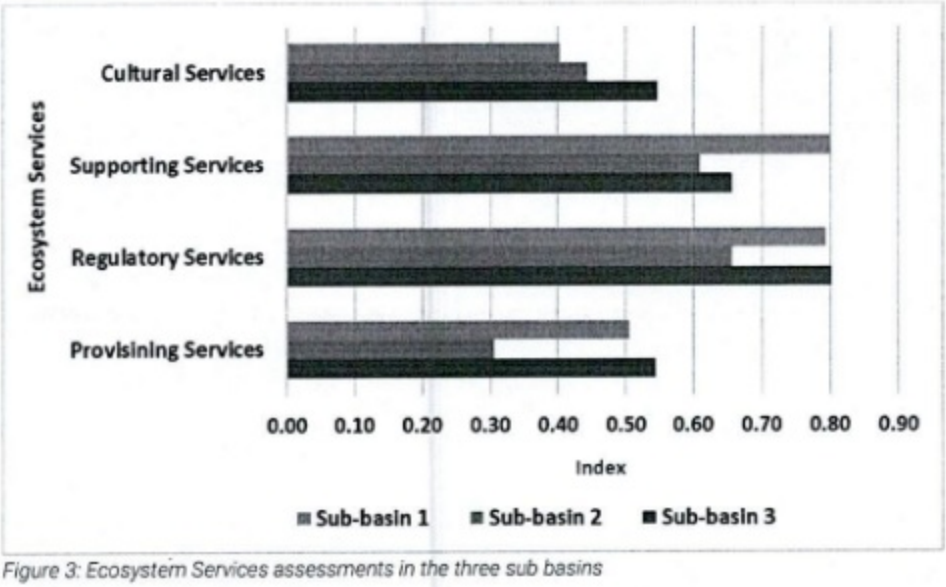


Figure 3: Ecosystem Services assessments in the three sub basins

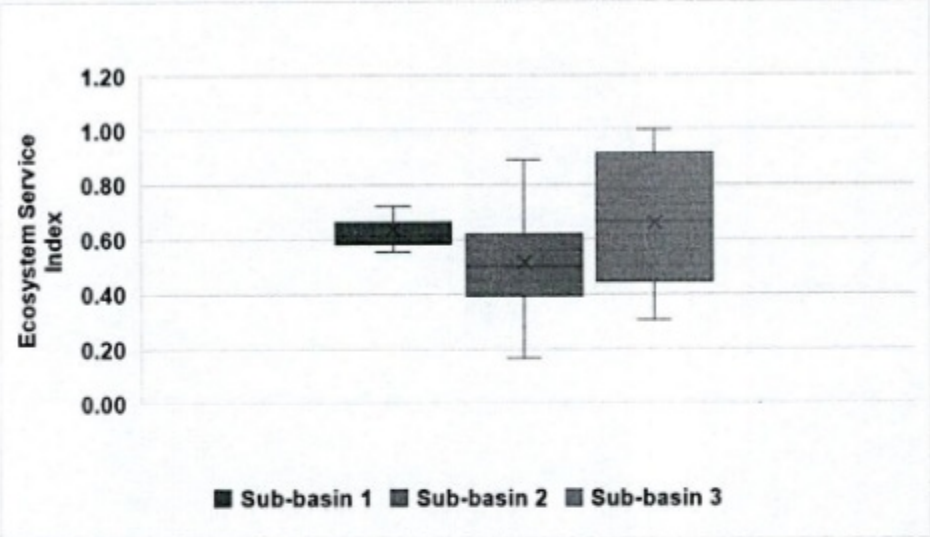


Figure 4: Comparative analysis of Ecosystem Service Index (Mean, Maximum and Minimum values) in the three sub basins

Regulating services

A key indirect value of floodplain wetlands to the communities living in the vicinity is their ability to buffer extreme events. It was recorded that around 11.3% of wetlands and their complex were recognized as providing a buffer to bank inundations by absorbing the flows and thereby reducing the risk of damages within the settlements around the complex. Wetlands like Gokul Jalashay in Buxar district and Sukhi Suiya in Bhojpur district significantly provide a buffer from floods. More than fifty-percent of wetlands are reported to retain water and thus recharge groundwater and support agriculture during lean seasons (Figure 5).

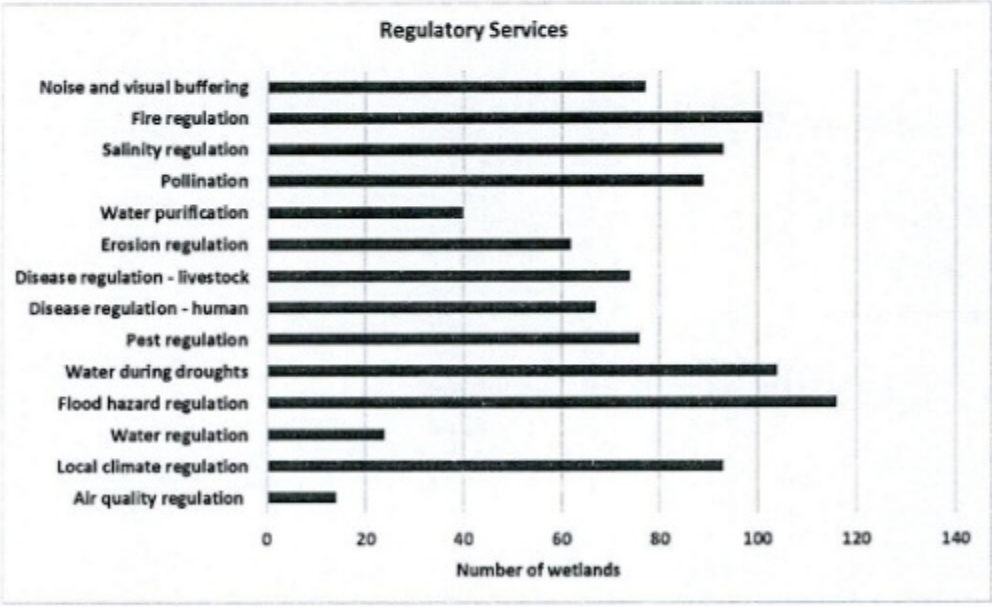


Figure 5: Number of surveyed wetlands providing regulatory services

Provisioning services

The surveyed wetlands in 12 districts lie in the highly fertile floodplains of the River Ganges, hence agriculture is the key economic activity, accounting for nearly 17.7% of the land use. Private land ownership within the wetland area has led to the expansion of agricultural activities. *Nishad* or *Mallah* Caste are common and practice boat rowing. They are also dependent on fishing (Figure 6). Districts such as Katihar and Begusarai have the highest extent of wetlands which cover about 10% of the geographical area of the respective districts. Since 2008, the state government has brought one-third of this available area under culture-based fisheries with average productivity of 300–400 kg/ha/yr.

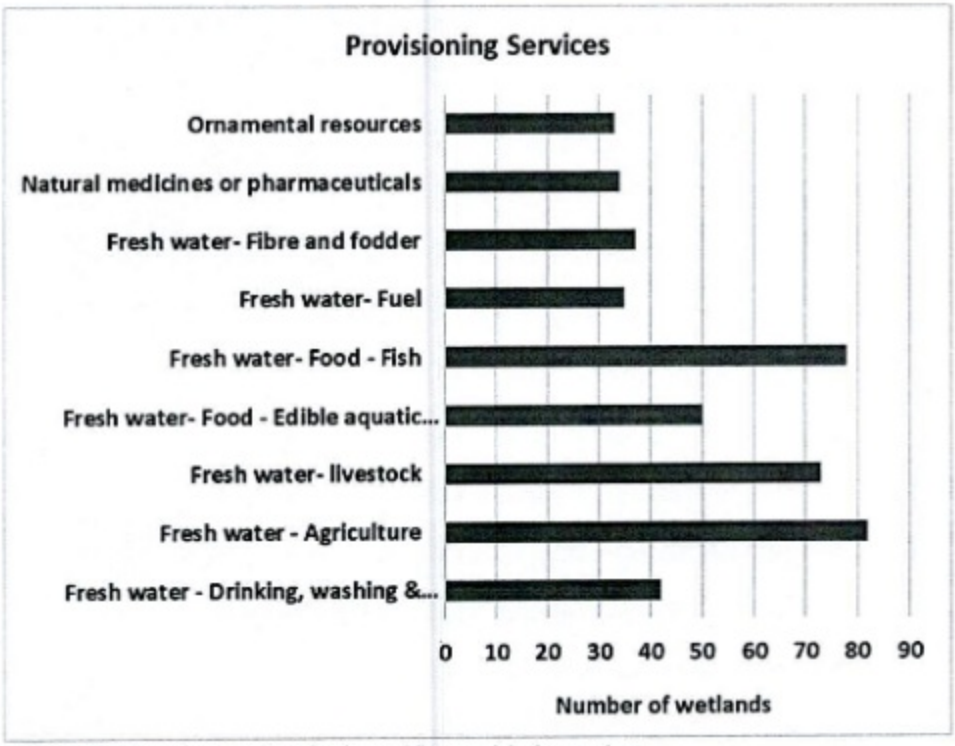


Figure 6: Number of surveyed wetlands providing provisioning services

Nishad or Mallah Caste are dependent on fishing

Cultural services

The Ganges is the most sacred freshwater ecosystem in India. The aesthetics, mythological connotations, and spiritual appeal have made it popular all over the world. It was recorded that 24% of wetlands are revered for their spiritual and religious values and local ritualistic purposes (Figure 7). During festivals such as *Chhath Puja, Kartik Amavasya* and *Ganga Dussehra* floodplains are crowded with pilgrims. Matkor (Haldi ceremony during the wedding) is also a prominent cultural activity performed at the wetland site. Wetlands like Badka Taal and Anjani Talaab in Buxar district hold an important place in the local culture, with several festivities and celebrations taking place nearly all the year-round.

Anjani Talaab forms a major religious attraction owing to its archaeological significance dating back to the Ramayana era. Locals informed that it is dedicated to 'Mata Anjani' – mother of Lord Hanuman. And due to its religious significance, the wetland is under consideration by the state government for including it in the 'Ramayana Tourism Circuit.' Thus, wetlands form a great potential to promote 'religious and festival tourism' in the state. And since festivals engage a diversity of participants, proper management of wetlands can attract travellers encouraging them to experience the local culture.

A range of diverse flora and fauna add to the scenic beauty of the wetlands. The local forest department in different districts celebrates conservation events like World Wetlands Day and Wildlife Week. They engage with local communities and schools in promoting conservation education and awareness programs.

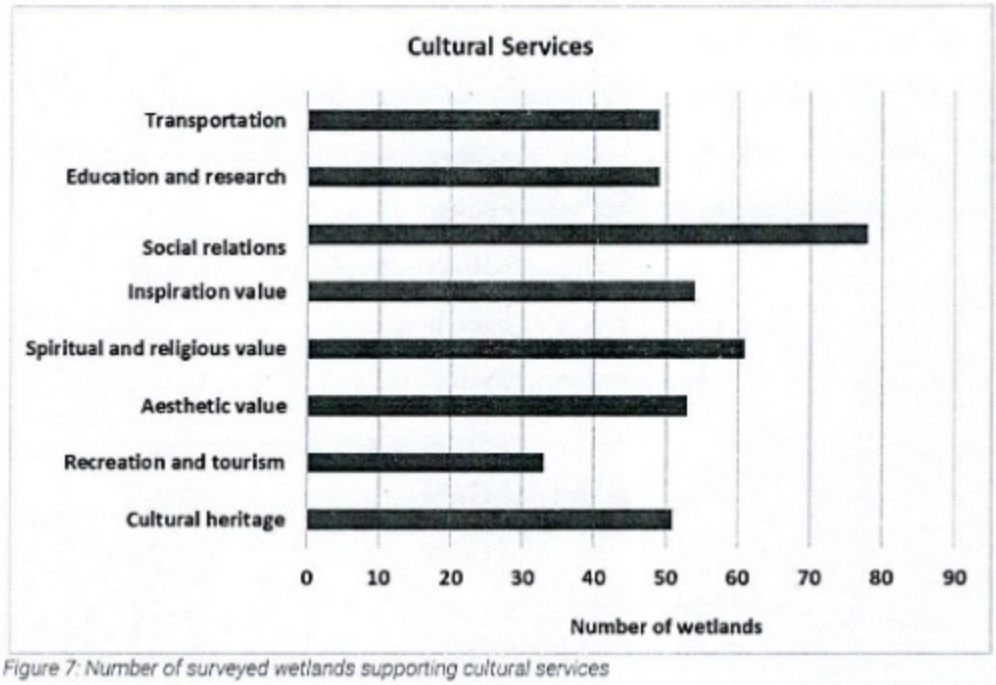
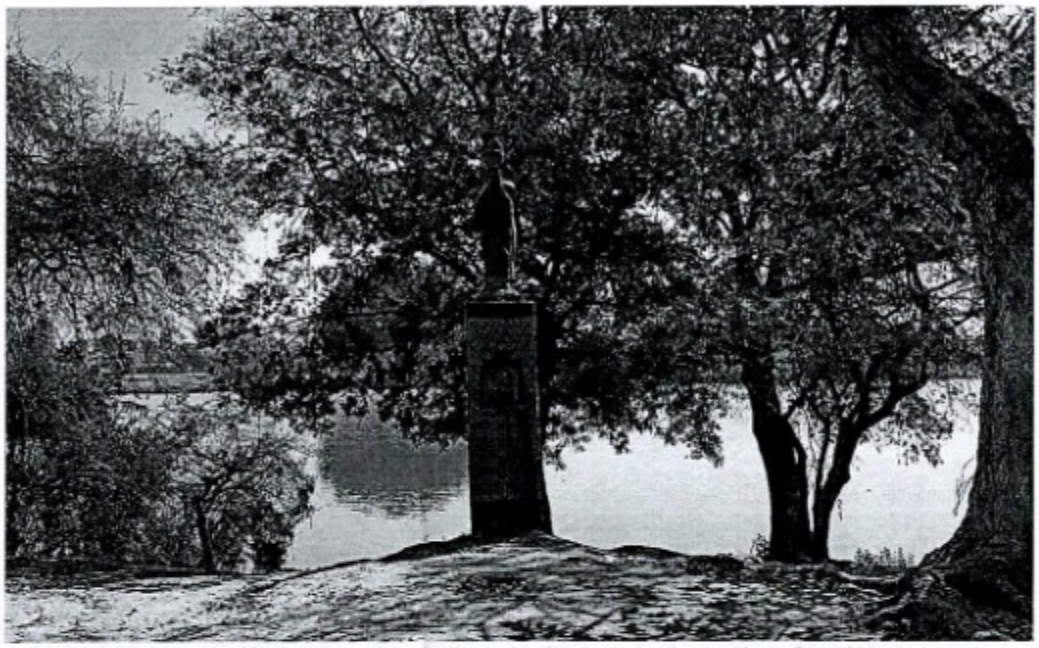


Figure 7: Number of surveyed wetlands supporting cultural services



Anjani Talaab is revered by locals as it is dedicated to 'Mata Anjani' – mother of Lord Hanuman

Supporting services

Floodplain wetlands in Bihar are locally known as *chaurs* (land depressions) and *moins* (ox-bow lakes). It was recorded that 24.4% of surveyed wetlands serve as a refuge to a range of diverse plant and animal species (Figure 8), but little is known about their conservation status. Supporting high avian diversity is one of the prominent features of the Gangetic floodplain wetlands. Though, no consistent records were available on the number of waterbirds at the surveyed wetland sites. Wetlands like Gokul Jalashay in Buxar district, Sukhi Suiya in Bhojpur district and Naugachhiya in Bhagalpur district were recorded to support good population of the Near Threatened Painted Stork *Mycteria leucocephala* and Black-headed Ibis *Threskiornis melanocephalus*. The importance of cyclic inundation and hydro-ecological connectivity between the river channel, riparian zone, and floodplains underpin high habitat heterogeneity which enhances biological diversity in the floodplain wetlands. The exchange of fish brooders and juveniles between the river channel and the floodplains helps to sustain high fish biodiversity and productivity of the entire Indo-Gangetic plains.

During monsoon the floodplain wetlands get deposited with nutrient-rich sediments received from the catchment, which supports in enriching the soil and enhancing agricultural productivity in the adjacent areas. Floodplain wetlands also play a vital role in the cycling of nutrients, particularly nitrogen and phosphorus, thus promoting nutrient availability.

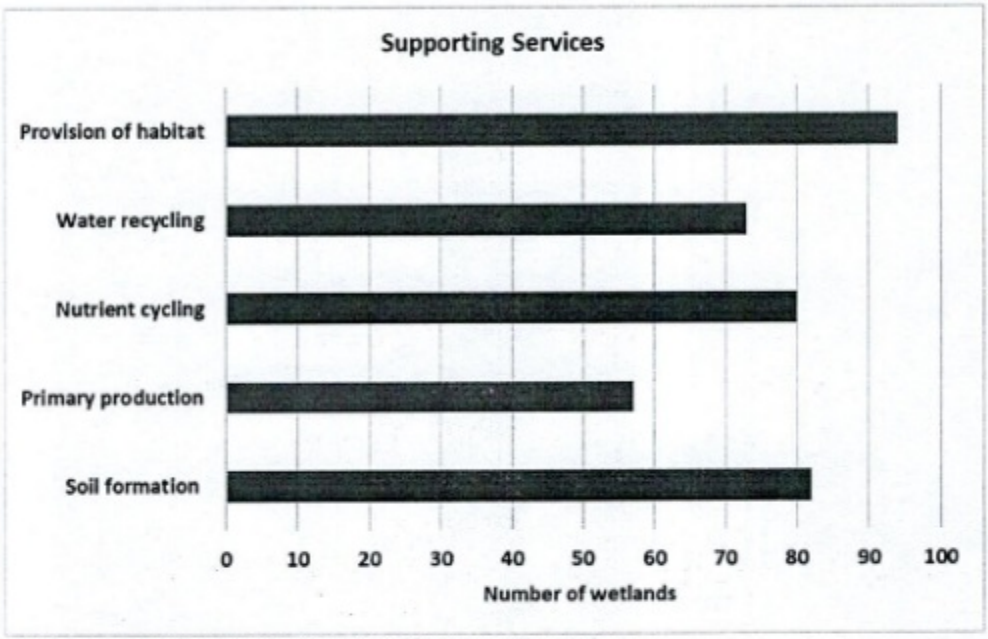
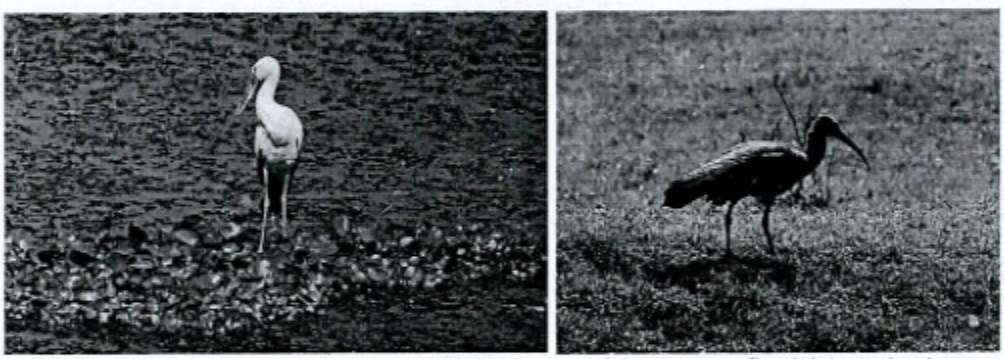


Figure 8: Number of surveyed wetlands providing supporting services



Supporting high avian diversity forms a prominent feature of the Gangetic floodplain wetlands

3.1.1.4 Wetlands biodiversity

Many plant and animal species live in the wetlands, including several rare and endangered species. Such species are characteristic to their environment and often described as indicator species that are used to monitor environmental changes, assess the efficacy of management, and provide warning signals for impending ecological shifts. Reed (1988)[10] first described the indicator status of a species (floral or faunal) through its expected occurrence in the wetland as follows in Table 3:

[10] Reed, P.B. Jr. (1988). National list of plant species that occur in wetlands: national summary. U.S Fish Wildl. Serv. Biol. Rep. 88 (24). 244 pp.

Table 3: Indicator status of a species (floral or faunal) based on its occurrence in the wetland

Species category	Description
Obligate wetland species	Occur almost always (estimated probability >99%) under natural conditions in wetland habitat
Facultative wetland species	Usually occur in wetlands (estimated probability 67%–99%), but occasionally found in non-wetlands habitat
Facultative	Equally likely to occur in wetlands or non-wetland habitat (estimated probability 34%–66%)
Facultative upland	Usually occur in non-wetland habitat (estimated probability 67%–99%), but occasionally found in wetlands (estimated probability 1%–33%)
Obligate upland	Occur almost always (estimated probability >99%), under natural conditions in the non-wetland habitat

Plant species occurrence

The Gangetic ecosystem forms a unique environment for hydrophytic, semi-hydrophytic, and submerged floral association. The vegetation pattern in the Ganga basin varies according to seasonal changes, hydrology, flood level, and different soil types. These factors have a sharp influence on plant species distribution and composition.

The present study was conducted in the three sub-basins of the Gangetic floodplains of Bihar. 124 wetlands in 12 districts were sampled. 50 wetland plant species representing 34 families were identified (Annex-II). Family Araceae, Cyperaceae, Nymphaeaceae, Polygonaceae and Potamogetonaceae were recorded as dominant. The plant species were grouped as; emergent, free-floating, moisture-loving, and submerged. The occurrence of emergent hydrophytes was recorded maximum (38%) followed by submerged hydrophytes (28%), free floating hydrophytes (18%) and moist loving hydrophytes were recorded least (16%) (Figure 9). Water hyacinth *Eichhornia crassipes*, Hornwort *Ceratophyllum demarsum*, Alligator weed *Alternanthera philoxeroides*, Hydrilla *Hydrilla verticillata*, Hemp *Cannabis sativa* and Congress Grass *Parthenium hysterophorus* were recorded as major invasive wetland plant species.

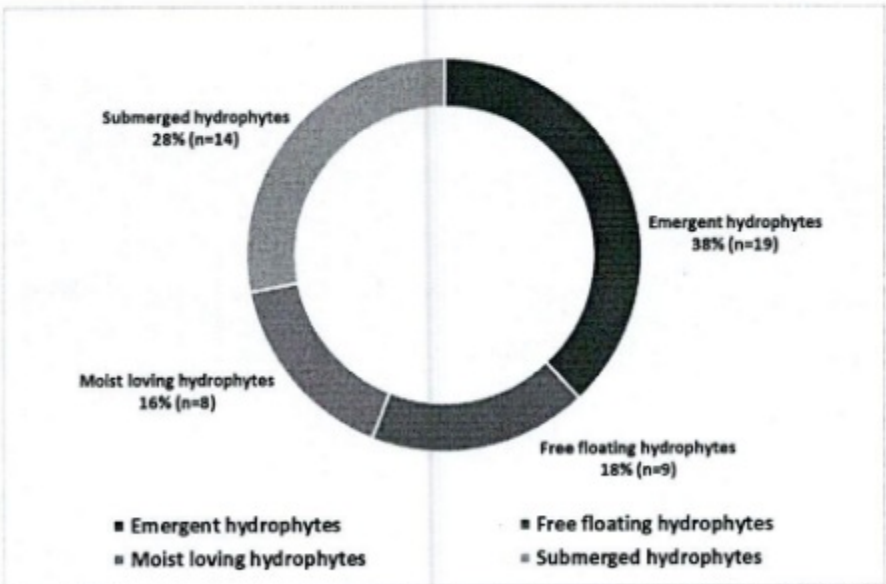


Figure 9: Hydrophytic plant species recorded in the wetlands surveyed along the Gangetic floodplains

Wetland plant species

Faunal species occurrence

Comprehensive information on the aquatic biodiversity and various ecological aspects of the River Ganga have been documented but the status of faunal elements of floodplain wetlands in Bihar state remains feebly documented. Studies have largely been conducted to document the bird diversity (Dey et. al. 2014)[11], reptiles of north Bihar (Ahmed and Dasgupta 1991)[12], patterns of fish diversity in Mauns and Chaurs of Samastipur, north Bihar (Saroj and Prasad, 2020)[13], diversity and habitat preference of amphibians (Nalinaksh and Nath, 2024)[14], and, diversity and conservation status of mammals in Bihar (Sahu et. al. 2021)[15].

In the present study, the occurrence of fauna was documented based on direct sightings during field visits and secondary data in the form of peer-reviewed published articles was also referred to. Species conservation status was described following the IUCN Red List.

A total of 50 species of fish (Annex-III), 1 species of amphibian (Annex-IV), 12 species of reptiles (Annex-V), 14 species of mammals (Annex-VI), and 63 species of birds (Annex-VII) were recorded. Nine species of high global conservation significance were recorded from across the three sub-basins (Figure 10). Occurrence of invasive species such as Tilapia *Oreochromis niloticus* sp., Chinese Carp *Ctenopharyngodon idellus*) and leech *Placobdella rampurai* was also recorded.

The Walking Catfish *Clarias batrachus* was recorded as a dominant fish species. It is a freshwater fish species that require wetlands as spawning grounds and as nursery areas for their young. The Floodplain region of Ganga along the districts Buxar and Bhagalpur form an important habitat for endangered species like Gangetic Dolphin *Platanista gangetica*, Gharial *Gavialis gangeticus*, Marsh Crocodile *Crocodylus palustris*, Smooth-coated Otter *Lutrogale perspicillata* and over 198 bird species, including at least 63 waterbirds.

a. Mycteria leucocephala *b. Cirrhinus sp.* *c. Wallago sp.*

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[11] Dey, S., Dey, Subhasis., Choudhary, S.K and Kelkar, N. 2014. An annotated bird checklist of the Vikramshila Gangetic Dolphin Sanctuary, Bhagalpur, Bihar, India, with an assessment of threats to bird conservation. FORKTAIL 30 (2014): 34–40.

[12] Ahmed, S and Dasgupta, G. 1991. Studies on the Lizard and Snakes of North Bihar. Rec. Zool. Surv. India, 88 (1): 75-80.

[13] Saroj, K.S and Prasad, J. 2020. Diversity Status of Fishes in Mauns and Chaurs of Samastipur, North Bihar. Applied Ecology and Environmental Sciences. 2020, 8(1), 21-24.

[14] Nalinaksh, P and Nath, B. 2024. Species Diversity and Habitat Preference of Amphibian Fauna of Sheohar District, Bihar. International Journal of Zoology and Animal Biology. Volume 7 Issue 4. Pp. 10.

[15] Sahu, N., Anand, A., Choudhury, S.R., and Singh, A., (2021). A Review on Diversity and Conservation Status of Mammals in Bihar, India. Chhattisgarh Journal of Science and Technology. Volume 18, Issue 3. Pp. 6.

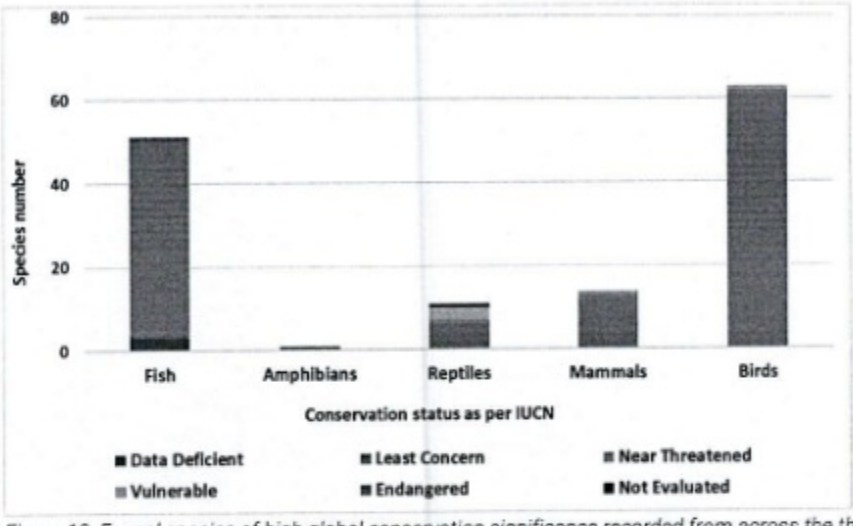


Figure 10: Faunal species of high global conservation significance recorded from across the three sub-basins

3.1.1.5 Threats

Driven by perceptions of being a waterlogged wasteland, wetlands are often subjected to a wide range of anthropogenic disturbances both direct and in-direct. The major threats range from extensive hydrological regime fragmentation to conversion for permanent agriculture. Assessments of change in land use and land cover has brought to fore the loss of wetlands to the tune of 4071ha amounting to (4.1%) for the landscape, assessed for the period of 2008-2023. A comparative analysis of major threats based on sample survey of 124 wetlands across the three sub-basins is depicted in Figure 11 and a brief description is provided below:

Floodplain wetlands are witnessing a rapid decline in area that can be attributed to land conversion due to encroachments and expansion of linear infrastructure and permanent agriculture. Change in physical regime being brought about by excess sedimentation is another significant threat that endangers the very existence of these wetlands. It leads to change in wetland attributes like depth and quality of water adversely affecting habitat quality along with the ecological communities that the wetland supports.

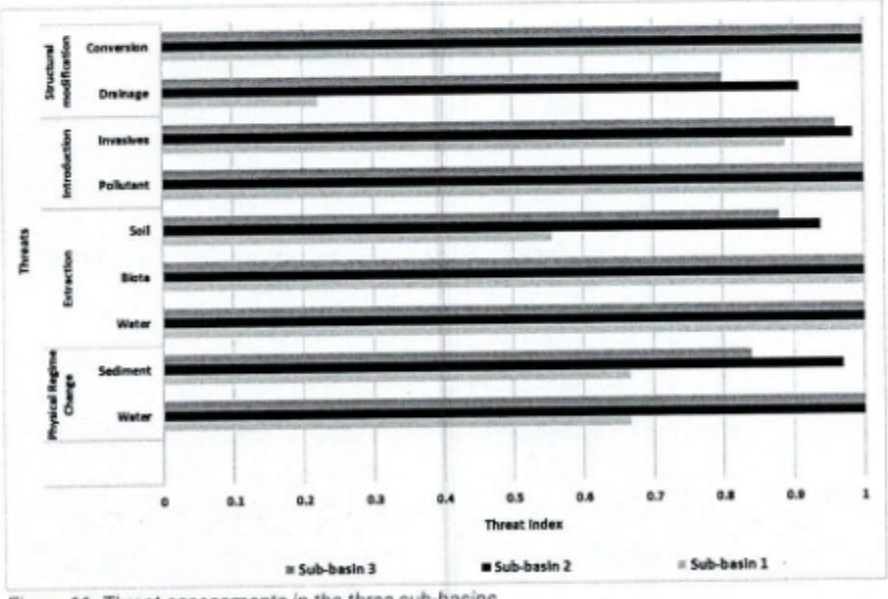
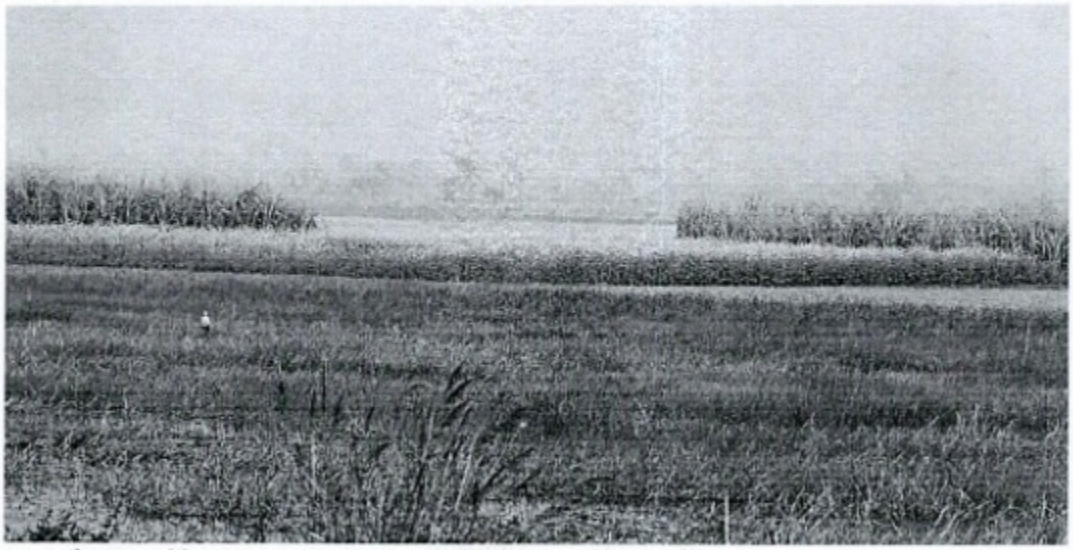


Figure 11: Threat assessments in the three sub-basins

Agricultural intensification has led wetland farming to transform from being based on natural inundation regimes to being highly dependent on groundwater. The number of cropping cycles have also increased from one to three in most areas, and traditional crops have been replaced by water-intensive varieties such as paddy, sugarcane and mentha. Inflowing channels connecting adjoining wetlands are blocked to protect croplands, impeding natural silt distribution.



Intensification of floodplain agriculture

Introduction of pollutants by discharge of wastewater, toilet sewage and solid waste disposal from the settlements present on the shoreline was also recorded as a dominant threat being faced by these wetlands. It is a major factor behind deterioration of water quality. Also, indiscriminate use of chemical inputs like pesticides and fertilizers, required for achieving higher agricultural productivity, have increased the risk of their leaching into wetlands with consequences like excessive nutrient loading, proliferation of invasive floral species and eutrophication.

Peri-urban wetlands as dumping ground

Production from culture fisheries operations within maun and chaur areas have declined significantly. The fisheries have transformed from a high-value mix of Indian Major Carps in the 1970s and 80s to low economic value air-breathing fishes and minnows at present. Decreased river connectivity, reduced surface water availability, shortage of fries and fingerlings, and weak institutional arrangements are critical constraining factors. The social contract between the fishers and farmers, which enabled the two dominant stakeholder groups to use the wetland area within an intra-annual variation of inundation regimes, has been stressed due to declining resources and changing land use.

Over abstraction of natural resources

3.1.1.6 Management arrangements

Policy and regulatory frameworks

Wetlands conservation for wise use has been placed within the mandate of the Ministry of Environment, Forest and Climate Change (MoEFCC). Since 2013 the MoEFCC has been implementing the National Plan for Conservation of Aquatic Ecosystems (NPCA), which aims at 'mainstreaming the full range of wetlands biodiversity and ecosystem services within development plans and programmes at various levels. The NPCA provides guidelines to promote an integrated and multidisciplinary approach to wetlands conservation and sustainable management.

Under the provisions of the Environment (Protection) Act, 1986, a regulatory framework for wetlands was introduced by the MoEFCC through the notification of Wetland (Conservation and Management) Rules, 2017. As per the provisions of these Rules, State Wetlands Authorities have been constituted as the main policy and regulatory bodies within states and stipulate the prohibition and regulation of a range of developmental activities within a wetland notified under its provision by the State Governments.

In 2017, the Ministry notified the Wetlands (Conservation and Management) Rules under The Environment (Protection) Act, 1986. The MoEFCC issued an Office Memorandum on March 8, 2022, reiterating that the 2,01,503 wetlands (>2.25 ha) as per the National Wetland Inventory and Assessment (NWIA), 2011 should be protected as per Rule 4 of the Wetlands (Conservation and Management) Rules, 2017. This regulation thus protects wetlands from development threats by prohibiting a range of activities such as discharge of untreated sewage, and construction within 50 meters of high flood lines. The Environment (Protection) Rules, 1986, empowers the Central government to prohibit or restrict the location of industries and carrying on of processes and operations in different areas including wetlands.

Wetlands receive protection from a number of centrally enacted rules and regulations. Provisions of the Indian Forest Act, 1927; the Forest (Conservation) Act, 1980; and the Indian Wildlife (Protection) Act, 1972 define the regulatory framework for wetlands located within forests and designated protected areas. The Indian Fisheries Act, 1897; The Water (Prevention and Control of Pollution) Act, 1974; and The Biological Diversity Act, 2002, provide instruments for regulating various development threats on wetlands. Further, under the Biological Diversity Act, 2002, the Central Government can issue directives to State Governments to take immediate ameliorative measures to conserve any area rich in biological diversity, biological resources and their habitats, especially when the area is threatened by overuse, abuse or neglect. The said Act also gives State Governments the power to notify areas of biodiversity importance as biodiversity heritage sites.

The Ministry of Water Resources, River Development, and Ganga Rejuvenation Notification of October 7, 2016, namely the River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016 sets the overarching regulation and management framework for the Ganga River System, including tributaries, floodplains and connected surface and groundwater regimes. The order defines floodplains as 'areas of River Ganga or its tributaries which comes under water on either side of it due to floods corresponding to its greatest flow or with a flood of frequency once in hundred years'. Rule 4 (ix) provides that the entire floodplain zone to be construction free zone to reduce pollution sources, pressures and to maintain its natural ground water recharge functions.

The National Environment Policy of 2006 articulated the core policy elements of wetlands: including their inclusion in poverty alleviation and rural development strategies, and taking into account explicit impact of developmental projects on wetlands. India's National Wildlife Action Plan (2017-2031) identifies the conservation of inland aquatic ecosystems as one of the 17 priority areas and envisages the development of a national wetlands mission, and a national wetlands biodiversity register as key interventions (MoEFCC, 2017). Integration of wetlands in river basin management has been identified as a strategy for the management of river systems (MoWR, 2012). The National Water Policy (2012) provides an important policy framework for linking wetlands to water resources management. It recommends the adoption of a basin approach for water resource management and identifies the conservation of river corridors, water bodies, along with the associated ecosystems as an important action area and together is proposed in the Draft River Basin Management Bill, 2018. The National Action Plan for Climate Change includes wetland conservation and sustainable management in the National Water Mission and the Green India Mission. The National Disaster Management Plan considers several non-structural measures for flood and cyclone risk reduction measures and makes direct reference to wetlands.

The Bihar Irrigation Act, 1997, Bihar Ground Water (Regulation and Control of Development and Management) Act, 2006 and Irrigation, Flood Management and Drainage Rules, 2003 (amended in 2015, 2016 & 2017) are the key legislative regulations for the management of water availability in the wetland and its catchment. The acts aim to maintain the water availability to meet the water demands of agricultural and domestic sectors along with the additional focus to store and channelise the excess water to enhance the irrigable area.

The Bihar Waste Lands (Reclamation, Cultivation, and Improvement) Act, 1946, and Bihar Agricultural and Rural Area Development Agency Act, 1978, guide land-related issues/disputes. Bihar Soil and Water Conservation & Land Development Act, 1970, have included waterlogged areas prompting the State to take measures for reducing these unproductive lands by essentially funding wetland drainage programmes.

Bihar Fish Jalkar Management Act, 2006 (amended in 2010), and Bihar Fish Seed Certification & Accreditation Act, 2018 have allowed the intensive fish culture of different varieties, including some of the exotic fishes in the waterbodies of Bihar. The Bihar Biological Diversity Rules, 2017 (framed per the powers conferred in Section-63 of The Biological Diversity Act, 2002) guides the Bihar State Biodiversity Board (BSBB) to collect, compile and manage the existing diversity in the state.

Several statutes of the Government of India and the Bihar state government directly or indirectly support wetland conservation in Bihar. These are described below in Table 4

Table 4: Key regulatory frameworks relevant for Ganga floodplain wetlands

Regulation	Purpose	Scope	Key implications for management of Ganga floodplain wetlands
Wetlands (Conservation and Management) Rules, 2017 under Environment (Protection) Act, 1986	Provides the regulatory framework for conservation and management of wetlands in the country	All wetlands >2.25 ha except those covered under the Indian Forest Act, 1927, the Wild life (Protection) Act, 1972, the Forest (Conservation) Act, 1980	Wetland boundary and zone of influence needs to be demarcated; A Management Plan for the wetlands needs to be formulated in line with the framework recommended under the Guidelines for implementation of Wetlands Rules; Prohibits conversion for non-wetland uses, solid waste dumping, discharge of untreated waste and effluents from cities and towns, poaching
The River Ganga (Rejuvenation, Protection and Management) Authorities Order, 2016, amended 2019	Constitutes authorities at central, state and district levels to take measures for prevention, control, and abatement of environmental pollution in River ganga and to ensure continuous adequate flow of water to rejuvenate the River Ganga to its natural and pristine condition	Applies to the states comprising River Ganga Basin including Bihar	National Mission for Clean Ganga, authority is constituted under the Act. It has administrative, appraisal and approval powers and duties, functions and powers to identify specific threats to River Ganga and remedial actions, make the River Ganga Basin Management Plan to maintain adequate ecological flows in the River Ganga and its tributaries and prevent, control, and check environmental pollution
The Indian Wildlife (Protection) Act, 1972 and The State Wildlife Protection Rules, 2020	Protection of wild animals, birds, and plants and for matters connected therewith	Applies to all wild habitats, protected areas, wild animals, specified plants, wildlife trade and related matters	Regulatory framework for management of all protected areas like National Parks, Wildlife Sanctuaries and Critically Endangered and Endangered Species

Regulation	Purpose	Scope	Key implications for management of Ganga floodplain wetlands
Environment Protection Act, 1986	Umbrella law to provide for the protection and improvement of the environment, and for matters connected therewith	Covers all forms of pollution and empowers the central government to take any all measures for improving environment quality and lay down standards for emissions and discharges throughout the country	The EPA, 1986 and related Acts as the Water Act, 1974, the Water Cess Act 1977, the Wetland (Conservation and Management) Rules 2017 lay the framework of regulatory tools to deal with pollution from industries, towns and settlements located along the Ganges and wetland management. The provision of the Act can be invoked to make new statutes. The NMCG was constituted under the provisions of EPA,1986. The Act has been used to designate Ecological Zones and to specify the land uses that are permitted around Protected Areas
The Water (Prevention and Control of Pollution) Act of 1974	Aims to prevent and control water pollution and to maintain/restore wholesomeness of water by establishing central and state pollution control board to monitor and enforce the regulations	National (Rules pertain to the State of Bihar)	Lays down effluent discharge standards of sewage and sullage; Provides for the constitution of State Level Boards for enforcement of various provisions of the Act
The Biological Diversity Act, 2002	Conservation of biological diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected in addition to that or incidental thereto	National	Prohibits, without the approval of the National Biodiversity Authority; Obtaining any biological resource or knowledge associated thereto for research or for commercial utilization or for bio-survey and bio-utilization; Transferring results for monetary consideration; Application for intellectual property rights

Regulation	Purpose	Scope	Key implications for management of Ganga floodplain wetlands
The Bihar Fish Jalkar Management Act, 2006	Prohibition of fishing	State	Fishing in rivers shall be prohibited from 15th June to 15th August; Fishing net or Gill net with less than 4 cm mesh size shall be prohibited in rivers; Fishing of fingerlings of culturable fishes of any species shall be prohibited; Putting offence or any obstruction restricting the movement of fish shall be prohibited in rivers and reservoirs
Bihar Fish Seed Certification & Accreditation Act, 2018	Provision of quality fish seeds which ensure production and potentiality in the grow-out farm in a scientific manner for successful and sustainable enterprises and strengthen seed – State certification and accreditation to meet the requirement of qualitative and quantitative seeds for sustainable aquaculture	State	The act includes the following aspects: Constitution of Seed Certification & Accreditation Committee at state and as well as district level; establishment of State/Range/District level fish seed laboratories; Registration and grant of license for seed production and marketing; Prohibition of using explosives, poisons, and any harmful chemicals in hatchery operations, fishing, or any other such operations and sale of brooders

Key Departments and Organisations

Bihar State Wetland Authority

The Government of Bihar, vide its notification no: Wildlife –16/2012 34 (E), constituted the Bihar Wetland Development Authority (BWDA) as the nodal policy-making and planning agency related to wetlands in the State. The BWDA, also known as Bihar State Wetland Authority (BSWA), is the nodal agency for wetland management in the state, per the guidelines of the National Plan for Conservation of Aquatic Ecosystems (NPCA), 2019. The Minister of Environment, Forest and Climate Change is the Chairman, while the Development Commissioner to Government is the Vice Chairperson and the Chief Conservator of Forest (Wetland & Climate Change) is the Member Secretary. The authority also comprises Secretaries of different state government departments (Environment, Forest & Climate Change, Water Resources, Animal & Fishery Resources, Micro Water Resources, Urban Development & Housing, Rural Development, Tourism, Land Reforms & Revenue) as members. The Authority also includes experts drawn from ecology, hydrology, fisheries, and socioeconomics.

The BSWA is responsible for the following functions:

- To formulate policy for the conservation and sustainable management of wetlands of the State and to advise the State Government for this purpose.
- To identify the wetlands of the state and recommend them to be identified as wetlands of international importance (Ramsar site) and other significant wetlands to be included under the National Plan for Conservation of Aquatic Ecosystem.
- To perform the functions assigned to the authority under the Wetlands (Conservation and Management) Rules, 2017.
- Reviewing and recommending the documents submitted for identification and classification of wetlands within the jurisdiction of various departments following the criteria specified by the State Government.
- Resolving disputes regarding the boundary of wetlands and multilateral rights to the catchment area.
- Cooperation with other state, national and international organisations for the conservation and sustainable management of wetlands.
- Other works are provided under the Wetland (Conservation and Management) Rules, 2017.

Department of Forest, Environment and Climate Change

The Department of Forest, Environment and Climate Change (DFECC) is the nodal department to coordinate with other line departments for addressing the issues related to climate change. The principal objectives of the department include protecting and improving the natural environment, including wetlands and rehabilitating natural ecological systems; creating biological resources for catering to various needs of the people on a sustainable basis; implementing the provisions under various Acts/Rules related to forest, wildlife and environment among others.

District Wetland Committees

The DFECC, in line with decisions of the BSWA, has constituted District Wetland Committees (DWC) through notification no. 50/ 2020/ 41, dated January 25, 2022. The DWCs are responsible for wetlands identification and demarcation, preparation of brief documents and health cards, Integrated Management Plans and constitution of wetland mitras. The District Collector chairs these committees and has representatives from all concerned line departments.

Bihar State Biodiversity Board

Bihar State Biodiversity Board has been constituted by the State Government as per the provisions of Biological Diversity Act, 2002 notified by the Government of India. Bihar Biological Diversity Rules, 2004 were notified by the State Government on 17.12.2004 under the provision of Section 63 (1) of Biological Diversity Act, 2002. The notification regarding the constitution of the Board was issued on 11th April. 2005.

The objectives of the Board are: a). Conservation of biodiversity, b). Sustainable use of its components and, c). Equitable sharing of benefits arising out of the use of biological resources and associated traditional knowledge.

- The activities of the Bihar State Biodiversity Board are categorized into the following thematic areas:
- Research and Documentation
- Education, Awareness and Training
- In-situ and Ex-situ Conservation
- Sustainable use and equitable sharing of benefits Governance
- Policy and Law
- To perform such other functions as may be necessary to carry out the provisions of this Act or as may be prescribed by the State Government.
- To regulate by granting of approvals or otherwise, requests for commercial utilization or bio-survey and bio-utilisation of any biological resource by Indians;
- To advise the State Government, subject to any guidelines issued by the Central Government, on matters relating to the conservation of biodiversity, sustainable use of its components and equitable sharing of the benefits arising out of the utilization of biological resources.

Water Resources Department

The Water Resources Department, formerly known as the Irrigation Department, protects the right of the State to share Water of Inter-State Rivers and Basins. Their fields of operations include the creation of irrigation potential and utilization of created potential through construction, maintenance, and regulation of major and medium irrigation schemes; restoration of lost irrigation potential of old irrigation schemes; construction and

maintenance of embankments, revetment in selected portions of river banks, land spurs and other necessary flood protection works; draining of waterlogged areas; implementation of participatory irrigation management; providing the optimum benefit of the major and medium irrigation projects to the beneficiaries, committees through administrative control over Command Area Development Agencies; and Intra State River Linking Schemes. The Minor water resources department is entrusted with the revival of associated mauns/chaurs/ponds such as Guabari, Bikramppur, Rahuya, Larbhaiya, Situha, Pasoya, Barila Chhoti and Badi Patiya, Dakshin chaur among others around the wetland through the implementation of various central and state government schemes.

Department of Animal Husbandry and Fisheries

The management of wetlands outside the Protected Area (PA) network lie within the jurisdiction of the State Department of Animal Husbandry and Fisheries. The Bihar Fish Jalkar Management Act (2006), as amended in 2007 and 2010, provides the overarching framework for the management of these areas. The term Jalkar refers to a range of wetlands (including tanks, ponds, lakes, rivers, and watercourse channels, among others) in which makhana (Euryale ferox), singhara (*Trapa natans*) and fish are reared and is under the administration of the Department of Animal Husbandry and Fisheries. The departmental work is supported by block-level functional co-operatives which are actively engaged at different wetland complexes. As per provisions under the Act, these Jalkars are leased to fisher cooperatives on a seven-year cycle. The lease value is based on average production (generally for the past five years), and a price fixation committee sets average prices.

The Bihar Krishi Roadmap was initiated in 2008. It forms a comprehensive strategy for agricultural development contributing to food security and rural development. Given the challenges posed by climate change, rising population, and economic struggle, the Bihar Krishi Roadmap aims to enhance agricultural productivity, sustainability, and farmers' livelihoods through various initiatives and reforms, such as;

- Improved agricultural practices
- Crop diversification
- Integrated pest management
- Organic farming
- Irrigation and water management through micro-irrigation, rainwater harvesting, watershed management
- Market access
- Financial support and insurance
- Capacity building and extension services

Revenue and Land Reforms Department

The Revenue and Land Reforms Department deals with land management, land survey and settlement, land consolidation, land acquisition for different Central and State Government schemes, and the Agriculture Census of national importance. The department is also entrusted with settlements of the private claims to the Protected Area wetlands such as the Kanwar Lake Bird Sanctuary.

Department of Panchayati Raj

The Panchayati Raj system in Bihar was implemented in 1959, following the recommendations of the Balwant Rai Mehta Committee. The system has evolved over time, with several amendments and reforms to enhance its effectiveness. The 73rd Constitutional Amendment Act, 1992, empowered the

states to establish a three-tier system of Panchayati Raj institutions (PRIs) consisting of Gram Panchayat (village level), Panchayat Samiti (block level), and Zila Parishad (district level). Each tier of governance has its own composition, functions, and responsibilities, ensuring local self-governance and participatory decision-making.

The functions and responsibilities of the Panchayati Raj Department are:

- Planning and implementing various developmental programs concerning agriculture, infrastructure, health, education, and sanitation.
- Allocation and utilization of funds from the state and central government for rural development. The Department monitors the proper use of resources and ensures transparency.
- The department plays a crucial role in implementing schemes related to poverty alleviation, employment generation, women empowerment, and education.
- Organizing training programs for elected representatives and local officials to enhance their skills in governance, project management, and community engagement.

Bihar State Disaster Management Authority

The Bihar State Disaster Management Authority (BSDMA) was set up in 2005 according to the National Disaster Management Authority (NDMA) guidelines. Following this, the District Disaster Management Authority (DDMA) was instituted. The BSDMA is accountable for various actions as envisaged in the National Disaster Management Act, as per Section 18 (2). It lays down guidelines to be followed by the different state and district departments to integrate measures such as embedding wetlands conservation for the prevention of disasters and mitigation in their development plans and projects and provides necessary technical assistance therein.

Research and Academia

Many knowledge institutions and centres of excellence are involved in the conservation and management of wetlands in the state. Research institutions like the Zoological Survey of India, Pondicherry University, Central University of South Bihar, Bhagalpur University, IIT-Kanpur and others have addressed various aspects of wetlands like biodiversity, avifauna, land use dynamics, hydrologic regimes, pollution and socio-economics.

Civil Society Organisations

There are multiple initiatives taken by different Non-Government Organizations (NGOs) like Wetland International South Asia (WISA), BNHS, SEEDS, Jamia Rizwania Educational and Charitable Trust, Dharti Foundation and others for the assessment and management of wetlands in cooperation with the local community-based organizations. The grassroots community-based organizations are broadly represented by cooperative groups formed around wetland produce like fisheries, agricultural products, value-added products, or local conservation organizations. They support capacity building of shoreline communities and facilitate the implementation of government schemes and programs related to wetlands conservation.

3.1.1.7 Preparation of brief documents

Brief documents of 124 wetlands have been compiled (Table 5) and will be uploaded into an electronic database of the Environment, Climate Change & Wetlands Wing of the Department of Environment, Forest & Climate Change, Bihar. Each brief document has the following sections - Identification, location and Jurisdiction; Site characteristics; Biodiversity; Ecosystem services; Pre-existing rights and privileges; Present and potential threats; Activities proposed to be regulated; Activities proposed to be permitted and List of available scientific resources used. Apart from this, the document also contains the wetland site map and the map of the zone of influence.

Table 5: Number of wetland brief documents compiled in respective sub-basins

Sub-basin	Districts	Number of wetlands brief documents compiled
Ghaghar, Ghaghara Confluence to Gomti Confluence and Sone	Bhojpur	4
	Buxar	5
		9
Gandak and others	Begusarai	9
	Bhagalpur	19
	Chapra	7
	Katihar	1
	Khagaria	6
	Lakhisarai	2
	Munger	5
	Patna	7
	Samastipur	4
	Vaishali	6
		66
Kosi, Bhagirathi and others (Ganga Lower)	Bhagalpur	8
	Katihar	41
		49

3.2 Component 2: Wetlands monitoring and prioritization

3.2.1.1 Ecosystem functions and threats mapping

The 10–km buffer region around River Ganga channel has primarily the following three landform types which serve as host to the wetlands and determine its size and shape:

- River– linear, though not necessarily straight open depression formed by River Ganga, its tributaries.
- Flats – flat or slightly undulating terrain adjoining the channels which also serve as the floodplains.
- Basins – contained, closed depressions in the landscape forming a trough.

Water distinguishes wetland habitats from other terrestrial habitats and influences biological response by its presence, depth, chemistry and movement. The period of water availability in the wetland also

termed as 'hydro-period' usually characterized in terms of its permanence or intermittence, reflects the balance between precipitation and evaporation, recharge and discharge, permeability of underlying sediments and shape of the wetland. Generally, a mix of two hydrological conditions is seen in the landscape: inundated (free standing water over soils with soil below the surface being saturated), and waterlogged (soils that are saturated with water yet water does not inundate the soil surface). Therefore, three types of water permanence can be discerned in the landscape:

- Permanently inundated – water covers the land surface throughout the year.
- Seasonally inundated – surface water is present for extended periods especially post monsoon but gradually recedes by the end of winters or early summers.
- Seasonally waterlogged – substrate is saturated for extended periods with surface water being seldom present.

Combining the various type of landforms with various types of water permanence provides five major wetland types, which are shown in the Table 6.

Table 6: Hydro-geomorphic classes of wetlands in River Ganga floodplains

Hydrology **Landform**	**Permanently inundated**	**Seasonally inundated**	**Seasonally waterlogged**
Basin	Lake/Swamp/Marsh	Sumpland	Dampland
Flat		Floodplain	Palusplain
Channel	River	River	River

A wetland function score was derived for functions like flood buffering, groundwater recharge and water purification for each of the 124 wetlands surveyed in this sub basin. The classification scheme was based on 7 components (a) geomorphology (b) water source (c) water permanence (d) hydrodynamics (e) soil type (f) vegetation cover (g) wetland area. The properties of these following components were given weights with respect to the significance of their delivery to the function as shown in the Table 7. Wetlands were classified as per the properties of each component and the properties were rated as per their significance of the property to deliver the respective functions. The ratings are as shown in the Table 8. The functional score was estimated using the equation given below:

$$\mathbf{FS=\sum W_c \times R_c}$$

where FS is functional score, W_c is the weightage given to particular function and R_c is the associated functional score.

In terms of water purification, flood buffering and groundwater recharge performed by the wetlands, the following assumptions have been used:

- Depressions and flats offer a certain degree of water storage as per the depth. Deeper the depression, more will be the water stored in the wetland.
- Wetlands that a greater ability to store precipitation and surface run off offer better groundwater recharge.
- Wetlands having a horizontal mobility of water offer better water purification due to exposure to sunlight and horizontal flushing.
- Soil with high permeability have more hydraulic conductivity, thereby storing and transporting more groundwater. High permeability also allows water to flow through a porous media which act as a filtration unit. It can also help in storing excess water during flooding event.
- Vegetation along wetlands trap excess sediments and heavy metals thereby helping in flood buffering and purification of water. However, a lesser vegetation cover facilitates greater groundwater recharge owing to the fact that vegetation cover is inversely proportional to the surface area of water in the wetland.

Table 7: Weights of the components to deliver the respective wetland function

Components/Functions	Flood buffering	Groundwater recharge	Water purification
Geomorphology	0.6	0.6	0.3
Water source	0.3	0.3	0.3
Water permanence	1	1	0.6
Hydrodynamics	0.6	1	0.3
Soil type	0.3	0.6	0.6
Vegetation Cover	0.3	0.6	1
Wetland Area	1	0.6	1

The influence gradient for each category on the functions has been listed in Figure 12

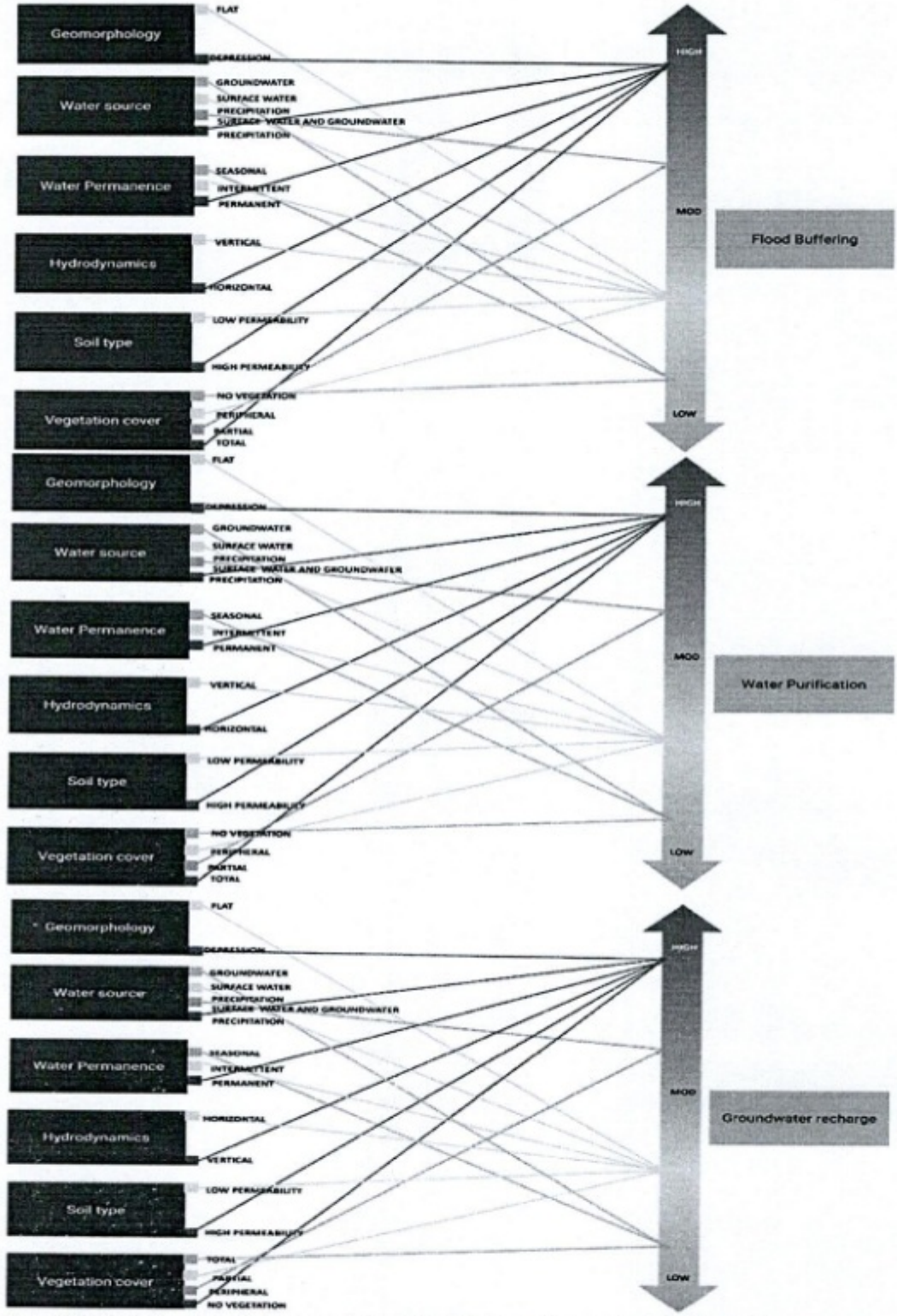


Figure 12: Functional score gradient of major identified functions based on its characteristic features

Table 8: Ratings of the properties of components to deliver the respective wetland function

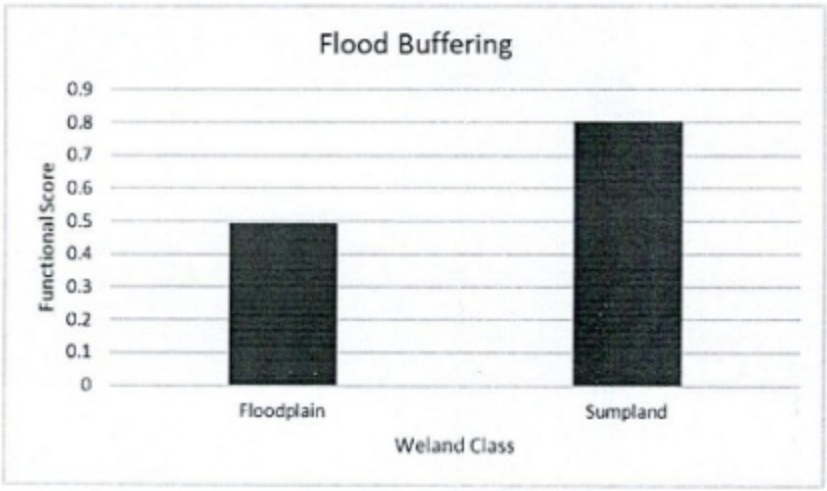
Components/Functions	Properties	Flood buffering	Groundwater recharge	Water purification
Geomorphology	Flat	5	5	5
	Depression	10	10	10
Water source	Only precipitation	10	10	10
	Precipitation and surface runoff	5	5	5
	Groundwater	1	1	1
	Surface water and groundwater	8	8	8
Water permanence	Seasonal	1	1	1
	Intermittent	5	5	5
	Permanent	10	10	10
Hydrodynamics	Horizontal	10	5	10
	Vertical	5	10	5
Soil type	Soil with high permeability	10	10	10
	Soil with low permeability	5	5	5
Vegetation Cover	Total	10	1	10
	Partial	8	5	8
	Peripheral	5	8	5
	No Vegetation	1	10	1
Wetland Area	<1 ha	1	1	1
	1 to 5 ha	3	3	3
	5 to 10 ha	5	5	5
	10 to 20 ha	7	7	7
	20 to 30 ha	8	8	8
	>30 ha	10	10	10

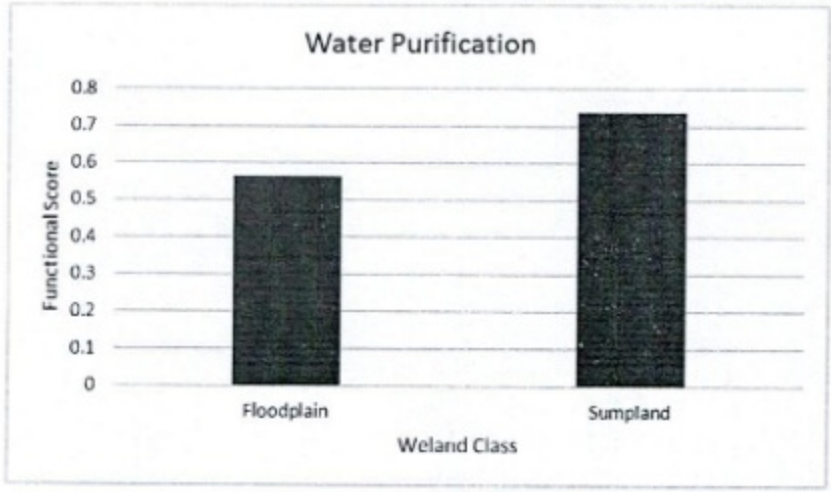
The functional scores for each function of all wetland classes are shown in Figure 13, Figure 14 and Figure 15.

In sub basin 1, the wetland classes of floodplain and sumpland are present. The overall functional scores for flood buffering, groundwater recharge, and water purification have been found to be higher for the sumpland compared to the floodplain within the basin.

Dampland, floodplain, lake, palusplain, river and sumpland wetland classes are present in sub basin 2. Lake has been found to be highly functional in the basin with highest functional score with respect to flood buffering, groundwater recharge and water purification within the basin.

Dampland, lake, palusplain, river and sumpland are the wetland classes present in basin 3. Among these, lake and sumpland were found to be highly functional with respect to flood buffering, groundwater recharge and water purification.





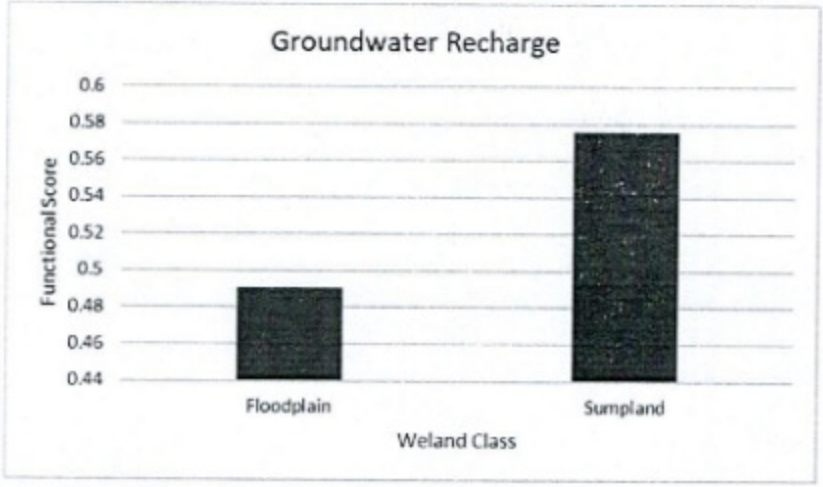
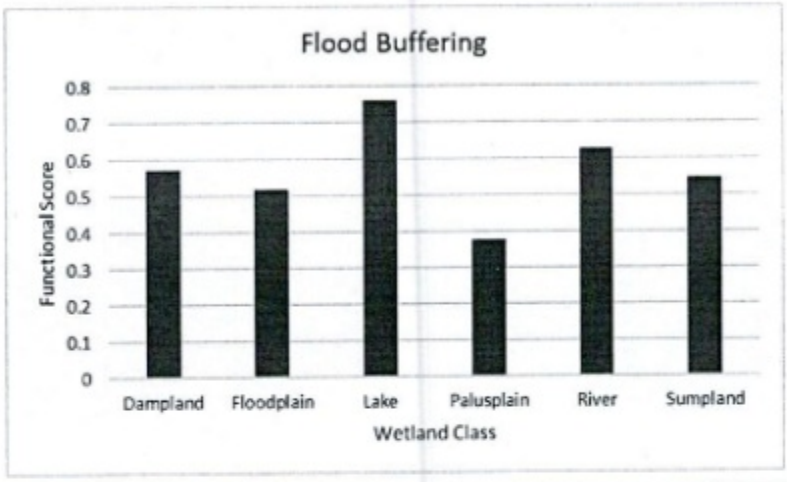
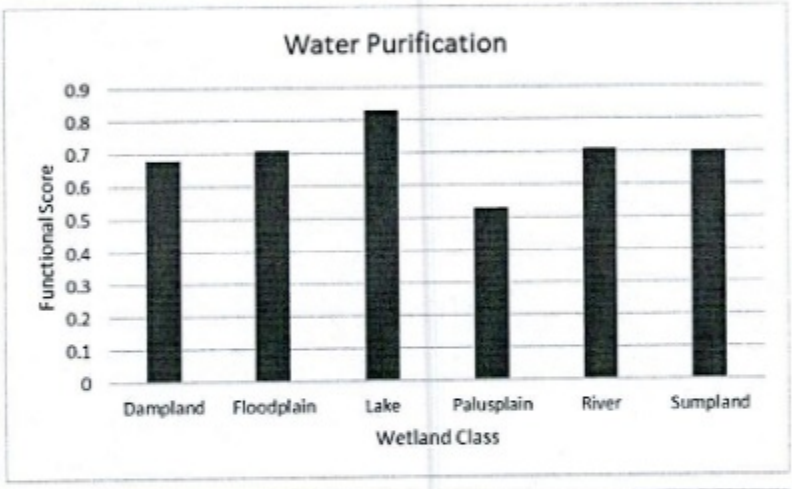


Figure 13: Functional scores for each function of all wetland classes in sub basin 1





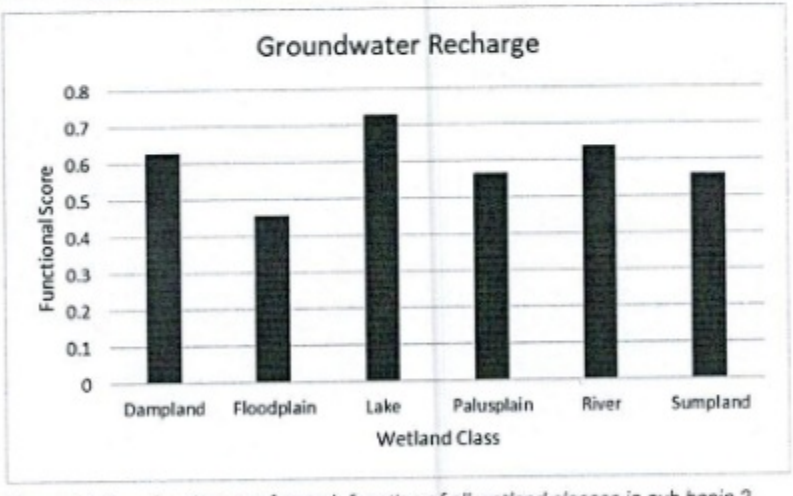
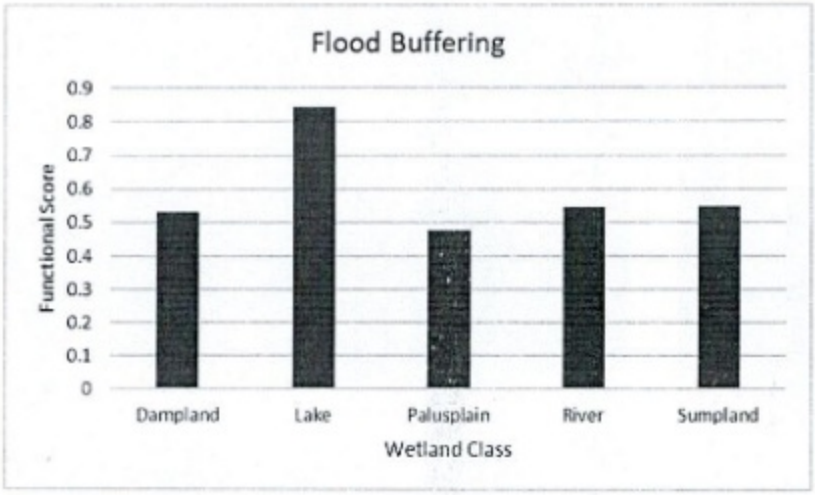
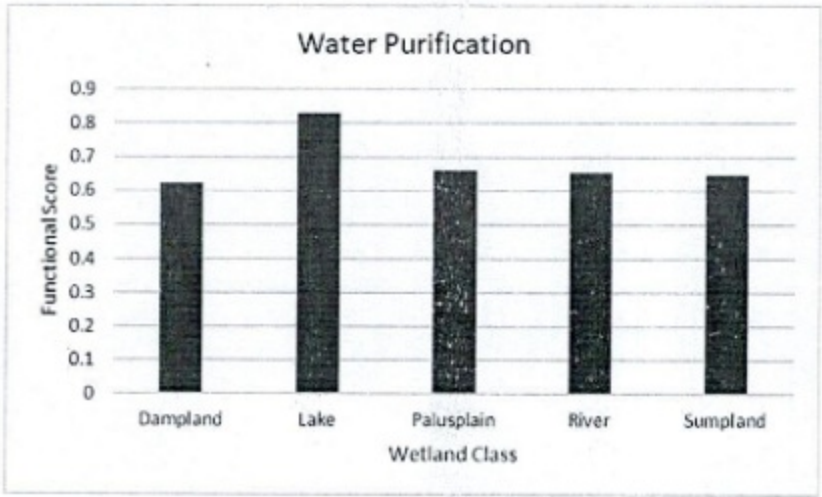


Figure 14: Functional scores for each function of all wetland classes in sub basin 2





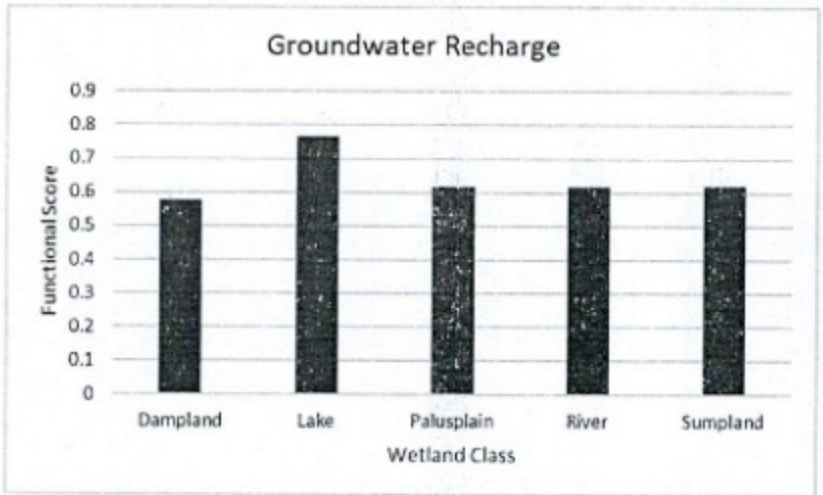


Figure 15: Functional scores for each function of all wetland classes in sub basin 3

3.2.1.2 Wetlands Prioritization

A functional score (FS) was derived for key functions of the wetland like groundwater recharge potential, flood buffering and water purification using the hydro-geomorphic approach wherein the wetlands were ranked as per the significance of functional attributes like geomorphology, water source, water permanence, hydrodynamics, soil type and vegetation. The score was then aggregated with the ecosystem service index (ESI) derived from the ecosystem services assessment using the RAWES tool for the surveyed wetlands. The aggregate score was the plotted in a quadrant chart against the threat score for the individual wetlands. Wetlands exhibiting High FS+ESI Score and High Threat Score were given High Priority for conservation and management. Wetlands having High FS+ESI Score and Low Threat Score and, Low FS+ESI Score and High Threat Score were given Moderate Priority for conservation and management Figure 16). The plotted graph (Figure 17, Figure 18 and Figure 19) for all surveyed wetlands summarises the wetlands prioritised and categorized into three phases based on their significance for management interventions in the sub basin. Thus, Phase 1 corresponds to high priority, 2 to moderate priority and 3 to low priority wetlands respectively.

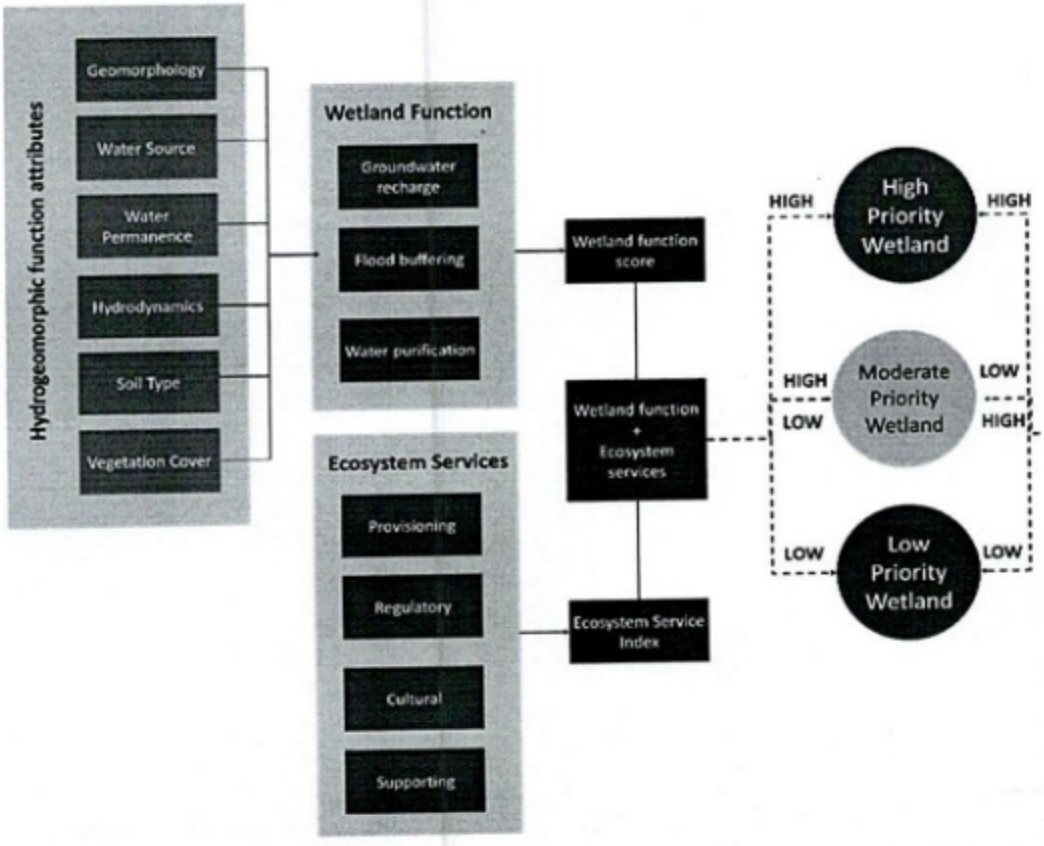


Figure 16: Phasing justification diagram based on cumulative aggregate of ecosystem services index, functional scores and threat scores

All the wetlands in sub basin 1 lies within high priority category with high function and high threat score. Wetlands like Gokul Jalashay, Badka Taal and Lohandiya has highest function and threat score and needs to be priortised for management.

In sub basin 2, around 50 wetlands lies under high priority category, 12 wetlands lies under moderate priority and 2 wetlands lies under low priority. Wetlands like Madhopur Patpar, Jamunapur Rudar, Paharpur and others needs to be priortised for management for their high functionality and threat.

In sub basin 3, 26 wetlands lies under high priority category with high threat and high function score, 20 wetlands lies under moderate priorty with high threat low function or low threat high function score and 3 wetlands lies under low priorty category with low threat and low function scores.

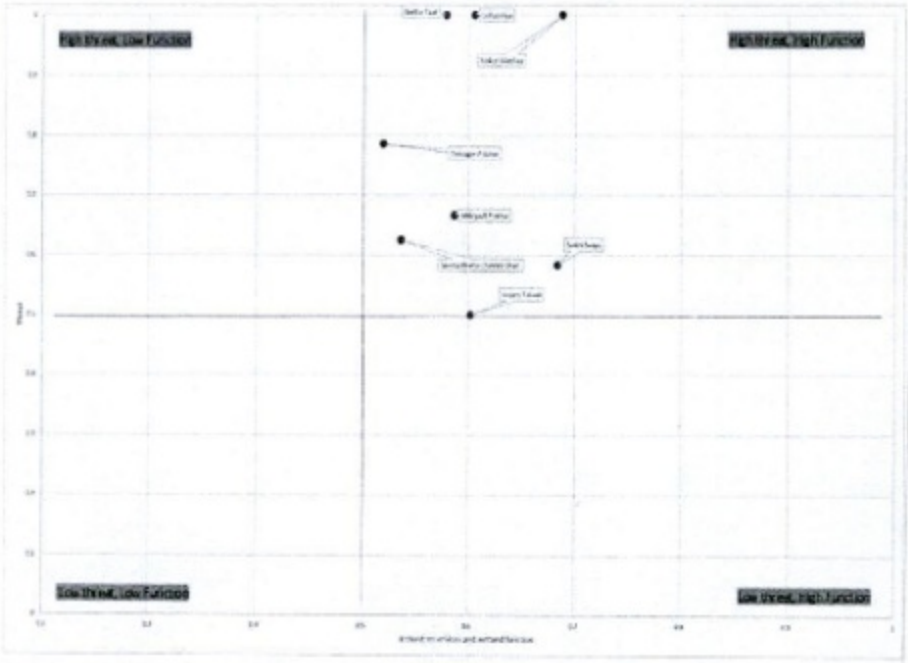


Figure 17: Categorising wetlands on the basis of their threat scores, ecosystem services index and phasing for basin 1

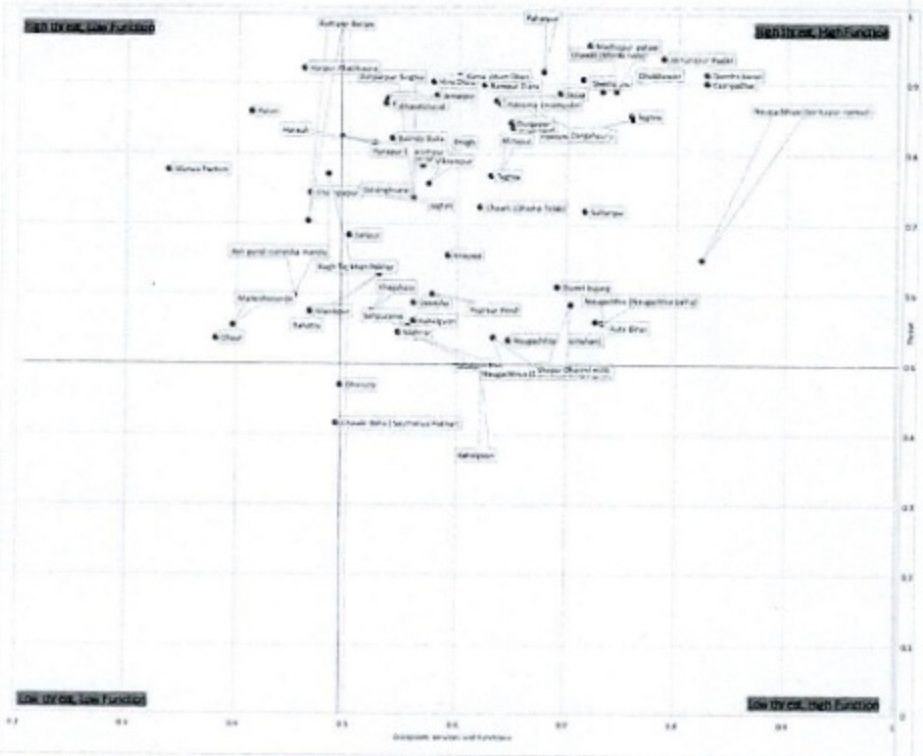


Figure 18: Categorising wetlands on the basis of their threat scores, ecosystem services index and phasing for basin 2

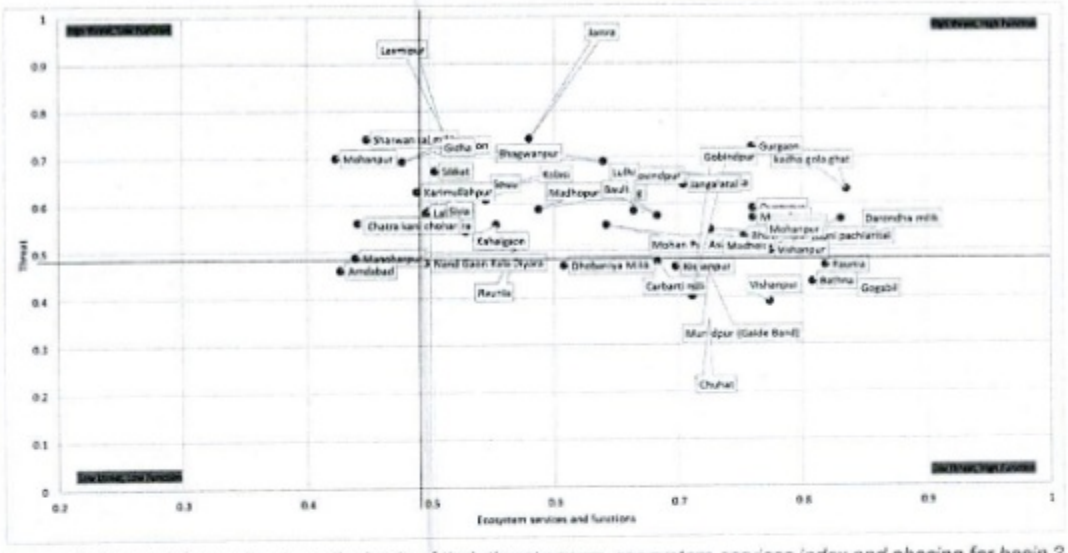


Figure 19: Categorising wetlands on the basis of their threat scores, ecosystem services index and phasing for basin 3

Wetlands have been categorised in four management categories i.e. Village Ponds, Urban and Peri-urban wetlands, Agricultural floodplains and Fishery wetlands. The Ganga floodplain wetlands can be classified in to different categories based on the landscape setting and wetland use. Wetland ownership is heterogenous but ownership can be attached to each class based on the dominant institution.

- Ponds - The wetlands less than 5 ha are classified as ponds. Mostly these wetlands fall within the jurisdiction of a Gram Panchayat. Funds are earmarked as part of village development plans for the development of wetland and water resources.
- Urban/Peri-urban wetlands - The wetlands within urban limits are mostly managed by municipalities unless privately owned.

Another classifier is the wetland use and rights and privileges that communities enjoy in these wetlands. Mostly wetlands are used for agriculture.

- Agricultural floodplains - Agricultural floodplains occupy peripheral areas around villages, rivers, roads. Located away from human settlements, many serve as buffer zones and as connectors and migration corridors between national parks, wildlife sanctuaries and reserved and protected forests.
- Fishery wetlands: Wetlands primarily used for fisheries have been classified as fishery wetlands. The ownership of these wetlands are mainly with the Fisheries department.

Table 9, Table 10 and Table 11provide detail description of wetlands under the different management categories in respective sub basin

Table 9: Description of management categories in sub basin 1

	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
Pond (N=3)	Small wetlands <5 ha area. The wetlands are naturally formed in flats or depressions. The majority of these wetlands (66%) are hydrologically connected, while all remain seasonally inundated. The median water depth across these wetlands is 2.5 meters.	These wetlands are noted for their regulatory services, particularly in mitigating water shortages during droughts and in regulating flood hazards, with a score of 0.78. Additionally, they play an important role in supporting ecosystem services (0.73), especially in nutrient cycling and soil formation.	These wetlands face several major threats, including excessive water extraction for irrigation, overfishing, overgrazing, and the leaching of animal waste.	Majority wetlands are under government control (66%)	Fishing and plant harvesting, managed by government departments and conducted without leases, occur in 100% of the wetlands. Furthermore, all wetlands are used for bathing and animal wallowing, with significant religious practices taking place in and around these wetland areas.
Fihseries Wetlands (N=2)	The wetlands are relatively large in size, with all (100%) naturally formed in depressions. They are seasonal and connected in nature.	The wetlands offer substantial supporting services, receiving a score of 1, particularly in habitat provision and nutrient cycling. Regulatory services are also highly valued, with a score of 0.78, followed by cultural services (0.5)	A major threat to these wetlands is the excessive extraction of water for irrigation and domestic use. They are also vulnerable to unsustainably high levels of fish harvesting. Furthermore, the presence of invasive plant species intensifies these threats.	The wetlands are jointly owned by Village Panchayats and Private owners	All of the wetlands (100%) report fishing activities carried out under government lease agreements as well as through private means. Additionally, water is withdrawn from all wetlands for both

`	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
		and provisioning services (0.4).			domestic and agricultural purposes. Religious activities are also commonly observed across all of these wetlands.
Floodplain Agricultural Wetlands(N=3)	Wetlands range in size from 6 to 460 hectares. All (100%) are permanently inundated and connected in nature. 6m is the median water depth	The wetlands provide high regulatory (0.83) and supporting services (0.80), including nutrient cycling, water regulation, pollination, and water availability during droughts. Additionally, they hold significant spiritual and religious value, with a score of 0.5.	The wetlands are threatened by excessive water extraction for irrigation, nutrient loading from agricultural runoff, alterations or reductions in natural water inflows, and the leaching of both animal and human waste.	All wetlands are owned by government. With (66.6%) under village panchayats and remaining 33% under revenue department	All of the wetlands (100%) are subjected to water abstraction for irrigation purposes. Additionally, nearly all are used for the wallowing or bathing of domesticated animals. Fishing activities under lease agreements take place in 100% of these wetlands.
Urban and Peri-Urban Wetlands (N=1)	The wetlands has an area of 3.24 ha and is surrounded by built up as roads and settlements. The flow of wetland is static with vertical flow and is seasonally inundated	The supporting services (0.8) were regarded as the most important, followed by regulatory services	the wetland face significant threats, including the construction of powerlines in and around its area. Pollution is a major concern, with the discharge of	fully owned by government	The wetland is utilized for fishing activities with formal government lease. It is also subject to water withdrawal for agricultural and domestic

	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
			untreated sewage and the dumping of solid waste being widespread. Furthermore, substantial groundwater extraction and the harvesting of wetland plants in the surrounding areas exacerbate these challenges.		purposes and experiences the bathing and wallowing of domestic animals.

Table 10: Description of management categories in sub basin 2

Management categories	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
Pond (N=8)	Small wetlands <5 ha area. The wetlands are naturally formed in flats or depressions. Th e majority of these wetlands (63%) are isolated, while only 13% remain permanently inundated. Additionally, 87% of the wetlands exhibit static waters with vertical flow patterns.	These wetlands are primarily recognized for their regulatory services, particularly in flood hazard regulation, with a score of 0.63. They also provide moderate levels of cultural services (0.53) and supporting services (0.52).	These wetlands are subject to several significant threats, including alterations in natural water inflows, increased sediment deposition within and around the wetlands, groundwater extraction for irrigation in nearby areas, the	75% of the wetlands are fully owned by Government, the rest are privately owned	Fishing and plant harvesting under government department leases are prevalent, occurring in more than 87% of the wetlands. Additionally, around 50% of these wetlands hold cultural significance, with religious practices conducted in

Management categories	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
		However, the overall ecosystem services offered by these wetlands are lower compared to those provided by agricultural wetlands.	introduction of invasive plant species, and the discharge of untreated sewage.		and around the wetland areas.
Floodplain Agriculture Wetlands (N=8)	Wetlands range in size from 5.5 to 75 hectares. Most of these wetlands are formed in depressions, with 75% being seasonal and connected in nature. Depths vary significantly, with a maximum range of 2 to 50 meters.	High regulatory (0.7) and supporting services (0.62) owing to local climate regulation, water regulation and provision of habitat,	The wetlands are threatened by excessive water extraction for irrigation, nutrient loading from agricultural runoff, drainage through channelization , the construction of power lines, and the leaching of animal waste.	75% are privately owned (50% fully owned and 25% partially by governments and private owners)	Agricultural practices are conducted in 75% of the wetlands, while all (100%) wetlands are subject to water abstraction for irrigation purposes. Additionally, 87% of the community utilizes these wetlands for willowing or bathing their domesticated animals. Fishing activities conducted under lease agreements occur in 38% of the wetlands.

Management categories	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
Fisheries Wetlands(N=22)	The size of the wetlands ranges from 6 to 74 hectares. Most of the wetlands are formed in depressions and channels, with 59% being connected and permanently inundated. The depth of these wetlands varies between 2 and 40 meters, with a median depth of 10 meters.	Provides substantial supporting services, with a score of 0.76, including habitat provision and water cycling. Regulatory services are also highly valued, scoring 0.67, followed by cultural services (0.47) and provisioning services (0.33).	A significant threat to the wetlands is the reduction or alteration of natural water inflows, accompanied by shifts in the timing of water availability. Over extraction of fish, due to the wetlands' use for fishing, has become a major concern, as has the discharge of sewage into the wetlands. Additionally, nutrient-rich runoff from nearby agricultural fields further exacerbates the threats facing these ecosystems	Majority wetlands are completely under government control (73%)	Nearly 91% of the wetlands report fishing activities conducted under government lease agreements. Additionally, water is withdrawn from 32% of the wetlands for domestic and agricultural purposes. Boating activities are also observed in 32% of these wetlands.

Management categories	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
Urban and Peri-Urban Wetlands (N=28)	The majority of the wetlands are smaller than 20 hectares in size, with a median depth of 10 meters. Half of the wetlands (50%) are isolated, while the other half (50%) are connected. Nearly all of the wetlands (90%) are seasonal in nature.	The regulatory services (0.64) were perceived to be important followed by supporting services (0.49).	The wetlands are located in areas with large populations, which renders them susceptible to pollution, particularly from the dumping of solid waste and the discharge of untreated sewage. Additionally, there is significant groundwater extraction in the surrounding areas. The construction of houses within the wetland zone, along with the presence of roads and power lines nearby, poses a continual threat to these ecosystems	69%of the wetlands are owned by government while around 32% are privately owned. These wetlands suffer from a lack of maintenance and are continuously exposed to various threats.	The primary uses of wetlands include irregular fishing activities (92%), grazing (64%), and bathing of animals (67%).

Table 11: Description of management categories in sub basin 3

Management categories	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
Village Pond (N=18)	Small wetlands <5 ha area. The wetlands are naturally formed in channels or depressions. All wetlands (100%) are isolated. The maximum depth varies from 2 to 20 m with a median value of 5 m. Majority of the wetlands (94 %) remain only seasonally inundated	These wetlands hold significant potential for providing regulatory services (0.79), though they exhibit limited cultural value (0.51), likely due to waste discharge into the ecosystem. Additionally, they play an important role in delivering supporting services (0.66). However, the provisioning services of these wetlands are comparatively lower and not prominent across all areas.	These wetlands face numerous threats, primarily driven by local factors. Notable among these is the extraction of groundwater near wetlands for irrigation purposes, alongside the discharge of nutrient-rich agricultural runoff, household toilet waste, and untreated sewage into the ecosystem.	Majority wetlands are privately owned (72.2%)	Fishing (66.6%) and the harvesting of aquatic plants (72.2%) are prevalent activities, occurring in over half of the wetlands. Additionally, 88% of these wetlands are utilized for agricultural purposes.
Floodplain Agriculture Wetlands (N=5)	Wetlands size varies from are 20-110 ha in size. Shallow wetlands with depth of 1 to 6 m. All wetlands (100%) are seasonal in nature.	High regulatory (0.85) and supporting services (0.76) owing to their groundwater recharge, local climate regulations and provisions of habitat	The wetlands face the threat of excessive water extraction for irrigation, alteration in natural water inflows, nutrient loading from agricultural runoff, excessive extraction of fish, and	40% partly or fully owned by governments and rest have private ownership	Agricultural practices are conducted in 60% of the wetlands, while 80% of these wetlands experience water abstraction for irrigation purposes. The use of boats is also common in

Management categories	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
			structural modification through construction of roads		approximately 80% of the wetlands. Additionally, grazing of domesticated animals is highly prevalent in these areas.
Fisheries Wetlands(N=25)	Wetland vary in terms of area ranging from 6 to 124 ha. The maximum depth varies from 2 to 20 m with a median value of 5 m. The wetlands are formed in channels or depressions with the Majority of the wetlands (80 %) remaining only seasonally inundated	The wetlands offer substantial regulatory services (0.82), which encompass water supply during droughts and disease regulation in livestock. Additionally, supporting services are highly valued (0.67), followed by cultural services (0.6) and provisioning services (0.56).	A shift in the timing of water availability has emerged as a significant threat to the wetlands. Given their use for fishing, the overextraction of fish has become a major concern, alongside the removal of wetland soils. Furthermore, the discharge of nutrient-rich runoff from adjacent agricultural fields poses an additional threat to these ecosystems.	60% of the wetland is fully government owned while around 40% is privately owned (20%) of which is jointly owned by government and individuals	The rights and privileges associated with the wetlands aim to meet the subsistence needs of local communities, with 84% of fishing activities conducted under government lease. Additionally, water from 92% of the wetlands is withdrawn for agricultural purposes. The utilization of these wetlands for religious practices is also significant.

Management categories	Area and other morphological features	Ecosystem services predominance	Threats predominance	Ownership	Rights & privileges
Urban and Peri-Urban Wetlands (N=1)	The wetlands has an area of 18.95 ha and is surrounded by built up as roads, settlements, railway. The wetland is isolated and is seasonally inundated	The regulatory services (0.5) were regarded as the most important, followed by provisioning services (0.4). No supporting or cultural services have been identified in association with the wetland.	The wetlands are subject to intense threats, including drainage through channelization and the construction of roads within wetland areas. Pollution is a particularly significant issue, with the discharge of untreated sewage and the dumping of solid waste being prevalent. Additionally, groundwater extraction in the areas surrounding the wetlands is substantial.	Fully Privately owned	The wetland is utilized for fishing activities without any formal government lease. It is also subject to water withdrawal for agricultural and domestic purposes and experiences the bathing and wallowing of domestic animals.

Table 12, Table 13 and

Table 14 provides the details of phasing of different wetlands within different basins and management categories. Phasing of wetlands for management has been done on the basis of their priortization. High priority wetlands have been scheduled to be managed in Phase 1. Similarly wetlands of moderate priority have been scheduled for Phase 2 and wetland of low priority have been scheduled for Phase 3.

Table 12: Category of wetlands in the basin 1 based on their phase and management category

Management Categories	Phase 1	Phase 2	Phase 3
Village Ponds	Badka Taal Dalsagar Pokhar Milkipull Pokhar		
Urban and peri-urban wetlands	Anjani Talaab		

Management Categories	Phase 1	Phase 2	Phase 3
Agricultural Floodplain wetlands	Lohandiya Nathmalpur Bhagad Semra Bhatu Chakiya Ghat		
Fishery	Gokul Jalashay Sukhi Suiya		

Table 13: Category of wetlands in the basin 2 based on their phase and management category

Management categories	Phase 1	Phase 2	Phase 3
Village Ponds	Harauli Kama sthan Dhan Minapur Sajua Shapur Dharmi milik	Chaur Patori	Chawki Balia (Sauthaliya Pokhar)
Urban and peri-urban wetlands	Ashpatpur Singhia Bahatra Begampur Bharatkhand Bihpur Dhighi Durgapur Jamalpur Kahalgaon Kasriyadhar Pokrama Emampakri Rampur Diara Sabalpur Pachami Sultanpur Temtha karari	Ash pond mahesha manda Bagh Taj khan Pokhar Champapur Maheshananda Manikpur Marwa Pachim Panapur Dharampur Kahalgaon	Dhanura
Agricultural Floodplain wetlands	Jagteli Khajuhata Kutlupur Diyara Papraur Pond		

Management categories	Phase 1	Phase 2	Phase 3
	Sahpur Sahpuraina Shekhpura Teghra Naugachhiya (Dumariya Chaparghat) Naugachhiya (Bornahan) Naugachhia (Naugachhia balha)		
Fishery	Auta Bihar Bakhda Balia Bishanpur ber Dalsinghsarai Dargahpur Deemha Dhobhawan Dumri bujurg Hiro Diara Jamunapur Rudar Khauwa Madhopur patpar Mahnar Paharpur Sonaru Teghra Vikrampur Naugachhiya (Jairmapur nankar) Chawki (Dhamp Talab) Chawki (Murda nala)	Harpur Phatikwara Rattipur Bariya	

Table 14: Category of wetlands in the basin 3 based on their phase and management category

Management categories	Phase 1	Phase 2	Phase 3
Village Ponds	Durgapur Jamra Jangalatal Lakhanpur Laxmipur Lulhi Madheli Muradpur	Chatra kani chohar Gidha Karimullahpur Lahsa Mohanpur Sisia Dhobaniya Milik Kishanpur	Amdabad Nand Gaon Kala Diyara
Urban and peri-urban wetlands	Kahalgaon		
Agricultural Floodplain wetlands	Lahsa Madhepura Madhopur bhorang Mardauni pachiarital	Raunia Vishanpur	
Fishery	Baulia Bhagwanpur Bhawanipur Darondha milik Govindpur Gurgaon kadha gola ghat Kolasi Mohan Pur Asia Mohanpur Raunia Sikkat Sowa	Ishapur Kahalgaon Sharwan tal milik Bathna Carbarti mili Chuhat Gobindpur Gogabil Muradpur (Gaide Band) Vishanpur	Manoharpur

3.2.1.3 Ecosystem Health Report Card

Wetland Health Cards for the surveyed wetlands were prepared to help identify immediate threats and identify priority areas for future conservation works. The scores assess wetlands using nine indicators

across four broad categories - Area, Hydrology, Biodiversity and Governance. The wetland health scores were categorized from A+ to E as per Table 15.

Table 15: Categorization of health score based on the ecosystem health assessment

Health Score	Excellent	0.96-1.00	A+
	Very Good	0.91-0.95	A
	Good	0.86-0.90	B+
	Moderate	0.81-0.85	B
	Fair	0.76-0.80	C+
	Bad	0.71-0.75	C
	Very Bad	0.61-0.70	D
	Worse	0.51-0.60	E

In sub basin 1, most of the floodplain wetlands are in category E indicating poor health. Isolated sumplands have poor health with wetlands lying under category D. Wetlands within the basin have Dissolved Oxygen more than 4 mg/l indicating good water quality. However, components such as lack of institutional and management framework, presence of invasive species and conversion of wetland to non-wetland use is leading to overall bad health score. (Figure 20 and Map 7)

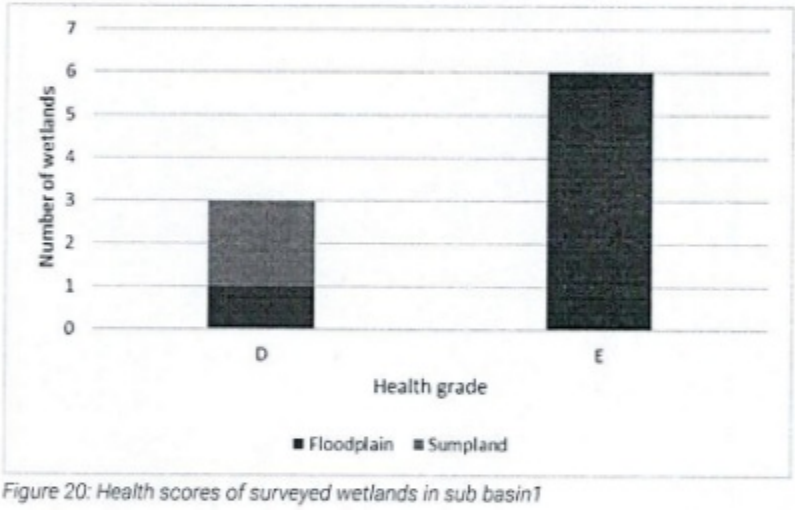
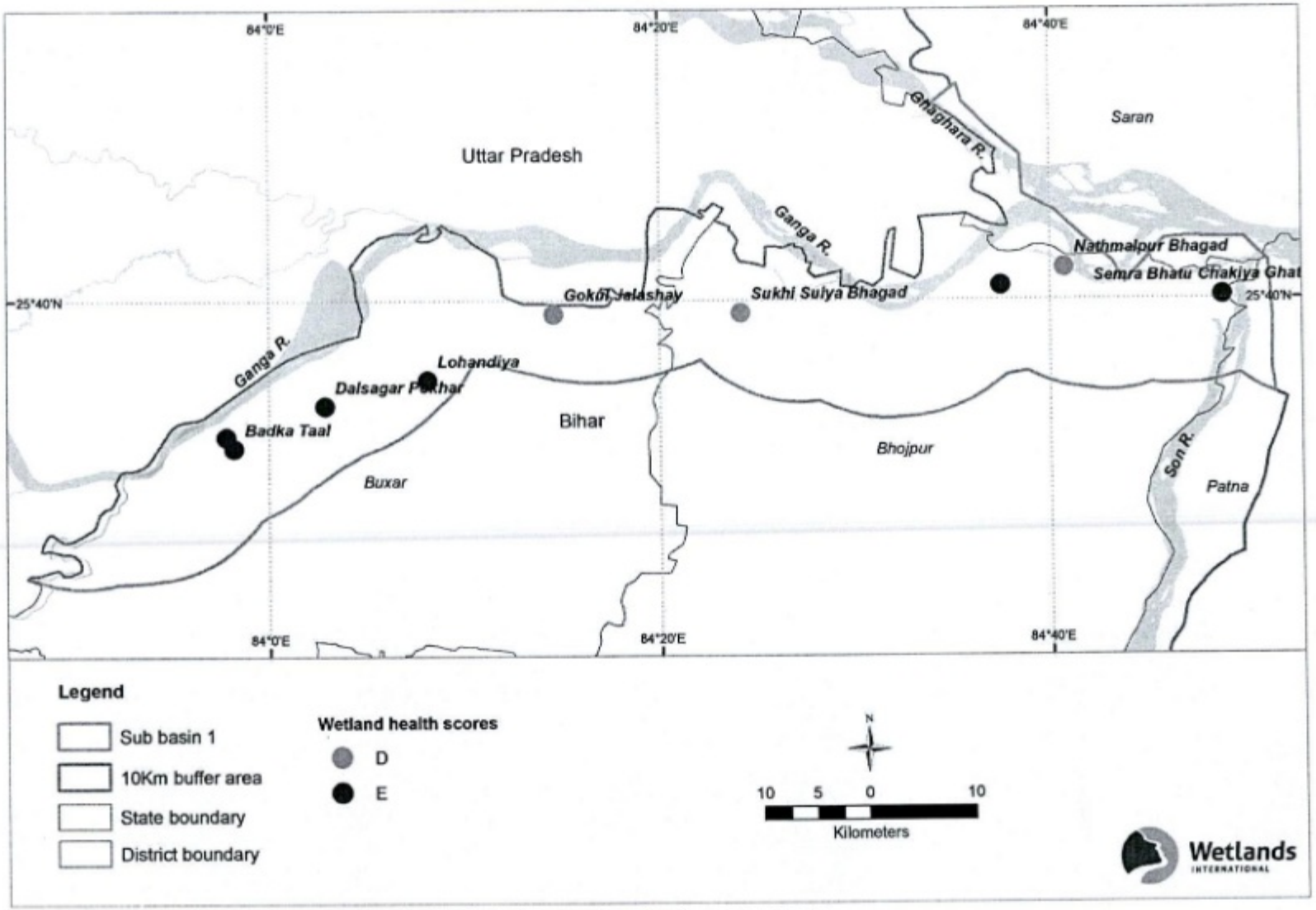


Figure 20: Health scores of surveyed wetlands in sub basin1



Map 7: Surveyed wetlands under different categories in the 10 km buffer zone along River Ganga in sub basin1

In sub basin 2, all wetlands are lying under category D and E indicating poor health status. Few wetlands within the basin like Sajua and Sahpur have not been converted to non-wetland use since 2008. However, there is a clear lack of governance structure within the basin for the conservation and management of these wetlands. Nearly 92% of the wetlands in the basin lies in category E of health grade whereas 8% of the wetlands lies in category D. (Figure 21 and Map 8)

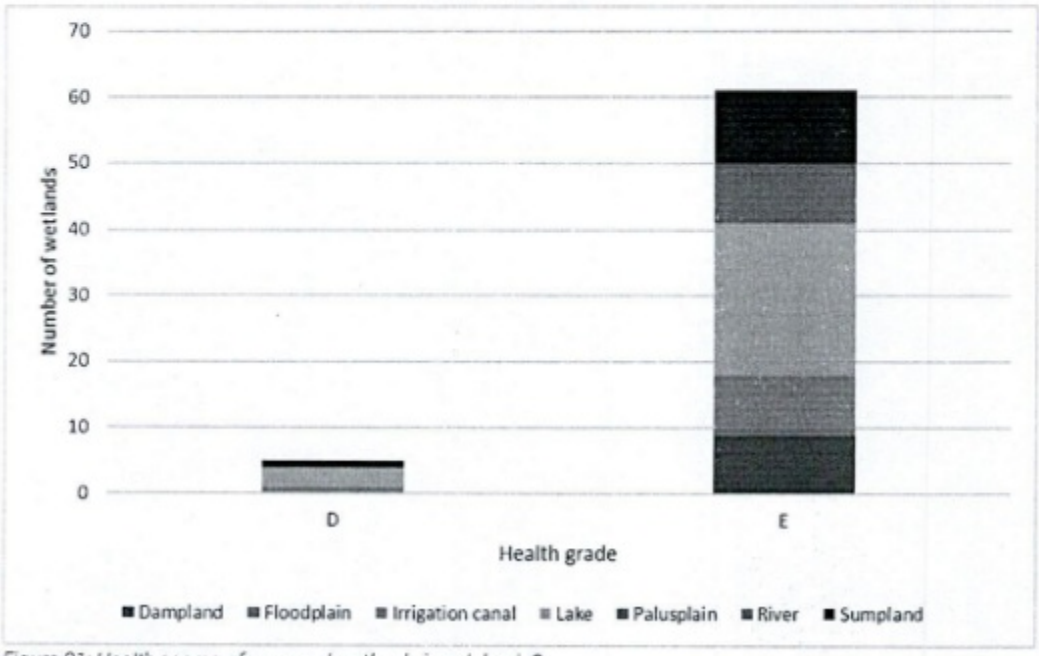


Figure 21: Health scores of surveyed wetlands in sub basin2

Wetlands within sub basin 3 have health grades of category D and E indicating poor health. Hydrological and catchment indicators such as status of inlets, outlets and water quality are in good state. However, indicators related to wetland biodiversity and governance are in poor condition. Most of the wetlands within the basin are converted for non-wetland use emphasising their protection through strong regulatory regime. (Figure 22 and Map 9)

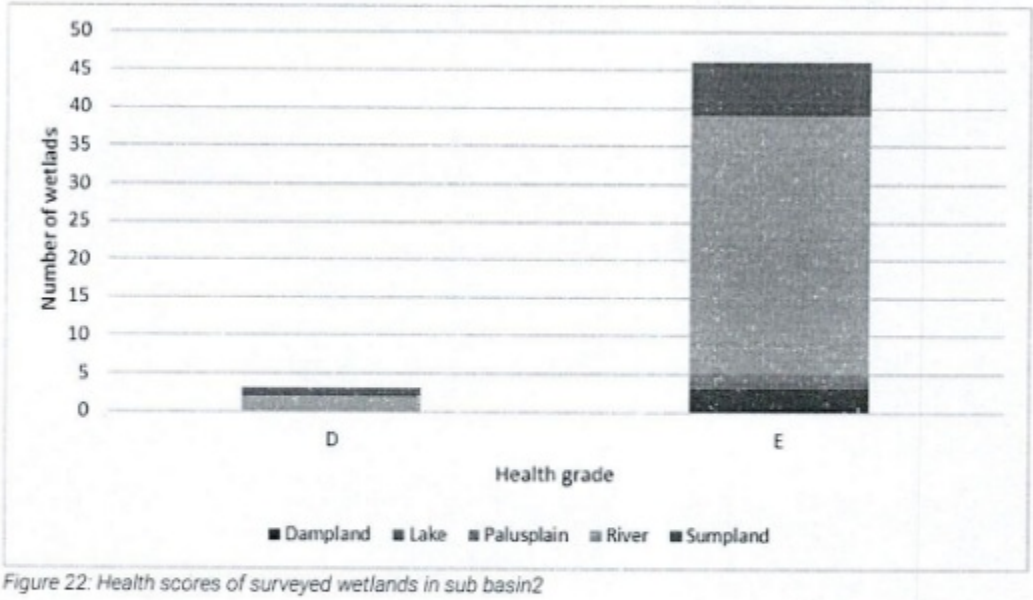
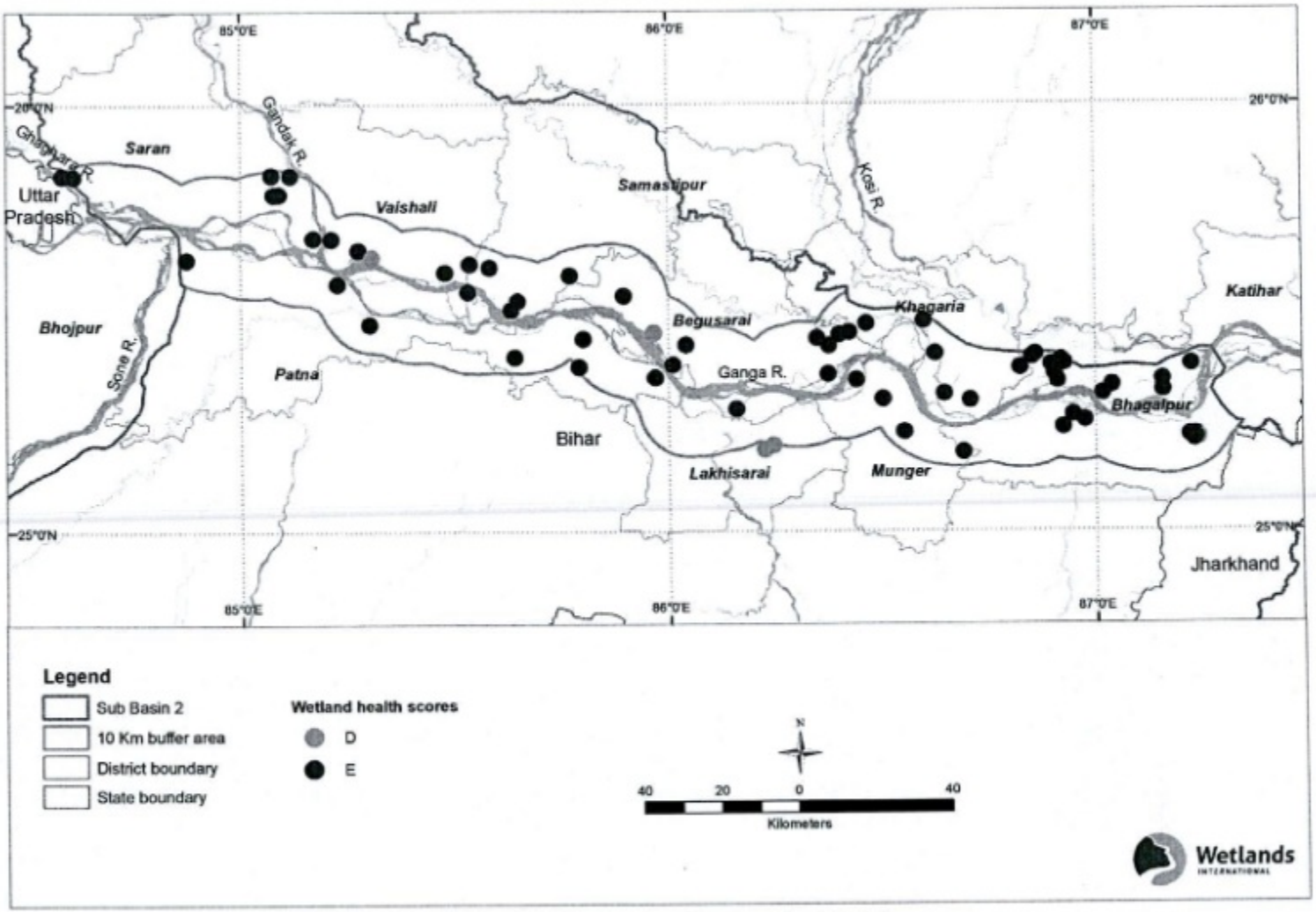
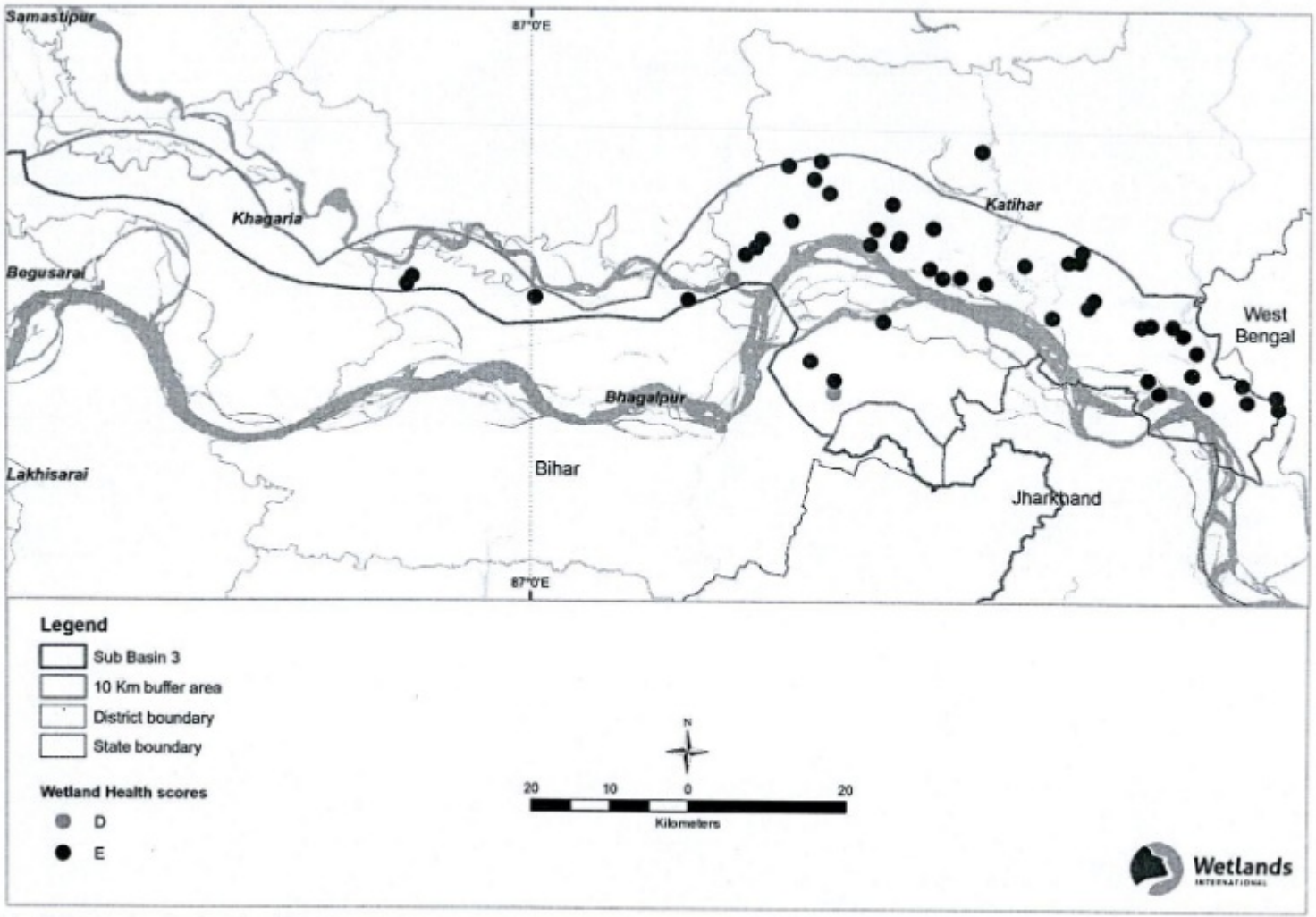


Figure 22: Health scores of surveyed wetlands in sub basin2



Map 8: Surveyed wetlands under different categories in the 10 km buffer zone along River Ganga in sub basin2



Map 9: Surveyed wetlands under different categories in the 10 km buffer zone along River Ganga in sub basin3

3.2.1.4 Threat Mapping

Gangetic floodplain wetlands in Bihar have been subjected to a wide range of anthropogenic disturbances accentuated by rapid and unregulated development along with an increase in use of chemicals in agricultural inputs since advent of green revolution. As an offshoot of the same, the region saw an increase in population due to rapid economic activities with repercussions for natural ecosystems including wetlands.

Assessments of change in land use and land cover has brought to fore the loss of wetlands to the tune of 4070 ha, assessed for the period of 2008-2023. The primary causes underpin conversion to non-wetland uses, pollution, declining groundwater levels and unsustainable harvest as major stressors that have contributed to this loss of wetlands. Also, embankments constructed as a response to annual flood inundation regime of River Ganga in the state, has caused a significant reduction in riverine connectivity and have adversely influenced hydrodynamics of floodplain wetlands.

Requirements of water intensive crops introduced by green revolution has led to development of extensive network of irrigation canals that have added to fragmentation caused by linear infrastructure while simultaneously giving rise to a new set of wetlands that are sited along these structures, receiving their inflows from these canals. It has also added to non-judicious abstraction of groundwater often influencing the local hydrodynamics of the region. Also, indiscriminate use of chemical inputs like pesticides and fertilizers, required for achieving higher agricultural productivity of such crops, have increased the risk of their leaching into wetlands with consequences like excessive nutrient loading, proliferation of invasive floral species and eutrophication for the ecosystem with implications for population of native species and ecosystem's life sustaining functions.

Increasing upstream demand for water for agriculture and fragmentation of hydrological regimes through the construction of dykes and channels have caused an overall reduction in water availability, Increase in sedimentation, and shrinkage in the wetland floodplain area.

It was also observed during baseline survey that overall vulnerability of wetlands was also increased due to a general lack of awareness about values and functions of wetlands amongst shoreline communities, that at many places consider them as mere "wastelands". This attitude of apathy amalgamated with broader governance and management issues has led to overall deterioration in condition and functions of wetlands in the landscape.

Identification of direct drivers of adverse change in wetlands is an important step in designing of efficient and cost-effective strategies for management of such threats. For the wetlands located within landscape, 25 direct drivers of threat (parameters) were identified, based on secondary research and field data collected on the same by means of semi-qualitative primary survey. These parameters were further classified under 4 broad classes and 9 sub-classes based on the schematic threat analysis provided by "Global Wetlands Outlook" 2018, as shown below in Table 16:

The threat data obtained through survey was then graded on a scale of 0-3, with 0 signifying none to 3, high level of threat faced by wetlands.

Scoring was done by considering average score in respective sub class and then calculating percentile score based on average score attained and a grading system generated for the same based on following criteria.

Table 16: Threat levels ascertained based on the score range and consequent threat grade.

Score Range	Assigned grade	Threat level
14 and above	A+	Very High
11	A	Very High
9	B+	High
7	B	High

Score Range	Assigned grade	Threat level
4	C+	Moderate
3	C	Moderate
2	D	Low
1	E	Very Low

All 124 sampled wetlands were assigned grades based on the threat scores and further analyzed for selection of corrective management interventions required for checking identified drivers of adverse change.

Baseline survey showed that extent of risk of adverse change was determined by the location of wetlands that influenced socio-economic, hydrological and developmental factors. The major threats observed for the wetland of sub basin 1 includes introduction of pollutant and invasives species and extraction of wetland resouces like water, soil and biota. Proliferation of invasives is prominent in sumplands as compared to floodplains as later has good flushing mechanism due to connectivity with rivers leading to transportation of invasive macrophytes (Figure 23).

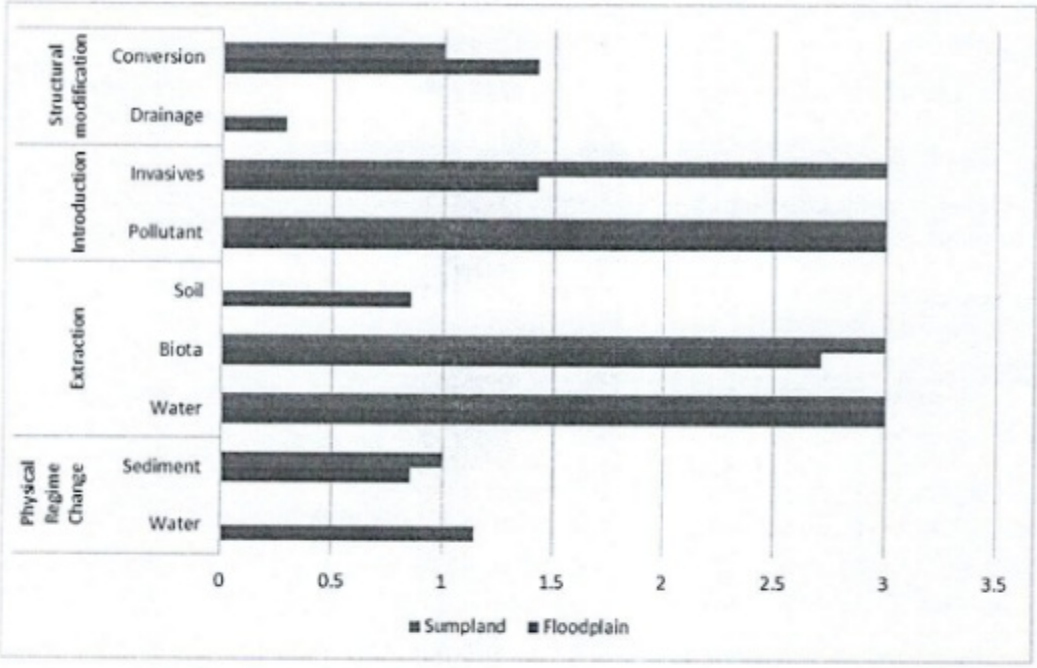


Figure 23: Comparative analysis of threats amongst wetland classes in basin 1

Wetlands of different classes in sub basin 2 are exposed to diverse range of threats including introduction, structural modification, extraction and physical regime change. Palusplain are highly exposed (threat score between 2 to 3) to extraction of wetland resources, introduction and conversion of wetland.

Sumplands within the basin are highly exposed to sediment deposition, extraction of wetland resources, introduction of invasives and pollutants and structural modifications. River channels are highly exposed to sediment deposition, extraction of biota and soil and drainage. Similarly, lakes within the basin were found to be highly exposed to all the classified threats except water regime change. Moreover,

floodplains are highly exposed to sedimentation and extraction of biota. On the other hand, damplands within the basin were highly exposed to sedimentation, extraction of biota and soil and drainage (Figure 24).

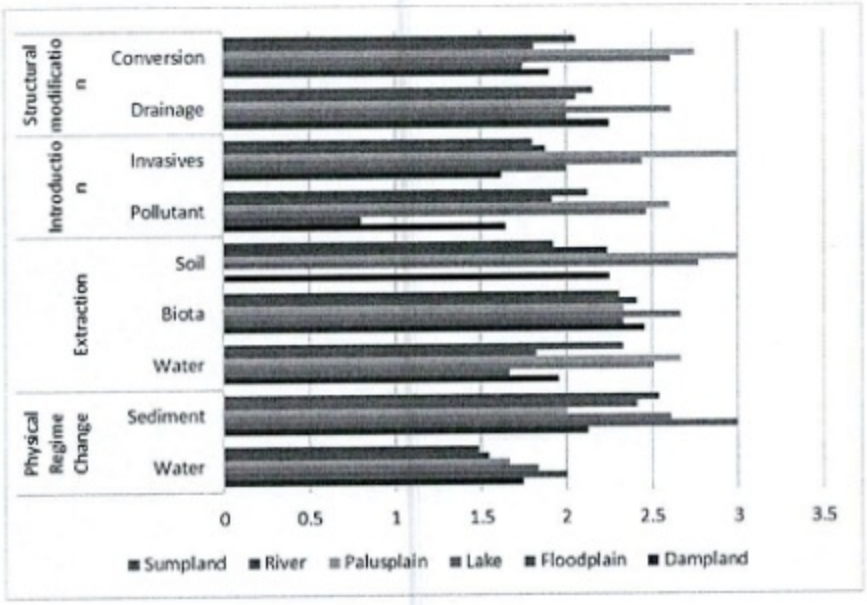


Figure 24: Comparative analysis of threats amongst wetland classes in basin 2

In sub basin 3, sumplands and river channel are highly exposed to threat of extraction of biota and soil. Moreover, palusplains are highly exposed to threat of extraction of biota and soil and introduction of pollutant. Lakes within the basin has been observed to be highly exposed to drainage. However, damplands faces high threat of sedimentation and extraction of water and biota (Figure 25).

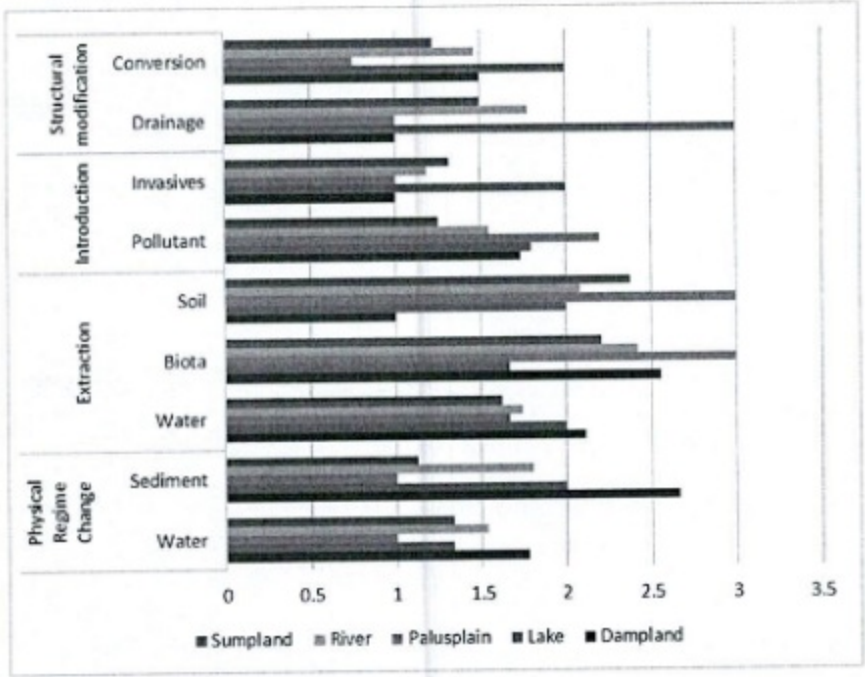


Figure 25: Comparative analysis of threats amongst wetland classes in basin 3

3.3 Component 3: Wetlands Management Planning

3.3.1 Management Planning Framework

Management of floodplain wetlands of River Ganga needs to be based on the recognition of their full range of ecosystem services and biodiversity values, their relationships with ecosystem health, and mainstreaming into conservation development plans and programmes at all levels. The effectiveness of management will be reflected in the ability to sustain the multiple values of wetlands based on the traditional knowledge of communities that have evolved over time, without undermining the key ecological and social processes that underpin the functioning of these wetlands as socioecological systems. Wise use of floodplain wetlands of River Ganga will be realized when the capability of these wetlands to provide diverse ecosystem services and sustain rich diversity is maintained now as well as in the future, on pathways that are aligned with ecosystem principles and guided by sustainable development.

The current chapter sets out the management planning framework including the management goal and purpose, management strategy, objectives, indicators and desired outcomes.

3.3.2 Management Goal and Purpose

The overarching goal of managing the floodplain wetlands of River Ganga is "conservation and wise use of wetland ecosystems so as to sustain their full range of ecosystem services and biodiversity values including their contribution to River Ganga ecosystem health".

The purpose is to: a) enhance river ecosystem health, b) enhance water security in the Lower Ganga basin, c) reduce water-related disaster risks to communities living in and around the wetlands, d) provide livelihood opportunities to local communities based on sustainable use of wetland resources and e) sustain habitats and migration corridors of wetland-dependent species.

3.3.3 Management Strategy

The ecological and hydrological connectivity of the floodplain wetlands with River Ganga provides the physical template in which these wetlands evolve and function. At the same time, the wetlands are also conditioned by the land use in the surrounding areas, traditional uses of the wetland, the cultural and relational linkages that communities have with wetland ecosystems, and the overarching regional developmental planning for different development sectors. Management of these floodplain wetlands is thereby proposed at two levels: a) the interventions at the sub-basin level which are aimed at ensuring that wetlands are embedded in the institutional and governance framework for water, land, and biodiversity management and b) interventions at wetland sites which address the direct drivers of adverse change.

Strategies for integrating wetlands within sub-basin level plans and programmes

As land and water resources development plans and programmes at the sub-basin level have a bearing on the functioning of floodplain wetlands, the set of strategies at the sub-basin level will be aimed at ensuring consideration of the full range of wetland ecosystem services and biodiversity values in the sub-basin level plans and programmes. The following strategies are proposed:

- Including wetlands conservation within the mandate of the District Ganga Committees. The committees would maintain an overview of the ecosystem health of wetlands within their jurisdiction, review implications of sectoral plans and programmes, commission specific research to address the knowledge gaps and approve the implementation of interventions at specific sites.
- Inventory assessment and monitoring of sub-basin scale processes that influence wetlands. These include weather patterns, geology and geomorphology, water regimes (surface and groundwater), land use and land cover change, and other parameters.

- Ensures the convergence of wetlands conservation action within the district-level plans for the environment, disaster risk reduction, agriculture, fisheries, and other sectors.
- Commissioning strategic impact assessment of major infrastructural development projects in terms of their likely impacts on wetlands and identify necessary impact-mitigation and abatement measures and ensure the implementation through appropriate institutional arrangements including the District Ganga Committee.
- Enhances public awareness of wetlands ecosystem services and biodiversity values through coordinated district-level campaigns.
- Develops the capacity of wetland managers in determining water regime requirements for wetland ecosystem health and communicating and engaging with concerned government departments to ensure their implementation.

Strategies for addressing drivers of adverse change within wetland sites

For the purpose of site management wetlands were classified using three descriptors - landscape setting, wetland use, and existing management regimes. Four management categories were identified, namely a) Floodplain agricultural wetlands, b) Urban and peri-urban wetlands, c) Wetland Production systems d) Ponds within the jurisdiction of village panchayats.

Wetlands within the jurisdiction of Village Panchayat

Wetlands less than 5 ha are classified as ponds. Located in a rural setting, mostly these wetlands fall within the jurisdiction of a Gram Panchayat. Funds are earmarked as part of village development plans for the development of wetland and water resources. They can also be privately owned. Ponds (interchangeably used with the phrase 'wetlands within the jurisdiction of village panchayats') provide decentralized storage and local water security benefits to village communities.

The strategy involves:

- Systematic and regular capacity development for PRI members.
- Increased participation and contribution of communities to decision making by providing representation to PRIs in the District Ganga Committee.
- Development of SOPs for wetlands conservation and sustainable use to guide village development planning.
- Mapping and building consensus on desired wetland conservation actions through Gram Panchayat Development Planning.
- Implementation of actions through Gram Sabha and convergence funds.
- Capacity development and involvement of village communities in monitoring and assessments activities.

Urban and Peri-urban wetlands

The wetlands within urban limits are mostly managed by municipalities, line departments and industrial units unless privately owned. The strategy for their management needs to be aligned with master plans forming an integral part of the city and urban planning.

The strategy for their management involves:

- Mapping of present and historical wetland regimes including landscape connectivity and preparation of a wetland restoration plan for all urban centres in consultation with water managers and all stakeholders.
- Revival of urban/peri-urban wetlands through various restoration measures (Such as boundary notification, removal of encroachment, restoration of inlets and outlets through selective dredging and desilting, cleaning, water treatment measures, catchment conservation measures) by embedding the restoration plan within AMRUT and Smart Cities mission.
- Creation of infrastructure for the interception, diversion, and treatment of point sources of pollution to manage the water issues (sanitation and availability of safe drinking water) of the city.

- Establishment of a systematic, monitoring and evaluation system involving various stakeholders to gauge the effectiveness of the implementation of wetland restoration actions and their benefits.
- Augment aesthetics of the wetlands for recreational benefits while preserving the ecological character of wetlands and their catchments.
- Plan for species conservation, habitat improvement, and maintenance of migratory routes should be developed as a core part of environmental protection.
- Capacity building, communications and outreach should be made an integral part of wetlands management.

Wetland Production Systems

Many wetlands in the Ganga basin are important for fisheries and are leased out for fishing by the State Department of Fisheries or the Gram Panchayat. Such wetlands also known as *Jalkars* in Bihar are managed by the local fishing cooperatives. The strategy would be to realize improved and sustainable fisheries production levels and curb destructive practices such as the introduction of exotic fish species.

The strategy involves:

- Demarcation of management zones for capture fisheries and culture fisheries. This is important for protected areas and ecologically important wetlands where core areas should be strictly used only for capture fisheries. Buffer zones and isolated wetlands can be managed as sustainable production systems under culture fisheries, ensuring that production processes do not create a direct adverse impact on ecosystem components and processes.
- Ecosystem improvement measures such as catchment treatment, hydrological connectivity restoration, and enhancement of the storage capacity of wetlands leased out for culture fisheries.
- Maintain ecological diversity and trophic level balance by promoting multiple species, and indigenous fish diversity in capture fishery wetlands
- Strengthening fisheries infrastructures such as seed farms, cold storage, ice plants, and fish marketing facilities.
- Strengthening of fish cooperative societies for collective ownership and management of fisheries
- Observing closed season for fishing during the breeding seasons of the economically important fish species.
- Stocking of capture fisheries wetlands with fingerlings of indigenous species.
- Regular capacity development of fishers on sustainable fishery practices.
- Provision of alternate livelihood opportunities for fishers.

Agricultural floodplains

- Agricultural floodplains are mostly shallow and occupy peripheral areas around villages, rivers, roads. Located away from human settlements, many serve as buffer zones and as connectors and migration corridors between national parks, wildlife sanctuaries and reserved and protected forests.

The management strategy involves:

- Awareness generation and incentivization to promote technology options such as the System of Rice Intensification (SRI) which are known to reduce water use by 40-50% and enhance productivity by 20-30%.
- Reducing the intensity of chemical fertilizer and pesticide use through promotion of organic cultivation and establishment of centers for the supply of quality agricultural inputs.
- Incentives to encourage adoption of alternate income generation programmes in convergence with ongoing schemes under the Fourth Krishi Roadmap 2023-28
- Incentives in the form of farming equipment, training, and soft loans to be provided to farmer groups for the adoption of sustainable agricultural techniques.

- Sensitization of farmers on reducing groundwater use in agriculture and on the role of wetlands in providing local water security and irrigation benefits, benefits of sustainable agricultural practices aligned with natural hydrology
- Monitoring and research activities pertaining to changes in land use and land cover within the wetland complex and basin, Overall water use pattern within the basin, Surface runoff, and trends in nutrient enrichment.

The management objectives and performance indicators and desired outcomes at the sub basin levels and site level are listed below

Table 17: Management objectives, performance indicators and desired outcomes

Level	Objectives	Performance indicators	Desired outcomes
Sub-basin level			
	Integration of multiple values of wetlands in sectoral development plans is enhanced	The number of sectoral plans and programmes wherein convergence with wetlands conservation has been achieved	Plans for water resources development, irrigation, land resources management, fisheries, and tourism do not lead to adverse impacts on wetlands
	A systematic wetland inventory assessment and monitoring system is used to inform management decisions and assess effectiveness.	Availability of long-term monitoring records on wetlands features Use of monitoring data and information to amend existing management framework	A hierarchical wetland monitoring and assessment system is functional Monitoring reports are produced periodically
	Compliance with existing rules and regulations is maintained	Number of natural wetlands notified under the Wetlands (Conservation and Management) Rules, 2017 Number of violations recorded of extant rules and regulations	All provisions of the Wetlands (Conservation and Management) Rules, 2017 and other extant rules and regulations are fully complied with
Site level			
Wetlands Production Systems	Maintain riverine connectivity of wetlands	Number and duration of flood pulses received in the wetlands Spawning of riverine species in wetlands	Inundation regimes achieved in the past 30 years are maintained

Level	Objectives	Performance indicators	Desired outcomes
	Wetland supports economically viable, and ecologically and environmentally sustainable fisheries	Fish composition, yield, and size structure	Non-declining fish yield, with a maintained proportion of native fish species of harvestable sizes Non-declining per-household income/benefits from fishing
	Wetland supports a diverse assemblage of plants that can be harvested for economic use	Plant harvest (abundance and type) Harvest of wetland products (wetland paddy, foxnuts)	Non-declining per-household income/ benefits from harvest of aquatic plants
	Provide livelihood opportunities to stakeholders through engagement in wetland-wise use	Income and number of employment days attributed to activities related to the wise use of wetlands	Wetland communities having income in lower quintiles have additional sources of income and employment
	Promote local stakeholder participation in wetlands management	Representation of local stakeholders in wetland management structures General participation in wetland management	Communities' views rights and capacities are reflected in wetland management decisions Pro-active engagement of fishers in wetland management
	Fishery cooperatives manage wetland fisheries and ensure equitable outcomes for their members	Adherence to State Fisheries Rules and Fishing bye-laws Instances of conflicts between members/fishers	Lesser instances of disputes between the fishers Lesser reported instances of conflicts between members/ fishers in benefit-sharing
	Enhance awareness of responsible and sustainable fisheries	The number of affirmative actions by fishers to ensure the sustainability of wetland fisheries, wetland	Increase in affirmative actions No use of illegal mesh size and gear in wetland fisheries

Level	Objectives	Performance indicators	Desired outcomes
		conservation, and wise use	
	Maintain water quality to support ecosystem processes and services	DO levels	4mg/l or more
	Maintain and enhance populations of species of high conservation significance	Species diversity, richness, and population trends	Species diversity, richness, and population trends remain stable or show an increasing trend
	Species invasion threats are reduced	Occurrence of invasives in fish catch	Species that are native, ecologically sensitive, and of conservation importance are protected
Floodplain agricultural wetlands	Maintain hydrological connectivity with the wetland catchment	Duration of flood pulse and connectivity of river channels with wetlands.	Inundation regimes (minimum and maximum) achieved in the past 30 years are maintained
	Promote good agricultural practices aligned with wise use of wetlands	Cropping practices that do not modify water regimes or deteriorate water quality or introduce exotic species	No structural modification of wetland No introduction of chemicals, fertilizers, and pesticides No introduction of exotic species. No intensive water abstraction
	Maintain the naturalness of shorelines	The extent of the wetland shoreline, devoid of any built-up area	No concretization of the shoreline Maintenance of at least 50 m buffer around the wetland

Level	Objectives	Performance indicators	Desired outcomes
	Maintain and improve habitat quality to support the diversity of wetland-dependent species	Habitat diversity	No species extirpation Migration corridors for fish and large mammals are maintained Sighting of key species is maintained in the range of 20% deviation from the average of last five years Counts of migratory waterbirds is maintained in the range of 20% deviation from the average of last five years
	Enhance awareness of wetlands biodiversity and ecosystem services amongst stakeholders	The number of affirmative actions by stakeholders for wetlands conservation and wise use	Increase in affirmative actions
	Promote local stakeholder participation in wetlands management	Representation of local stakeholders in wetland management structures	Communities' views rights and capacities are reflected in wetland management decisions. Pro-active engagement of women, youth, and children in wetland management.
Urban and peri-urban wetlands	Maintain the naturalness of shorelines	The extent of the wetland shoreline, devoid of any built-up area	No concretization of the shoreline Maintenance of at least 50 m buffer around the wetland
	Maintain hydrological connectivity with the wetland catchment	Duration of flood pulse and connectivity of river channels with wetlands	Inundation regimes (minimum and maximum) achieved in the past 30 years is maintained
	Maintain water quality to support ecosystem processes and services	DO levels, heavy metal concentrations	4 mg/l or more Heavy metal conc. in sewage brought to permissible levels

Level	Objectives	Performance indicators	Desired outcomes
	Limit anthropogenically induced sedimentation	Sedimentation quantity and location	Natural profiles of inlets and outlets are maintained
	Maintain and improve habitat quality to support the diversity of wetland-dependent species	Habitat diversity	No species extirpation Migration corridors for fish and large mammals (Nilgai) are maintained Sighting of key species is maintained in the range of 20% deviation from the average of the last five years Counts of migratory waterbirds are maintained in the range of 20% deviation from the average of the last five years
	Preserve the scenic and aesthetic beauty of wetlands	Presence of natural wetland features Landscape naturalness	Preserved naturalness of the landscape No
	Preserve the recreational and touristic value of wetlands.	Tourist footfall and ecologically sensitive behaviour of tourists.	Registering higher revenues through tourism.
	Enhance awareness of wetlands biodiversity and ecosystem services amongst stakeholders	The number of affirmative actions by stakeholders for wetlands conservation and wise use	Increase in affirmative actions
	Promote local stakeholder participation in wetlands management	Representation of local stakeholders in wetland management structures	Communities views rights and capacities are reflected in wetland management decisions. Pro-active engagement of women, youth, and children in wetland management.
Ponds	Maintain the naturalness of shorelines.	The extent of the wetland shoreline,	No concretization of the shoreline.

Level	Objectives	Performance indicators	Desired outcomes
		devoid of any built-up area.	Maintenance of a 50 m buffer around the pond.
	Maintain water quality to support ecosystem processes and services	DO levels	4mg/l or more
	Maintain non-declining harvest of fish and wetland plants for economic use	Fish harvest (size, quantity, and diversity) Plant harvest (abundance and type)	No individuals of below minimum harvestable size in fish catch No use of illegal mesh size and gear in wetland fisheries. No harvest beyond regenerative capacity
	Preserve cultural and spiritual values and traditional and customary practices aligned with the wise use of wetlands	Celebration of traditions and practices aligned with the wise use of wetlands	Continuation and perpetuation of wise use aligned with traditional and customary practices
	Enhance awareness of wetlands biodiversity and ecosystem services amongst stakeholders	The number of affirmative actions by stakeholders for wetlands conservation and wise use	Increase in affirmative actions
	Promote local stakeholder participation in wetlands management	Representation of local stakeholders in wetland management structures	Communities' views rights and capacities are reflected in wetland management decisions Pro-active engagement of women, youth, and children in wetland management

Monitoring and evaluation

Wetland management is an exercise in decision-making– choosing actions that are expected to best achieve the management objectives. Monitoring plays a central role in wetlands management because these ecosystems are dynamic and variable, and often do not align with the desired results of intended decisions and actions. There are several sources of uncertainty that affect natural resource decisions. Primarily, environmental variation in space and time often drives natural systems in ways that may or may not be consistent with management prescriptions. Secondly, many system variables are not measured directly (i.e., partial system observability), and thirdly, outcomes of management actions often deviate in degree and spatial extent from management prescriptions. Thus, by integrating monitoring into decision-making, adaptive management explicitly addresses these sources of uncertainty and allows decision-makers to simultaneously achieve management objectives and generate new knowledge about how the system responds to management.

Management of floodplain wetlands in the Bihar is primarily focused on meeting the objectives of achieving 'wise use'. Having a system to monitor, detect and describe changes in ecological character is therefore critical to support decision-making for wise use of wetlands. Equally important is ability to assess the effectiveness of management in terms of the capacity to develop and implement integrated planning, management, and evaluation systems to secure wise use of the wetland.

This chapter describes a monitoring framework for the Gangetic floodplain wetlands at the scale of both sub-basin and individual wetland sites to support integrated management for wetlands wise use. It essentially delineates monitoring objectives, strategy and associated resource requirements.

Monitoring Objectives

Developing a monitoring plan for the Gangetic floodplain wetlands requires addressing the inter-related requirements of wetland inventory (which is the collection and/ or collation of basic information for wetland management) and wetland assessment (identification of status of, and threats to wetlands which provides a basis for wetlands monitoring. It is imperative therefore to put in place an integrated Wetland Inventory, Assessment and Monitoring System (WIAMS) to address the overall information needs for wetland management, and to provide a robust decision support system for the same. Following are the specific objectives for establishing WIAMS:

- Developing up-to-date and scientifically valid information on the status and trends of wetland features and influencing factors.
- Establishing a baseline for measuring the change in ecosystem components, processes, and services.
- Informing decision-makers and stakeholders on the status and trends in biodiversity, ecological functioning, and ecosystem services of the wetland
- Supporting compliance with national and state specific legal requirements and regulatory regimes.
- Determining the impacts of developmental projects on ecosystem components, processes, and services.
- Identifying risks to the ecological character and supporting the development of response strategies.
- Assessing the effectiveness of wetland management.

3.3.4 Monitoring Strategy

Monitoring is proposed to be undertaken at following two levels:

- Sub-basin level to explain status and trends in key hydrological and ecological processes that influence wetland functioning (Table 18).
- At specific sites that explain status and trends in wetland ecological character in response to natural and anthropogenic stresses (Table 19).

The monitoring parameters have been selected on the basis of their ability to reflect the degree to which management objectives are met. Given the large number of wetlands in the floodplain zone, it is recommended that a few representative sites are taken up for monitoring purposes. These are as follows:

Village Ponds: Badka Taal, Dalsagar Pokhar, Milkipull Pokhar, Harauli, Kamasthan Dhan, Minapur, Sajua, Durgapur, Jamra, Jangalatal

Agricultural Floodplain wetlands: Jagteli, Khajuhata, Kutlupur Diyara, Papraur Pond, Sahpur, Sahpuraina, Lahsa, Madhepura, Madhopur bhorang, Mardauni pachiarital

Urban and peri-urban wetlands: Anjani Talaab, Lohandiya, Nathmalpur Bhagad, Semra Bhatu, Chakiya Ghat, Ashpatpur Singhia, Bahatra, Begampur, Bharatkhand, Bihpur, Kahalgaon

Fishery: Gokul Jalashay, Sukhi Suiya, Auta Bihar, Bakhda Balia, Bishanpur ber, Dalsinghsarai, Baulia, Bhagwanpur, Bhawanipur, Darondha milik

The information needed for inventory are derived from the core datasets required to establish a baseline on ecological character for the sub-basin and contains all essential ecosystem components, processes, and services, as well as management related parameters that characterize the site. Within the aquatic environment, information needs pertain to inflow, quality, and ecosystem services such as provisioning, regulating, culture and supporting. At the level of wetland, information needs to pertain to land-use and land cover change, and threats such as over household effluent discharge. At the basin scale, the information required is related to geo-morphological and climatological setup, as well as basin-wide management arrangements, particularly those related to land, water resources and urban planning. At all levels, information on institutional arrangements and management practices is included so as to enable the creation of a database on sectoral programmes, and the linked stakeholders, which are likely / have an impact on the wetland state. While not explicitly mentioned, strategic environmental assessments can be commissioned for any developmental project that has/is likely to have a negative impact on the wetlands.

Information needs for monitoring the Gangetic floodplain wetlands have been derived from the assessment of ecological character carried out for the development of the management plan. Four clusters of needs have been identified: a) land use and land cover change, to assess the dynamics of land use within the catchment; b) hydrological regimes, to assess the flux of water, sediments, and nutrients; c) ecological components and processes, to assess the biodiversity, habitat quality and resource productivity; and d) socioeconomics and livelihoods to assess the trends in ecosystem services – livelihoods interlinkages. This monitoring information adequately addresses the needs of the Gangetic floodplain wetlands under the Wetlands (Conservation and Management) Act, 2017, and the NPCA Guidelines, 2019.

The monitoring and assessment needs are envisaged to be addressed by a dedicated monitoring programme and specific research and assessment projects. Inventory, being based on collated information on identified wetland features and management practices, will be developed based on the monitoring and assessment information, as well as secondary sources. Inventory, assessment, and monitoring form an integral part of wetland management, and thereby the core activity of BSWA. The management plan proposes to establish a dedicated wetland monitoring unit with adequate infrastructure support to effectively deliver this function.

Linkages also need to be developed so that data from the existing monitoring networks of different agencies (for example, inundation and flooding information from Central Water Commission and Department of Water Resources; groundwater quality and quantity from Central Ground Water Board; select surface water quality parameters from Bihar Pollution Control Board; and fish production from Fisheries Department) can be accessed and shared. Similarly, provision for participation of NGOs and civil society in a monitoring programme has also been built, especially for socioeconomics and livelihoods aspects and biodiversity monitoring (for example, the waterbird census being implemented by NGOs under the aegis of the Asian Waterbird Census). Thematic management needs-based research can be taken up by specialized agencies such as ZSI, BSI, and CIFRI, to complement the monitoring programme.

Table 18: Monitoring Parameters and corresponding indicators at the sub-basin level.

	Monitoring parameter	Monitoring Indicator	Monitoring Method	Frequency	Location
Sub-basin	Ecological Changes	Conservation Sector Plans	Number of wetlands conservation & management activities proposed	Review	Once in 10 years
			Collaboration between various stakeholders	Review	Once every year
			Funds available through various Central and State Government schemes	Review	Once every year
	Landscape Changes	Development Sectoral Plans	Number of wetlands conservation & management activities proposed	Review	Once in 5 years
			Collaboration between various stakeholders	Review	Once every year
			Funds available through various Central and State Government schemes	Review	Once every year
	Institutional Gaps	Effective implementation of WIAMS (Wetlands Inventory, Assessment and Monitoring Systems)	Availability of WIAMS	Review	Once every year

Table 19: Monitoring Parameters and corresponding indicators at the wetland site level

	Monitoring parameter	Monitoring Indicator	Monitoring Method	Frequency	Location
Physical regime	Ecological boundary & area	Wetland extent defined by inundation & hydrophytic vegetation	Remote Sensing & GIS	Once in 2 years	All Wetlands

	Monitoring parameter	Monitoring Indicator	Monitoring Method	Frequency	Location
	Boundary defined by Law & regulation	PA boundary as per the respective notification / Wetland boundary as per the notification	Literature review	Once in 5 years	Selected Wetlands
	LULC within the wetland	% Cover of various LULC classes within the wetland boundary	Remote Sensing & GIS	Once in 2 years	Selected Wetlands
Hydrological regime	Water regimes	Inundation (Minimum, Maximum, Interannual variability)	Remote Sensing & GIS	Seasonal (Monsoon, Post-Monsoon and Summer)	Selected Wetlands
		Inflows (Number, Seasonality/Extent of choking)	Physical survey	Seasonal (Monsoon, Post-Monsoon and Summer)	Selected Wetlands
		Outflows (Number, Seasonality/Extent of choking)	Physical survey	Seasonal (Monsoon, Post-Monsoon and Summer)	Selected Wetlands
		Water use (Volume and Purpose)	Physical survey (Bathymetric profile)	Once every year	Selected Wetlands
		Water balance	Monitoring gauging station	Once every year	Selected Wetlands
		Water chemistry (DO, BOD, COD, pH, Nutrients, Heavy metals)	Physical survey (Standard protocols of CPCB to be followed)	Monthly	Selected Wetlands
	Sedimentary regime	Sediment flux (Inflow, Outflow & Balance)	Physical survey (Monitoring gauging station)	Once every year	Selected Wetlands
		Soil texture	Physical survey (Standard protocols of CPCB to be followed)	Monthly	Selected Wetlands

	Monitoring parameter	Monitoring Indicator	Monitoring Method	Frequency	Location
		Soil pH	Physical survey (Standard protocols of CPCB to be followed)	Monthly	Selected Wetlands
		Soil organic carbon	Physical survey (Standard protocols of CPCB to be followed)	Monthly	Selected Wetlands
		Bathymetry	Physical survey (Bathymetric profile)	Once in 2 years	Selected Wetlands
	Connectivity	Extent of flood pulse (spatial and temporal)	Remote Sensing & GIS	Once every year	Selected Wetlands
		Active channels between river and wetlands and within wetlands	Remote Sensing & GIS	Once every year	Selected Wetlands
		Migratory pattern of key groups (Fish, Reptile, Mammals, Birds)	Physical survey	Once every year	Selected Wetlands
Catchments	Catchment boundary and area	Catchment area	Remote Sensing & GIS	Once in 5 years	All Wetlands
	LULC	% Cover of various LULC classes within the catchment	Remote Sensing & GIS	Once in 5years	All Wetlands
	Degree of fragmentation	Location and Length of linear structures on wetlands inflow & outflow	Remote Sensing & GIS and Physical survey	Once in 5 years	All Wetlands
Species & Habitats	Different forms of flora & fauna	Richness & Abundance List of Flora & Fauna	Physical survey	Once in 2 Years	Selected Wetlands
		Species distribution	Literature review and Physical survey	Once in 2 Years	Selected Wetlands

	Monitoring parameter	Monitoring Indicator	Monitoring Method	Frequency	Location
		Conservation status	Literature review	Once in 10 years	Selected Wetlands
		Relative abundance	Physical survey	Once in 2 Years	Selected Wetlands
		Keystone	Literature review and physical survey	Once in 2 Years	Selected Wetlands
		Economic importance of flora	Literature review and Physical survey	Once in 5 Years	Selected Wetlands
	Habitat	Type	Physical survey and Remote Sensing & GIS	Once in 2 Years	Selected Wetlands
		Area	Physical survey and Remote Sensing & GIS	Once in 2 Years	Selected Wetlands
		Associated flora & fauna	Physical survey	Once in 2 Years	Selected Wetlands
		Biological importance	Literature review and Physical survey	Once in 2 Years	Selected Wetlands
	Vegetation cover	Type	Physical survey and Remote Sensing & GIS	Once in 2 Years	Selected Wetlands
		Area	Remote Sensing & GIS	Once in 2 Years	Selected Wetlands
		Density	Physical survey and Remote Sensing & GIS	Once in 2 Years	Selected Wetlands
		Composition	Physical survey and	Once in 2 Years	Selected Wetlands

	Monitoring parameter	Monitoring Indicator	Monitoring Method	Frequency	Location
			Remote Sensing & GIS		
		IVI (Importance value index)	Physical survey and Remote Sensing & GIS	Once in 2 Years	Selected Wetlands
	Migratory species	Population Counts	Physical survey	Twice each year	Selected Wetlands
		Concentration areas	Physical survey and Literature review	Once each year	Selected Wetlands
		Migration period	Physical survey	Seasonal (Winter Migrant; Summer Migrant)	Selected Wetlands
		Conservation status	Literature review	Once in 10 Years	Selected Wetlands
	Invasive species	Species list (Presence/Absence)	Physical survey and Literature review	Once in 2 Years	Selected Wetlands
		Proliferation rate of invasive macrophytes	Physical survey	Once in 2 Years	Selected Wetlands
		Proliferation rate of invasive fish species	Physical survey	Once in 2 Years	Selected Wetlands
		Area occupied	Physical survey	Once in 2 Years	Selected Wetlands
	Species mortality	Incidental, Mass	Physical survey	Once in 2 Years	Selected Wetlands
Ecosystem Services &	Type of ecosystem service	Provisioning (Presence/Absence)	Field survey	Once in 5 Years	Selected Wetlands
		Regulatory (Presence/Absence)	Field survey	Once in 5 Years	Selected Wetlands

	Monitoring parameter	Monitoring Indicator	Monitoring Method	Frequency	Location
Livelihoods		Supporting (Presence/Absence)	Field survey	Once in 5 Years	Selected Wetlands
		Cultural (Presence/Absence)	Field survey and Literature review	Once in 5 Years	Selected Wetlands
	Availability of the ecosystem services	Seasonal variation in ecosystem services	Field survey	Once in every season	Selected Wetlands
	Beneficiaries of the ecosystem services	List of stakeholders dependent on wetland services	Field survey	Once in 2 Years	Selected Wetlands
	Demography around the wetland	Population	Field survey	Once in 2 Years	Selected Wetlands
		Occupation profile	Field survey	Once in 2 Years	Selected Wetlands
		Duration of dependency on the wetland,	Field survey	Once in 2 Years	Selected Wetlands
		Income profile	Field survey	Once in 2 Years	Selected Wetlands
Institutions & Governance	Stakeholder mapping	List of formal & informal institutions and networks related to wetlands management, their mandates, roles & responsibilities and decision-making process	Field survey; Workshops and Literature review	Once in 5 Years	Selected Wetlands
	Laws & Regulation	Policy, Legal and Regulatory Framework	Literature review	Once in 5 Years	Selected Wetlands
	Resource availability (Finance & Human)	State, Central or CSR funds available	Literature review	Once every year	Selected Wetlands

Gangetic floodplain wetlands in Bihar are dynamic ecosystems and so are their management needs. Management plans, which are developed based on assumptions known to managers, need to be periodically assessed to make sure that the set goals and objectives are being achieved.

The effectiveness of management towards achieving the overarching objective of maintenance of ecological character can be greatly enhanced if the following questions are periodically reflected upon:

- What is the current status of the wetlands in the landscape?
- Is the management achieving the goal of maintenance of ecological character?
- What are the current and future threats?
- Are adequate resources available for implementing management, and if not, how can they be accessed?
- Are management processes adequate, effective, and efficient?
- What other steps can be taken to improve management?

The MoEFCC has developed a METT framework for management effectiveness evaluation of Ramsar sites (https://indianwetlands.in/wp-content/uploads/library/1707134041.pdf)

It is proposed that management effectiveness assessments for Gangetic floodplain wetlands be done at least once in three years so that management action plans are revised and updated to reflect the real time condition of wetlands as well as the ability of management to prevent adverse changes in ecological character.

Infrastructure and Human Resources Requirements

Implementing the monitoring strategy as outlined in the previous sections requires the following physical and human infrastructure support:

- Remote Sensing and GIS unit with advanced capabilities of remote sensing image processing, preparation of maps and development and maintenance of spatial datasets.
- Ecological monitoring laboratory with capabilities for analysis of chemical, physical and biological properties of water and soil.
- Mobile-based citizen reporting system for recording and reporting illegal encroachments.
- Database management system for storing and retrieving monitoring and assessment data. The monitoring data would be stored along with metadata, as per the quality control procedures suggested in the following sections.
- Network of hydro-meteorological and water quality stations for real time monitoring of weather, hydrological -biological variables.

Deployment of the aforementioned resources can be done cost-effectively by applying the lessons and expertise of the existing infrastructure created by the state government for the management of floodplain wetlands. Need-based training programmes can also be conducted to upgrade the skills of the concerned state government departments and agencies.

3.3.5 Management implementation and review

A mid-term and end-term review of management plan implementation is proposed to assess the extent to which stipulated objectives have been achieved with a high degree of
resource efficiency and in participation with stakeholders. Wetlands International South Asia shall carry out the evaluation, specifically looking at the following elements:

- Degree to which wetland ecological character is being maintained as a result of management being applied
- Implementation quality, timeliness and resourcing of activities
- Quality and comprehensiveness of wetlands monitoring
- Effectiveness of management being applied, in terms of design, activities, outcomes and impacts
- Quality of stakeholder engagement in implementation of various activities and discharging wetl and management functions

- Changes in external environment, requiring adaptation in management plan

Site level action plan

Actions specific to the management categories are provided in Annex ???. The actions are guided by the wetland strategies outlined for the management categories. While many actions cater to category specific management needs, some of these activities apply to all categories.

4. Recommendations

Conserving and sustainably managing the Gangetic floodplain wetlands of Bihar requires an integrated approach that combines effective policy, community engagement, scientific research, and sustainable practices. By implementing these recommendations, stakeholders can work collectively to preserve these vital ecosystems, ensuring their ecological functions and benefits for future generations. It is crucial to foster stewardship among local communities and stakeholders so as to recognise the importance of wetlands in sustaining societal benefits and biodiversity conservation.

1. Strengthening Policy and Legal Frameworks

Integrated Wetland Policy: Develop and implement a comprehensive state-level Wetland Conservation Policy that integrates conservation goals with sustainable resource management.

Enforce Existing Regulations: Strengthen enforcement of existing environmental laws and regulations concerning pollution control, land use, and resource extraction to protect wetlands.

Zoning Regulations: Establish clear zoning regulations that limit development and agriculture in critical wetland areas to minimize encroachment and degradation.

2. Community Involvement and Education

Participatory Management: Involve local communities in the planning and management of wetland resources through participatory approaches. Empower them to take an active role in monitoring and conservation efforts.

Awareness Campaigns: Conduct community education campaigns to raise awareness about the ecological and economic importance of wetlands and promote sustainable practices.

Training Programs: Provide training on sustainable agricultural practices, resource management, and alternative livelihoods to reduce pressure on wetlands.

3. Restoration and Rehabilitation Initiatives

Wetland Restoration Projects: Identify and implement restoration projects in degraded wetlands, utilizing native plant species and natural regeneration techniques.

Rehabilitating Ecosystems: Focus on restoring natural hydrology by removing invasive species and re-establishing natural water flow patterns to revive ecological balance.
Buffer Zones: Establish buffer zones around wetlands to protect them from pollution and encroachment, enhancing habitat quality and biodiversity.

4. Conservation and Biodiversity Protection

Biodiversity Conservatories: Designate specific areas within wetlands as conservatories to protect threatened species and native ecosystems.
Monitoring Biodiversity: Implement biodiversity monitoring programs to collect data on species populations, health, and ecological conditions, informing conservation actions.

Habitat Connectivity: Ensure connectivity between wetland habitats and surrounding ecosystems to facilitate wildlife movement and genetic exchange.

5. Sustainable Agriculture Practices

Agro-Ecological Practices: Promote agroecological practices that enhance soil health and minimize chemical inputs, such as organic farming, crop rotation, and intercropping, to reduce the agricultural impact on wetlands.

Integrated Farming Systems: Encourage integrated farming systems that combine agriculture with aquaculture and agroforestry, optimizing the use of resources and minimizing waste.

Water Management Techniques: Train farmers on water-efficient irrigation practices, such as drip irrigation and rainwater harvesting, to reduce water extraction from wetlands.

6. Water Quality Management

Pollution Control Measures: Establish strict regulations on industrial effluents, sewage disposal, and agricultural runoff, coupled with monitoring mechanisms to enforce compliance.

Waste Treatment Facilities: Invest in wastewater treatment facilities and promote biogas digesters to manage sewage and organic waste from surrounding communities before reaching wetlands.

Natural Filters: Restore and maintain natural vegetative buffers along riverbanks and wetland peripheries to act as filters for pollutants.

7. Enhancing Research and Capacity Building

Research Partnerships: Foster partnerships between government, research institutions, and local NGOs to conduct research on wetland ecosystems and develop conservation strategies based on scientific evidence.

Capacity Building for Stakeholders: Train local government officials, NGOs, and community leaders in wetland management practices, policy development, and the use of technology for conservation.

Data Management Systems: Develop a centralized database for monitoring wetland health, resource use, and biodiversity to support informed decision-making.

8. Traditional Knowledge Integration

Incorporate Indigenous Practices: Recognize and integrate traditional ecological knowledge of local communities into wetland management practices, promoting sustainable use of resources.

Cultural Heritage Conservation: Acknowledge the cultural significance of wetlands and promote practices that preserve traditional ways of life while ensuring ecological sustainability.

9. Funding and Incentives

Diversified Funding Sources: Explore various funding mechanisms, including government budgets, international grants, and partnerships with private organizations, to ensure the financial sustainability of wetlands management initiatives.

Economic Incentives: Implement economic incentives such as payment for ecosystem services (PES), where communities receive financial compensation for conservation practices that benefit the larger ecosystem.

Annexes

Annex 1

List of wetlands Sub basin1

S.No	District	Wetland Name	Latitude	Longitude
1	Buxar	Lohandiya	25.59878	84.13541
2	Buxar	Badka Taal	25.5412	83.9705
3	Buxar	Anjani Talaab	25.5509	83.9642
4	Buxar	Gokul Jalashay	25.62223	84.27216
5	Buxar	Dalsagar Pokhar	25.5771	84.0477
6	Bhojpur	Sukhi Suiya Bhagad	25.6559	84.403
7	Bhojpur	Milkipull Pokhar	25.6782	84.6251
8	Bhojpur	Nathmalpur Bhagad	25.6932	84.6793
9	Bhojpur	Semra Bhatu Chakiya Ghat	25.6696	84.8148

List of wetlands Sub basin 2

Sl_No	District	Wetland_Na	Latitude	Longitude
1	Chapra	Dumri bujurg	25.79168	85.08999
2	Chapra	Khauwa	25.79146	85.09054
3	Chapra	Sabalpur Pachami	25.68921	85.16970
4	Chapra	Khajuhata	25.83555	85.11644
5	Chapra	Dhighi	25.83510	84.58102
6	Chapra	Sahpuraina	25.83391	84.60756
7	Bhagalpur	Jagteli	25.34093	87.03996
8	Bhagalpur	Bahatra	25.32222	87.01851
9	Bhagalpur	Champapur	25.24236	86.92407
10	Bhagalpur	Manikpur	25.25895	86.98211
11	Bhagalpur	Bihpur	25.39232	86.92663
12	Bhagalpur	Naugachhiya	25.38973	86.89630
13	Bhagalpur	Vikrampur	25.36234	86.91855
14	Bhagalpur	Sahpur	25.35889	86.92182
15	Bhagalpur	Naugachhiya	25.35376	87.15971
16	Bhagalpur	Deemha	25.32970	87.16015
17	Bhagalpur	Marwa Pachim	25.40006	86.91999
18	Bhagalpur	Naugachhiya	25.41370	86.85711
19	Bhagalpur	Ash pond mahesha manda	25.22097	87.23913
20	Bhagalpur	Maheshananda	25.22340	87.24590
21	Bhagalpur	Naugachhia	25.40685	86.85106
22	Bhagalpur	Kahalgaon	25.21034	87.23120
23	Bhagalpur	Dhanura	25.21805	87.23490
24	Bhagalpur	Kahalgaon	25.22585	87.21929
25	Bhagalpur	Rattipur Bariya	25.27149	86.94805
26	Vaishali	Mahnar	25.56293	85.52954
27	Vaishali	Bagh Taj khan Pokhar	25.68748	85.21225
28	Vaishali	Panapur Dharampur	25.66077	85.27467
29	Vaishali	Ashpatpur Singhia	25.64386	85.30663
30	Vaishali	Harpur Phatikwara	25.62792	85.53436
31	Vaishali	Sultanpur	25.60837	85.47615

Sl_No	District	Wetland_Na	Latitude	Longitude
32	Katihar	Shapur Dharmi milik	25.39000	87.22630
33	Lakhisarai	Pokrama Emampakri	25.20163	86.24427
34	Patna	Auta Bihar	25.36116	85.96909
35	Patna	Shekhpura	25.45188	85.80005
36	Patna	Dhobhawan	25.38613	85.79053
37	Patna	Harauli	25.40849	85.63950
38	Patna	Begampur	25.58219	85.22546
39	Patna	Sonaru	25.48630	85.30054
40	Patna	Rampur Diara	25.63950	84.87270
41	Begusarai	Papraur Pond	25.43765	85.04733
42	Begusarai	Chawki 1	25.46696	86.42448
43	Begusarai	Minapur	25.39151	86.01040
44	Begusarai	Bakhda Balia	25.45294	86.34813
45	Begusarai	Chawki Balia	25.43554	86.37570
46	Begusarai	Chawki 2	25.46063	86.40084
47	Begusarai	Dargahpur	25.55314	85.89524
48	Begusarai	Teghra	25.46630	85.96602
49	Munger	Paharpur	25.23214	86.55224
50	Munger	Hiro Diara	25.35458	86.44142
51	Munger	Kutlupur Diyara	25.36875	86.37398
52	Munger	Jamalpur	25.30982	86.50309
53	Munger	Sajua	25.18370	86.69024
54	Khagaria	Bharatkhand	25.38274	86.82332
55	Khagaria	Durgapur	25.48628	86.46474
56	Khagaria	Madhopur patpar	25.32165	86.64603
57	Khagaria	Temtha karari	25.30655	86.70635
58	Samatipur	Jamunapur Rudar	25.52004	85.63081
59	Samatipur	Bishanpur ber	25.54083	85.64622
60	Samatipur	Dalsinghsarai	25.60074	85.76907
61	Samatipur	Patori	25.61916	85.58089
62	Chapra	Chaur	25.83642	85.07284
63	Begusarai	Teghra	25.28730	86.15858
64	Khagaria	Kasriyadhar	25.49322	86.59858
65	Khagaria	Kama sthan Dhan	25.41580	86.62531
66	Lakhisarai	Pokrama Emampakri	25.19098	86.22415

List of wetlands Sub basin 3

Sl_No	District	Wetland_Na	Latitude	Longitude
1	Bhagalpur	Ishapur	25.40899	87.00489
2	Bhagalpur	Mohanpur	25.42380	86.85729
3	Bhagalpur	Mohanpur Asia	25.43258	86.86360
4	Bhagalpur	Madhopur bhorang	25.30037	87.34697
5	Bhagalpur	Kahalgaon	25.33661	87.31986
6	Bhagalpur	Madhepura	25.31463	87.34734
7	Bhagalpur	Mardauni pachiarital	25.40708	87.17988

Sl_No	District	Wetland_Na	Latitude	Longitude
8	Bhagalpur	Kahalgaon	25.38242	87.40320
9	Katihar	Lahsa	25.46301	87.63120
10	Katihar	Manoharpur	25.40893	87.64483
11	Katihar	Kishanpur	25.31681	87.70682
12	Katihar	Jamra	25.34907	87.76307
13	Katihar	Sowa	25.39983	87.63807
14	Katihar	Durgapur	25.29261	87.82107
15	Katihar	Carbarti mili	25.47638	87.26424
16	Katihar	Madheli	25.49747	87.29806
17	Katihar	Vishanpur	25.43269	87.47107
18	Katihar	Raunia	25.51712	87.41323
19	Katihar	kadha gola ghat	25.47070	87.38760
20	Katihar	Darondha milik	25.48774	87.39684
21	Katihar	Vishanpur	25.43326	87.49122
22	Katihar	Bhawanipur	25.42678	87.52012
23	Katihar	Muradpur	25.45885	87.24540
24	Katihar	Muradpur	25.43011	87.23025
25	Katihar	Gobindpur	25.28503	87.85709
26	Katihar	Dhobaniya Milik	25.46700	87.25815
27	Katihar	Chuhat	25.56039	87.29456
28	Katihar	Gogabil	25.37794	87.69932
29	Katihar	Laxmipur	25.52950	87.34145
30	Katihar	Sharwan tal milik	25.47105	87.41937
31	Katihar	Sikkat	25.48965	87.46010
32	Katihar	Raunia	25.48823	87.39493
33	Katihar	Sisia	25.44350	87.45617
34	Katihar	Gidha	25.47813	87.42187
35	Katihar	Chatra kani chohar	25.54492	87.32370
36	Katihar		25.57729	87.51609
37	Katihar	Bhagwanpur	25.30160	87.71980
38	Katihar	Govindpur	25.29788	87.85435
39	Katihar	Amdabad	25.31178	87.81516
40	Katihar	Gurgaon	25.45135	87.61528
41	Katihar	Lahsa	25.45213	87.62797
42	Katihar	Bathna	25.37897	87.73532
43	Katihar	Lakhanpur	25.36866	87.74730
44	Katihar	Jangalatal	25.38001	87.70994
45	Katihar	Nand Gaon Kala Diyara	25.29703	87.77404
46	Katihar	Baulia	25.38818	87.59682
47	Katihar	Mohanpur	25.44769	87.56505
48	Katihar	Karimullahpur	25.32295	87.75748
49	Katihar	Lulhi	25.56573	87.33140

List of plant species

Scientific Name	Common name	Family	Type
Ruellia prostrata	Bell weed	Acanthaceae	Emergent hydrophytes
Alternanthera philoxeroides	Alligator weed	Amaranthaceae	Moist loving hydrophytes
Alternanthera sessilis	Sessile joy weed	Amaranthaceae	Moist loving hydrophytes
Aponogeton natans	Aponogetone	Aponogetonaceae	Submerged hydrophytes
Azolla pinnata	Mosquito Fern	Salviniaceae	Emergent hydrophytes
Bacopa monenieri	Pennywort	Apiaceae	Moist loving hydrophytes
Butomopsis latifolia	Broadleaf Flowering Rush	Butomaceae	Submerged hydrophytes
Cannabis sativa	Hemp	Cannabaceae	Emergent hydrophytes
Centella asiatica	Indian coinwort	Apiaceae	Moist loving hydrophytes
Ceratophyllum demersum	Horn wort	Ceratophyllaceae	Submerged hydrophytes
Ceratophyllum demersum	Horn wort	Ceratophyllaceae	Submerged hydrophytes
Chara globularis	Chara	Characeae	Submerged hydrophytes
Colocasia sp.	Jangali Kochu	Araceae	Emergent hydrophytes
Commelina benghalensis	Benghal dayflower	Commelinaceae	Emergent hydrophytes
Cyperus deformis	Small flower umbrella-sedge	Cyperaceae	Emergent hydrophytes
Eichhornia crassipes	Water hyacinth	Pontederiaceae	Free floating hydrophytes
Eleochais acutangula	Spike-rush	Cyperaceae	Emergent hydrophytes
Hydrilla verticillata	Water thyme	Hydrocharitaceae	Submerged hydrophytes
Ipomea aquatica	Water spinach	Convolvulaceae	Emergent hydrophytes
Lemna minor	Duck weed	Lemnaceae	Free floating hydrophytes
Marsilea minuta	Shushni	Marsileaceae	Emergent hydrophytes
Nelumbo nucifera	Lotus	Nelumbonaceae	Emergent hydrophytes
Nitella mucronata	Stonewort	Characeae	Submerged hydrophytes
Nymphaea caerulea	Blue water lily	Nymphaeaceae	Free floating hydrophytes
Nymphaea pubescence	Pink water lily	Nymphaeaceae	Free floating hydrophytes
Nymphoides hydrophylla	Crested floating heart	Menyanthaceae	Submerged hydrophytes
Nymphoides indica	Water lily	Nymphaeaceae	Emergent hydrophytes
Oryza rufipogon	Brownbeard rice	Poaceae	Emergent hydrophytes
Oxalis acetosella	Wood sorrel	Oxalidaceae	Emergent hydrophytes
Oxalis tetraphylla	Four leaf clover	Fabaceae	Free floating hydrophytes
Parthenium hysterophorus	Congress grass (Carrot grass)	Asteraceae	Emergent hydrophytes
Persicaria hydropiper	Water pepper	Polygonaceae	Moist loving hydrophytes
Phragmites spp.	Common reed	Poaceae	Moist loving hydrophytes
Pistia stratiotes	Water Lettuce (Chhoti Jalkumbhee)	Araceae	Free floating hydrophytes
Pistia stratiotes	Water lettuce	Araceae	Free floating hydrophytes
Polygonum plebeium	Knot weed	Polygonaceae	Moist loving hydrophytes
Potamogeton crispus	Potamagetone	Potamogetonaceae	Submerged hydrophytes
Potamogeton nodosus	Long leaf pond weed	Potamogetonaceae	Submerged hydrophytes
Potamogeton pectinatus	Sago pondweed	Potamogetonaceae	Submerged hydrophytes
Ranunculus sceleratus	Cursed buttercup	Ranunculaceae	Emergent hydrophytes
Rumex dentatus	Ban Palak	Polygonaceae	Emergent hydrophytes
Sagittaria sagtifolia	Arrow head	Alismataceae	Emergent hydrophytes

Scientific Name	Common name	Family	Type
Scirpus articulatus	Scirpus (Club-rush)	Cyperaceae	Emergent hydrophytes
Spirodela polyrhiza	Pond Silk	Araceae	Free floating hydrophytes
Trapa natans	Water chestnut	Trapaceae	Free floating hydrophytes
Typha angustifolia	Narrowleaf cattail	Typhaceae	Moist loving hydrophytes
Utricularia sp.	Bladderwort	Lentibulariaceae	Submerged hydrophytes
Vallisnaria spiralis	Tape weed	Hydrocharitaceae	Submerged hydrophytes
Veronica anagallis-aquatica	Water speedwell	Plantaginaceae	Emergent hydrophytes
Xanthium strumarium	Rough cockleburr	Asteraceae	Emergent hydrophytes
Zostera marina	Eel grass	Zosteraceae	Submerged hydrophytes

List of fish species

S.no	Common name	Scientific name	IUCN
1	Arangi	*Labeo dero*	Least Concern
2	Bachwa	*Eutropichthys vacha*	Least Concern
3	Baghua	*Botia dario*	Least Concern
4	Bami	*Mastacembelus armatus*	Least Concern
5	Barari; Boari	*Wallago attu*	Least Concern
6	Chalhawa	*Oxygaster bacaila*	Least Concern
7	Chamwa	*Ambassis nama*	Least Concern
8	Chanari	*Ambassis ranga*	Least Concern
9	Chapri	*Gadusia chapra*	Least Concern
10	Chelhwa	*Laubuca laubuca*	Least Concern
11	Cheli	*Colisa fasciatus*	Data Deficient
12	Chenga	*Channa orientalis*	Least Concern
13	Chilwa	*Aspidoparia morar*	Least Concern
14	Daryai tengra	*Sperata aor*	Least Concern
15	Dendua	*Esomus danricus*	Least Concern
16	Dharhee	*Puntius sarana*	Least Concern
17	Dhawai	*Amblypharyngodon mierolepis*	Least Concern
18	Dhebari	*Nandus nandus*	Least Concern
19	Gaphulmi	*Tetrsdon cutcutia*	Data Deficient
20	Garai	*Channa punctatus*	Least Concern
21	Gonchi	*Macrognathus aral*	Least Concern
22	Jalcapoor	*Ompok bimaculam*	Least Concern
23	Jhinga	*Macrobrachium rosenbergii*	Least Concern
24	Kabai; Kawai	*Anabas testudineus*	Least Concern
25	Katla / Farha	*Catla catla*	Least Concern
26	Kursa	*Labeo gonius*	Least Concern
27	Maguri	*Clarias batrachus*	Least Concern
28	Moh	*Notopterus notopterus*	Least Concern
29	Naini	*Cirrhinus mrigala*	Least Concern
30	Nakati	*Lapidocephalus guntia*	Least Concern
31	Patasi	*Ailia coilia*	Data Deficient
32	Phasa	*Setipinna phasa*	Least Concern
33	Pothia	*Puntius tico*	Least Concern
34	Pothia	*Puntius sophore*	Least Concern
35	Reba	*Cirrhinus reba*	Least Concern
36	Rohu	*Labeo rohita*	Least Concern
37	Saur	*Channa marulius*	Least Concern
38	Sauri	*Channa striatus*	Least Concern
39	Sauri	*Cololabis adocetus*	Least Concern
40	Sindhari	*Puntius conchonius*	Least Concern
41	Sindhari	*Puntius phutunio*	Least Concern
42	Singhi	*Heteropneustes fossilis*	Least Concern
43	Suiya	*Gonialosa manmina*	Least Concern

S.no	Common name	Scientific name	IUCN
44	Sumla	*Badis badis*	Least Concern
45	Telapia	*Telapia Sp.*	Least Concern
46	Tengra	*Mystus tengara*	Least Concern
47	Tengra	*Mystus cavasius*	Least Concern
48	Tengra	*Sperata seenghala*	Least Concern
49	Tengra	*Mystus vittatus*	Least Concern
50	Tengra	*Tengara mystus*	Least Concern

Annex 4

List of Amphibian species

S.no	Family	Common name	Scientific name	IUCN	WPA-1972	CITES
1	Dicroglossidae	Indian Bull Frog	*Hoplobatrachus tigerinus*	Least Concern	Schedule IV	Appendix II

Annex 5

List of Reptile species

S.no	Family	Common name	Scientific name	IUCN	WPA-1972	CITES
1	Agamidae	Indian Garden Lizard	*Calotes versicolor*	Least Concern	Schedule II	Not Listed
2	Varanidae	Common Indian Monitor Lizard	*Varanus bengalensis*	Least Concern	Schedule I	Appendix I
3	Crocodylidae	Mugger Crocodile	*Crocodylus palustris*	Vulnerable	Schedule I	Appendix I
4	Gavialidae	Gharial	*Gavialis gangeticus*	Critically Endangered	Schedule I	Appendix I
5	Elapidae	Cobra	*Naja naja*	Vulnerable	Schedule II	Appendix II
6	Elapidae	Common Krait	*Bungarus caeruleus*	Not Evaluated	Schedule IV	Not Listed
7	Colubridae	Rat Snake	*Ptyas mucosus*	Least Concern	Schedule II	Not Listed
8	Pythonidae	Indian Python	*Python molurus*	Near Threatened	Schedule I	Appendix I
9	Colubridae	Wolf Snake	*Lycodon aulicus*	Least Concern	Not Listed	Not Listed
10	Colubridae	Worm Snake	*Carphophis amoena*	Least Concern	Not Listed	Not Listed
11	Colubridae	Checkered Keelback	*Fowlea piscator*	Least Concern	Schedule I	Not Listed
12	Trionychidae	Indian Black Turtle	*Melanochelys trijuga*	Vulnerable	Schedule I	Appendix I

Annex 6

List of Mammal species

S.no	Family	Common name	Scientific name	IUCN	WPA-1972	CITES
1	Viverridae	Asian Palm Civet	*Paradoxurus hermaphroditus*	Least Concern	Schedule I	Appendix III
2	Bovidae	Black Buck	*Antilope cervicapra*	Near Threatened	Schedule II	Appendix III
3	Bovidae	Blue Bull	*Boselaphus tragocamelus*	Least Concern	Schedule III	Appendix III
4	Cercopithecidae	Common Gray Langoor	*Semnopithecus (Presbytis) entellus*	Least Concern	Schedule II	Appendix II
5	Herpestidae	Common Mongoose	*Herpestes edwardsii*	Least Concern	Schedule II	Appendix III
6	Sciuridae	Five-striped Squirrel	*Funambulus pennantii*	Least Concern	Schedule IV	Not Listed
7	Canidae	Golden Jackal	*Canis aureus*	Least Concern	Schedule II	Appendix III

S.no	Family	Common name	Scientific name	IUCN	WPA-1972	CITES
8	Hystricidae	Indian Crested Porcupine	*Hystrix indica*	Least Concern	Schedule IV	Not Listed
9	Leporidae	Indian Hare	*Lepus nigricollis*	Least Concern	Schedule IV	Not Listed
10	Felidae	Jungle Cat	*Felis chaus*	Least Concern	Schedule I	Appendix II
11	Cercopithecidae	Rhesus Macaque	*Macaca mulatta*	Least Concern	Schedule II	Not Listed
12	Viverridae	Small Indian Civet	*Viverricula indica*	Least Concern	Schedule II	Appendix III
13	Mustelidae	Smooth Coated Otter	*Lutrogale perspicillata*	Vulnerable	Schedule II	Appendix I
14	Suidae	Wild Boar	*Sus scrofa*	Least Concern	Schedule II	Not Listed

Annex 7

List of Bird species

Sl No	Common name	Scientific name	Family	IUCN
1	Ashy-crowned Sparrow Lark	Eremopterix griseus	Alaudidae	LC
2	Asian Koel	Eudynamys scolopaceus	Cuculidae	LC
3	Asian Openbill	Anastomus oscitans	Ciconiidae	LC
4	Asian Palm Swift	Cypsiurus balasiensis	Apodidae	LC
5	Asian Pied Starling	Sturnus contra	Sturnidae	LC
6	Bank Myna	Acridotheres ginginianus	Sturnidae	LC
7	Barn Owl	Tyto alba	Strigidae	LC
8	Baya Weaver	Ploceus philippinus	Ploceidae	LC
9	Black crowned Night Heron	Nycticorax nycticoras	Ardeidae	LC
10	Black Drongo	Dicrurus macrocercus	Dicruridae	LC
11	Black hooded Oriole	Oriolus xanthornus	Oriolidae	LC
12	Black shouldered Kite	Elanus caeruleus	Accipitridae	LC
13	Black-headed Ibis	Threskiornis melanocephalus	Threskiornithidae	NT
14	Black-winged Stilt	Himantopus himantopus	Recurvirostridae	LC
15	Blue tailed Bee-eater	Merops philippinus	Meropidae	LC
16	Bronze-winged Jacana	Metopidius indicus	Jacanidae	LC
17	Cattle Egret	Bubulcus ibis	Ardeidae	LC
18	Chestnut shouldered Petronia	Gymnoris xanthocollis	Passeridae	LC
19	Common Hawk Cuckoo	Hierococcyx varius	Cuculidae	LC
20	Common Kingfisher	Alcedo atthis	Alcedinidae	LC
21	Common Moorhen	Gallinula chloropus	Rallidae	LC
22	Common Myna	Acridotheres tristis	Sturnidae	LC
23	Common Pigeon	Columba livia	Columbidae	LC
24	Common Tailorbird	Orthotomus sutorius	Sylviidae	LC
25	Cotton Pigmy-Goose	Nettapus coromandelianus	Anatidae	LC
26	Eurasian Collared Dove	Streptopelia decaocto	Columbidae	LC
27	Eurasian Golden Oriole	Oriolus oriolus	Oriolidae	LC
28	Greater Coucal	Centropus sinensis	Cuculidae	LC
29	Green Bee-eater	Merops orientalis	Meropidae	LC
30	Grey Francolin	Francolinus pondicerianus	Phasianidae	LC
31	Grey-headed Swamphen	Porphyrio poliocephalus	Rallidae	LC

Sl No	Common name	Scientific name	Family	IUCN
32	House Crow	Corvus splendens	Corvidae	LC
33	Indian Grey Hornbill	Ocyceros birostris	Bucerotidae	LC
34	Indian Peafowl	Pavo cristatus	Phasianidae	LC
35	Indian Pond Heron	Ardeola grayii	Ardeidae	LC
36	Indian Silverbill	Euodice malabarica / Lonchura malabarica	Estrildidae	LC
37	Intermediate Egret	Ardea intermedia	Ardeidae	LC
38	Jacobin Cuckoo	Clamator jacobinus	Cuculidae	LC
39	Jungle Babbler	Turdoides striata	Timaliidae	LC
40	Jungle Prinia	Prinia sylvatica	Cisticolidae	LC
41	Large-billed Crow	Corvus macrorhynchos	Corvidae	LC
42	Lesser whistling Duck	Dendrocygna javanica	Anatidae	LC
43	Little Cormorant	Microcarbo niger / Phalacrocorax niger	Phalacrocoracidae	LC
44	Little Grebe	Tachybaptus ruficollis	Podicipedidae	LC
45	Oriental Magpie Robin	Copsychus saularis	Muscicapidae	LC
46	Paddy Field Pipit	Anthus rufulus	Motacillidae	LC
47	Pheasant-tailed Jacana	Hydrophasianus chirurgus	Jacanidae	LC
48	Pied Kingfisher	Ceryle rudis	Alcedinidae	LC
49	Plain Martin	Riparia paludicola	Hirundinidae	LC
50	Plain Prinia	Prinia inornata	Cisticolidae	LC
51	Purple Sunbird	Nectarinia asiatica	Nectariniidae	LC
52	Red-naped Ibis	Pseudibis papillosa	Threskiornithidae	LC
53	Red-vented Bulbul	Pycnonotus cafer	Pycnonotidae	LC
54	Red-wattled Lapwing	Vanellus indicus	Charadriidae	LC
55	Sand Lark	Calandrella raytal	Alaudidae	LC
56	Sarus Crane			VU
57	Shikra	Accipiter badius	Accipitridae	LC
58	Spotted Dove	Spilopelia chinensis	Columbidae	LC
59	Striated Babbler	Argya earlei	Timaliidae	LC
60	White-breasted Waterhen	Amaurornis phoenicurus	Rallidae	LC
61	White-throated Kingfisher	Halcyon smyrnensis	Alcedinidae	LC
62	Yellow Bittern	Ixobrychus sinensis	Ardeidae	LC
63	Ziting Cisticola	Cisticola juncidis	Cisticolidae	LC

Annexe 8

Sub basin level action plan

1	**Institutional Set-up**
1.1	Notification of wetlands under Wetland Rules
1.2	Notification of district wetland committees
1.3	Infrastructure development-human resources
2	**Integrated wetland inventory assessment and monitoring system**
2.1	Establishment of wetland monitoring and research center
2.2	Development of database management system
2.3	Wetland monitoring
2.4	Ecosystem health report
2.5	Identification of land cadastre(survey number, area and ownerships details) within the wetland and its zone of influence and entry in to land use records as wetlands
3	**Research Studies**
3.1	Climate Risk Assessment
3.2	Hydrological connectivity assessment
3.2	Inventorization of wetlands biodiversity
3.3	Socio-cultural inventory of wetlands
3.4	Multiple wetland values assessment
4	**Capacity development**
4.1	Training needs assessment
4.2	Development of training plan
4.3	Capacity development workshops
4.4	Post-training handholding support
4.5	Effectiveness assessment
5	**Communication and outreach**
5.1	Webpage
5.2	Resource material
5.3	Newsletter
5.4	Workshop and public events
6	**Management implementation and review**
6.1	Mid-term review
6.2	Annual learning events

Site level action plan

Management Category – Village Ponds

	Wetlands		Bhojpur	Milkipull Pokhar	Buxar	Badka Taal	Dalsagar Pokhar
I	Institutional Set-up						
		Constitution of wetland mitra network		✓		✓	✓
		Training and orientation on wetland management		✓		✓	✓
		Issue-specific training		✓		✓	✓
		Finalisation and endorsement of site-management plan		✓		✓	✓
		Signage		✓		✓	✓
		Outreach programmes		✓		✓	✓
		Sensitisation of land owners and stakeholders on wetland ecosystem services, waste management, wise use approaches and provisions of Wetland Rules		✓		✓	✓

	Wetlands		Bhojpur	Milkipull Pokhar	Buxar	Badka Taal	Dalsagar Pokhar
		Regular surveillance and reporting to support wetland wise use		✓		✓	✓
2	**Wetlands delineation & demarcation**						
2.1	Wetland demarcation						
		Placement of geo-tagged boundary pillars		✓		✓	✓
		Mapping of land cadastre and entry in to land use records with the help of District Ganga Committee and Bihar State Wetland Authority		✓		✓	✓
		Removal of encroachments					
2.2	Creation of vegetative buffers						
		Plantation of native species				✓	
		Maintenance				✓	

	Wetlands		Bhojpur	Milkipull Pokhar	Buxar	Badka Taal	Dalsagar Pokhar
3	**Enhancing hydrological regimes**						
3.1	Clearing inlets and outlets						
3.2	Selective desilting					✓	
4	**Pollution abatement**						
		Survey of wastewater nallahs		✓		✓	✓
		Manual scouring of scum and other waste materials				✓	
		In-situ inflowing nallah treatment					
		Relocation of dumping sites				✓	
		Establishment of solid waste collection and disposal systems in Panchayats		✓		✓	✓
5	**Species and habitat conservation**						
5.1	Creation and Maintenance of People's						

	Wetlands		Bhojpur	Milkipull Pokhar	Buxar	Badka Taal	Dalsagar Pokhar
	Biodiversity Registers						
		Training		✓		✓	✓
		Creation of People's Biodiversity Registers		✓		✓	✓
5.3	Management of invasive species						
		Removal of water hyacinth and other invasive macrophytes		✓		✓	
6	**Resource development and livelihoods**						
		Sustainable fisheries development		✓		✓	✓
		Water hyacinth-based enterprise		✓		✓	
		Multi-purpose shelter		✓		✓	✓
		Construction of approach roads		✓		✓	✓
		Incentives to land owners for adoption of wetland friendly practices		✓		✓	✓

	Wetlands		Bhojpur	Milkipull Pokhar	Buxar	Badka Taal	Dalsagar Pokhar
7	**Monitoring and review**						
		Monitoring		✓			
		Monitoring (Representative Sites)		✓		✓	
		Management plan mid-term review (External)		✓			

Management Category – Urban-Peri urban

	Wetlands		Buxar	Anjani Talaab
1	**Institutional Set-up**			
		Constitution of wetland mitra network		✓
		Training and orientation on wetland management		✓
		Issue-specific training of Wetland Mitra		✓
		Finalisation and endorsement of site-management plan		✓
		Signage		✓
		Outreach programmes		✓
		Sensitisation of land owners and stakeholders on wetland ecosystem services, waste management, wise use approaches and provisions of Wetland Rules		✓
		Regular surveillance and reporting to support wetland wise use		✓
2	**Wetlands delineation & demarcation**			
2.1	Wetland demarcation			
		Placement of geo-tagged boundary pillars		✓
		Mapping of land cadastre and entry in to land use records with the help of District Ganga Committee and Bihar State Wetland Authority		✓
		Removal of encroachments		
2.2	Creation of vegetative buffers			
		Plantation of native species		
		Maintenance		
3	**Enhancing hydrological regimes**			
3.1	Clearing of inlets and outlets			
3.2	Selective desilting			

	Wetlands		Buxar	Anjani Talaab
4	**Pollution abatement**			
		Survey of wastewater nallahs		✓
		Manual scouring of scum and other waste materials		
		Installation of waste sieves at inlets		
		Construction of sand gravel-beds for inflow filtration		✓
		Establishment of floating treatment wetlands		✓
		Relocation of dumping sites		✓
5	**Species and habitat conservation**			
5.1	Creation and Maintenance of People's Biodiversity Registers			
		Training		✓
		Creation of People's Biodiversity Registers		✓
		Asian Waterbird Census		✓
5.3	Management of invasive species			
		Removal of water hyacinth and other invasive macrophytes		
6	**Resource development and livelihoods**			
6.1	Sustainable fisheries development			
		Training on sustainable fisheries management		✓
		Assistance for craft and gear		✓
		Construction and upgradation of jetties		✓
7	**Wetland education and interpretation**			
		Watch Towers		✓
		Walking trails		✓

	Wetlands		Buxar	Anjani Talaab
8	**Monitoring and Review**			
		Monitoring		✓
		Regular Monitoring (Representative Sites)		✓
		Managemnet Plan Mid term reiew (External)		✓

Management Category – Floodplain Agriculture

	Wetlands		Bhojpur	Nathmalpur Bhagad	Semra ka Pokhar	Buxar	Lohandiya
1	**Institutional Set-up**						
		Constitution of wetland mitra network		✓	✓		✓
		Training and orientation on wetland management		✓	✓		✓
		Issue-specific training		✓	✓		✓
		Finalisation and endorsement of site-management plan		✓	✓		✓
		Signage		✓	✓		✓
		Outreach programmes		✓	✓		✓
		Sensitisation of land owners and stakeholders on wetland ecosystem services, waste management, wise use approaches and provisions of Wetland Rules		✓	✓		✓
		Regular surveillance and reporting to support wetland wise use					
2	**Wetlands delineation & demarcation**						
2.1	Wetland demarcation						
		Placement of geo-tagged boundary pillars		✓	✓		✓
		Mapping of land cadastre and entry in to land use records with the support of District Ganga Committee and BSWA		✓	✓		✓
		Removal of encroachments					✓
3	**Enhancing hydrological regimes**						
3.1	Clearing inlets and outlets			✓	✓		✓
4	**Species and habitat conservation**						
4.1	Creation and Maintenance of People's Biodiversity Registers						
		Training		✓	✓		✓

	Wetlands		Bhojpur	Nathmalpur Bhagad	Semra ka Pokhar	Buxar	Lohandiya
		Creation of People's Biodiversity Registers		✓	✓		✓
4.2	Management of invasive species						
		Removal of water hyacinth and other invasive macrophytes		✓	✓		
5	**Resource development and livelihoods**						
5.1	Sustainable fisheries development						
		Formation of user groups and setting up rules and regulations		✓	✓		✓
		Microcredit support		✓	✓		✓
		Training on sustainable fisheries management		✓	✓		✓
		Assistance for craft and gear		✓	✓		✓
		Construction and upgradation of jetties		✓			✓
5.2	Promoting sustainable agriculture practices						
		Training through KVKs on sustainable and climate resileint wetland agriculture practices		✓	✓		✓
		Microcredit support to farmers		✓	✓		✓
		Wetland agro-product based microenterprise		✓	✓		✓
		Financial incentive to land owners for adoption of wetland friendly practices		✓	✓		✓
		Establishment of agri centres units for supply of quality farm inputs to farmers for organic cultivation like organic herbicides and pesticides		✓			✓
5.3	Promoting additional livelihood enterprise	Training and capacity development on additional livelihood opportunities		✓	✓		✓
		Financcial incentives to farmers for establishment of poultry, piggery, goatry and dairy enterprises		✓	✓		✓
		Training on prevention and control of zoonotic diseases		✓	✓		✓
		Establishment of veterinary clinics		✓	✓		✓

	Wetlands		Bhojpur	Nathmalpur Bhagad	Semra ka Pokhar	Buxar	Lohandiya
		Incentivization to landowners to promote cultivation of native fodder species in wetland periphery		✓	✓		✓
6	**Monitoring and review**						
		Monitoring		✓			✓
		Monitoring (Representative Sites)		✓			✓
		Management plan mid-term review (External)		✓			✓

Management Category – Production Systems

	Wetlands		Bhojpur	Sukhi Suiya	Buxar	Gokul Jalashay
I	**Institutional Set-up**					
		Constitution of wetland mitra network		✓		✓
		Training and orientation on wetland management		✓		✓
		Issue-specific training		✓		✓
		Finalisation and endorsement of site-management plan		✓		✓
		Signage		✓		✓
		Outreach programmes		✓		✓
		Sensitisation of land owners and stakeholders on wetland ecosystem services, waste management, wise use approaches and provisions of Wetland Rules		✓		✓
		Regular surveillance and reporting to support wetland wise use		✓		✓

2.2	Creation of vegetative buffers					
		Plantation of native species		✓		✓
		Maintenance		✓		✓
2	**Wetlands delineation & demarcation**					
2.1	Wetland demarcation					
		Placement of geo-tagged boundary pillars		✓		✓
		Mapping of land cadastre and entry in to land use records with the support of District Ganga Committee and BSWA		✓		✓
		Removal of encroachments				
3	**Enhancing hydrological regimes**					
3.1	Clearing inlets and outlets			✓		✓
3.2	Selective desilting			✓		✓
4	**Pollution abatement**					
		Survey of wastewater nallahs		✓		✓

		Manual scouring of scum and other waste materials		✓		✓
		In-situ inflowing nallah treatment		✓		
		Relocation of dumping sites		✓		
		Installation of waste sieves at inlets		✓		
5	**Species and habitat conservation**					
5.1	Creation and Maintenance of People's Biodiversity Registers					
		Training		✓		✓
		Creation of People's Biodiversity Registers		✓		✓
5.2	Management of invasive species					
		Removal of water hyacinth and other invasive macrophytes				✓
		Training for prevention and control of invasive fish species		✓		✓
6	**Resource development and livelihoods**					
6.1	Sustainable fisheries development					

		Formation of user groups and setting up rules and regulations incldluing marking zones for capture, culture fisheries, closed areas, fishing seasons		✓		✓
		Microcredit support to fishers		✓		✓
		Training on sustainable fisheries management		✓		✓
		Assistance for craft and gear, ice boxes		✓		✓
		Construction and upgradation of jetties		✓		✓
		Financial incentive to land owners for sustainable fishery management				
		Improving cold chain facilities such as ice plants and cold storage facilities		✓		✓
		Setting/ Operationalization of fish hatcheries		✓		✓
		Monitoring of catch data		✓		✓
		Microenterprise development based on water hyacinth and wetland products		✓		✓
6.2	Promoting sustainable agriculture practices					
		Training through KVKs on sustainable wetland agriculture practices		✓		✓
		Microcredit support to farmers		✓		✓
		Wetland agro-product based microenterprise		✓		✓

6.3	Promoting additional livelihood enterprise					
		Training and capacity development of fishers on additional livelihood opportunities		✓		✓
		Finacial support to fishers for establishment of poultry, piggery, goatry and dairy enterprises		✓		✓
		Training on prevention and control of zoonotic diseases		✓		✓
		Incentivization to promote cultivation of native fodder species in wetland periphery		✓		✓
7	**Monitoring and review**					
		Monitoring		✓		✓
		Monitoring (Representative Sites)				
		Management plan mid-term review (External)		✓		✓

Stay in touch

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