

KUSHESHWAR ASTHAN BIRD SANCTUARY AND NAGI & NAKTI RAMSAR SITES: BIODIVERSITY, CHALLENGES, AND CONSERVATION IMPERATIVES



ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE

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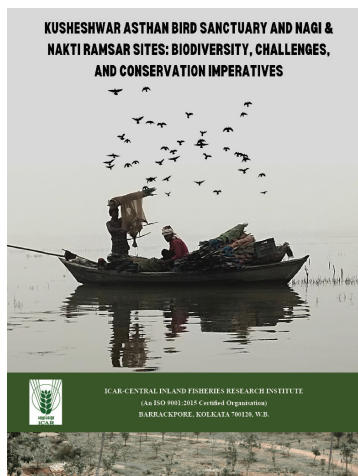


**Kusheshwar Asthan bird sanctuary and Nagi & Nakti Ramsar
sites: Biodiversity, Challenges, and Conservation Imperatives
(Darbhanga and Jamui, Bihar)**

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Authors

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FOREWORD

Wetlands are among the most productive and ecologically significant ecosystems, serving as biodiversity hotspots, natural water regulators, and crucial resources for local livelihoods. Kusheshwar Asthan Bird Sanctuary, located in the Kosi-Gandak basin, is one such vital wetland complex that supports a rich aquatic ecosystem, diverse fish species, and a thriving avian population. This book presents an in-depth study of the fish diversity, ecological services, conservation challenges, and sustainable management of these rainfed wetlands, emphasizing their importance for both fisheries and biodiversity conservation.

The exploratory survey conducted across four key *chaur*s—Mahrailachaur (North), Narail *chaur* (East), Barari *chaur* (West), and Manoria *chaur* (South)—has provided critical insights into the aquatic biodiversity of the region. A total of 72 fish species, including several vulnerable, near-threatened, and endangered species, have been recorded, highlighting the urgent need for conservation action. The presence of rare aquatic species, such as the freshwater sponge (*Ephydatia fluviatilis*) and the anchor catfish (*Erethistes jerdoni*), further underscores the ecological significance of these wetlands. However, despite their rich biodiversity, Kusheshwar Asthan wetlands face multiple threats, including unregulated fishing, habitat destruction, siltation, loss of connectivity with rivers, and conflicts among stakeholders.

One of the unique aspects documented in this study is the prevalence of traditional fishing practices, such as ‘Jaing’ fishing, which demonstrate the deep-rooted connection between local communities and the wetlands. The study also highlights the various ecological services these wetlands provide, from fisheries and agriculture to bird conservation and edible macrophyte resources. This bulletin serves as both a scientific documentation and a call to action, providing valuable insights for researchers, policymakers, conservationists, and local communities. It stresses the need for integrated conservation approaches, habitat restoration, and sustainable fisheries management to protect Kusheshwar Asthan’s wetland ecosystems.

The Nagi and Nakti Bird Sanctuaries, two vital wetland ecosystems, continue to serve as crucial habitats for a diverse array of flora and fauna, particularly migratory birds, aquatic life, and macrophytes. This bulletin presents a comprehensive study of the ecological dynamics within these sanctuaries, shedding light on seasonal variations, species distribution, and emerging conservation challenges.

One of the key observations in this study is the difference in migratory bird influx between Nagi and Nakti, reflecting variations in habitat quality and ecological conditions. Birds, being sensitive bio-indicators, offer critical insights into the health of wetland ecosystems. Similarly, water transparency fluctuations during the dry season at Nagi Bird Sanctuary underscore the influence of algae proliferation, a factor that directly impacts aquatic ecosystems.

The findings also highlight the significance of water depth in shaping aquatic biodiversity, with deeper waters providing essential refuge and feeding grounds for various species. The study further emphasizes the role of planktonic organisms as indicators of ecosystem health, showcasing a notable increase in phytoplankton abundance and diversity during the dry season. The documented presence of specific zooplankton and benthic species further reinforces the intricate relationship between seasonal changes and ecological responses.

Macrophyte diversity within these sanctuaries is another key aspect explored, with dominant submerged species such as *Potamogeton nodosus* playing a crucial role in supporting avian and aquatic life. The study also presents an extensive inventory of fish species, with observations on their conservation status, taxonomic diversity, and ecological interactions. A particularly important finding is the impact of introduced Tilapia populations in Nagi Bird Sanctuary, highlighting the need for careful management to prevent ecological imbalances.

As we strive to protect and conserve these vital ecosystems, the insights presented in this bulletin serve as a valuable resource for researchers, conservationists, and policymakers. Understanding the ecological intricacies of Nagi and Nakti Bird Sanctuaries is essential for formulating effective conservation strategies that ensure the long-term sustainability of these biodiversity-rich wetlands.

We hope this bulletin inspires collective action toward the preservation of these remarkable sanctuaries and fosters a deeper appreciation for the delicate balance of nature within them.

B. K. Das
Director,
ICAR-CIFRI

Kusheshwar Asthan bird sanctuary

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- Principal Chief Conservator of Forests, Bihar
- Chief Wildlife Conservator, Wildlife, Darbhanga District
- Forest Ranger and other officials of Kusheshwar Asthan Bird Sanctuary

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1. EXECUTIVE SUMMERY

1. Exploration of fish diversity and identification in priority habitat was performed in Kusheshwar Asthan Bird Sanctuary. Kusheshwar Asthan *chaurs* are under the Kosi-Gandak basin and have been highly significant for fisheries and biodiversity. They were notified as a bird sanctuary by the Govt. of Bihar in 1994.
2. The *chaurs* are rainfed wetlands, and monsoons run off with flow from a network of rivers like Kamala, Balan, Bagmati, and Kareh, which are the prime sources of water. The Kusheshwar Asthan *Chaur*s are interspersed with 14 highly populated villages. The protected water bodies provide numerous ecological services and harbor a rich aquatic diversity. The exploratory survey was conducted in four *chaurs*, viz., Mahraila *chaur* (North), Narail *chaur* (East), Barari *chaur* (West), and Manoria *chaur* (South) of Kusheshwar Asthan.
3. Fish diversity and their conservation status were assessed in four *chaurs*; a total of 72 fish species under 24 families, 2 prawn species, and 2 crabs have been recorded. The most abundant native species were small-sized fishes (viz. *Anabas testudineus*, *Macrognathus aral*, *pancalus*, *Puntius* spp., *Pethia* spp., *Chanda nama*, *Parambasis ranga*, *Amblypharyngodon mola*, *Pseudambassis ranga*, *Rasbora* spp., *Trichogester* spp., *Channa* spp., *Wallago attu*, *Nandus nandus*, etc.), and many of them have ornamental value. Among the fish species reported, 5 are vulnerable, 3 species are near-threatened, and 1 species (*Clarias magur*) is in the endangered category based on IUCN Red List status.
4. A freshwater sponge, *Ephydatia fluviatilis*, was recorded during the post-monsoon season. Anchor Catfish *Erethistes jerdoni* was recorded in the fisher's catch. Maximum length as per the fishbase record is 4cm; the present study recorded 4.6–4.8 cm.
5. A major issue noticed in this wetland complex was conflict among forest conservators, landowners, and fishermen about the utilization of resources. Unregulated fishing and destroying the breeding grounds of small indigenous fishes are concerns for the self-recruiting fish population. Disconnecting water connectivity from rivers in the name of infrastructure development such as rail routes, bridge construction, building construction, etc. Increased siltation of *chaurs*, poor water storage ability, increased occurrences of floods, conflicts between various stakeholders like fishing and non-fishing communities, indiscriminate and destructive fishing practices, decreased bird sightings, poor government interventions, a lack of community participation in management, and inept fisheries cooperatives were the major issues observed.
6. The study also identified various ecological services provided by the wetland

system, such as fisheries, agriculture, aesthetic value, bird conservation, fuel and fodder sources, edible resources such as macrophyte tubers and seeds, etc.

7. A traditional fishing practice based on the concept of FADs, called 'Jaing' fishing, was prevalent in the *chaurs*.
8. There is a great need for implementing a proper conservation management plan and raising awareness about the importance of conservation of aquatic resources, considering the vast potential of these important wetland resources for livelihood support and conservation of fish as well as birds.



2. Introduction

The declaration of protected areas (PAs) is increasing globally to conserve natural flora and fauna and associated ecosystem services (Lehikoinen et al., 2021). Between 2010 and 2019, protected areas expanded from covering 14.1% to 15.3% of global land (Maxwell et al., 2020) and freshwater environments (excluding Antarctica) and from 2.9% to 7.5% of the marine realm (UNEP-WCMC, 2019). Protected areas are the most widely used tools for conservation of biodiversity. These tools include mandatory legal procedures for strict implementation of limited human interference in defined geographical spaces to enhance diversity. There are a total of 18,075 freshwater fish species in the world, accounting for 51 percent of all fish species and 25 percent of all vertebrates. These species provide irreplaceable goods and services but are increasingly affected by human activities. They are an important food source for 200 million people and provide work for 60 million. But their numbers are in decline. The IUCN Red List of Threatened Species has declared 80 to be extinct, 16 of those in 2020 alone. In fact, freshwater biodiversity is plummeting at twice the rate of biodiversity in the oceans and forests.

The state of Bihar, situated along the Ganga River basin, includes 38 districts, of which 21 are in north Bihar and 17 are in south Bihar. The state of Bihar is endowed with a variety of natural water resources, viz., rivers and associated water bodies like floodplain wetlands (Oxbow Lake, meanders, seasonal floodplain), reservoirs, ponds, and tanks. Despite abundant aquatic resources in terms of about 2800 km of rivers, 43500 hectares of *chaurs* and floodplain wetlands, 9,000 hectares of oxbow lakes or *mauns*, 7,200 hectares of reservoirs, and 68,050 hectares of ponds and tanks, fish supply is short of demand in the State of Bihar. Apart from the Ganga River system, there are 15 rivers and rivulets such as Koshi, Gandak, Budhi Gandak, Kareh, Kamla, Bagmati, etc.

Protected areas are the principal mechanism of biodiversity conservation on Earth and serve as the most important units for in-situ biodiversity conservation. Globally, wetland conservation mainly focuses on the conservation of aquatic birds, and most times, the fish diversity in those protected water bodies is not explored or documented. Although the Ramsar Convention, which came into existence in 1971, adopted fish criteria to designate wetlands as Ramsar sites in 1996, An assessment of the contribution of fisheries in Ramsar sites is necessitated, but adequate relevance has not been given to fisheries and fish diversity assessments in many such designated wetlands. The study of fish diversity in bird sanctuaries holds immense significance for both ecological balance and human well-being. The project was formulated with the aim of exploring the status and diversity of fish fauna in some of the protected waters of India. Studying fish diversity in bird sanctuaries not only aids conservation efforts but also benefits both nature and people.

Ecological Balance:

- **Breeding and Nursery Grounds:** Bird sanctuaries often encompass wetlands, lakes, and rivers that serve as breeding and nursery grounds for various fish species. Studying fish diversity helps us understand the health of these ecosystems.
- **Food Web Dynamics:** Fish play a crucial role in food webs. They consume insects, plankton, and other aquatic organisms, maintaining a balance in the ecosystem. Their diversity ensures stability in these intricate food chains.
- **Indicator Species:** Fish diversity acts as an indicator of overall ecosystem health. Changes in fish populations can signal environmental disturbances, pollution, or habitat alterations.

Human Well-Being:

- **Livelihoods:** Many local communities depend on fishing for their livelihoods. A diverse fish population ensures sustainable fishing practices, supporting these communities economically.
- **Recreation and Tourism:** Recreational fishing and ecotourism thrive in bird sanctuaries. Diverse fish species enhance the attractiveness of these areas, drawing tourists and contributing to local economies.
- **Biodiversity Heritage:** Fish sanctuaries conserve unique fish species, preserving biodiversity for future generations.

Objective:

- To develop a biological inventory of fish and shellfish in selected protected water bodies
- To identify the priority habitat of fish and shellfish in the protected water bodies

Study period: April, 2021-March, 2023

3. Background of Project site

The Kusheshwar Asthan *Chaur*s, located in the district of Darbhanga, is a group of seasonally flooded wetlands of various sizes (locally known as *Chaur*) with a total area of 2921.4 ha interspersed with private land and notified by the Government of Bihar as Kusheshwar Asthan Bird Sanctuary vide notification No. 41/94-881-E/15 dated July 5, 1994 (Appendix 1A; Appendix 1B). The Kusheshwar Asthan *Chaur* is situated at a distance of 65 km from Darbhanga town, Bihar on SH 56 (Figure 1.1). Kusheshwar Asthan *Chaur* is characterized by sub-tropical to sub humid climate. Summer temperature rises upto 40°C and during winter it dips down to 4°C. Relative humidity of the area ranges from 60% to 90%. The average annual rainfall in the area is 1168 mm. The district receives about 85% of its total annual rainfall from the south-west monsoon. The area is fed by the overflow of the Koshi, Kamla Balan, Jibish Dhar and Kamla Rivers. Kamla Balan River enters the wetland from its north-eastern side through the Mohim Buzurg village while Jibish Dhar River enters from the north-western side through the Laranch and Mohim Khurd villages. The overflow of the Kamla River feeds the wetland from the western side. The outflow is from the southern part of the wetland through the Reota, Dharampur and Bhaluka villages. The Kusheshwar Asthan *Chaur* exhibit variation in its size and is subject to the quantum and intensity of water inflow from the nearby riverine sources. During the monsoon months (June to October), approximately 84.6% area of the wetland remains flooded. The water recedes post-monsoon and only 28.2% area remains inundated. During the summer months, only 3.55% of the total area remains underwater in the form of perennial water bodies.

Kusheshwar Asthan *Chaur* has a rich diversity of flora with 186 species of plants including 30 aquatic species (hydrophytes) dominant species viz. *Eichhornia Ottelia*, *Alternanthera*, *Ipomea* and *Vallisneria*. Total 80 species of birds were encountered in Kusheshwar Asthan *Chaur*. Reota village recorded highest number of bird species (41-50 species) followed by Mohim Buzurg, Pando and Badgaon (31-40 species). The Kusheshwar Asthan Bird Sanctuary area supports three “Vulnerable” and five “Near Threatened” bird species according to IUCN Red List of Threatened species (IUCN 2015). The Vulnerable species, Fishing Eagle (*Haliaeetus leucoryphus*), Woolly-necked Stork (*Ciconia episcopus*) and the Lesser Adjutant Stork (*Leptoptilos javanicus*) were reported from five different places in the area while Near Threatened species, Ferruginous Pochard (*Aythya nyroca*), Painted Stork (*Mycteria leucocephala*), Eurasian Curlew (*Numenius arquata*), Darter (*Anhinga melanogaster*) and White Ibis (*Threskiornis melanocephalus*) was reported from four different places of the area.

An area of 2921.4 ha was notified as Bird Sanctuary and is under the management of the Environment and Forest Department, Government of Bihar, India. This area is managed under the statutes and rules of the Wild Life (Protection) Act, 1972. The remaining area of

the wetland is under private ownership (22.4%). This area includes agricultural lands and water bodies along with human settlements. Kusheshwar Asthan *Chaur* is interspersed with fourteen densely populated villages. Agriculture is one of the major occupations of the local communities with major crops grown are Maize, Paddy and Wheat.

The entire area of inundation of the Kusheshwar Asthan wetland during monsoon season. Ecosystem services as the communities are mainly dependent on the wetland for fuel and fodder, alternative and efficient source of these should be introduced. Priority villages were selected for the introduction of alternatives of fuel, fodder, fishing, grazing and livelihood sources. For the fishery related issues, the management should focus on Bairo, Mohim Khurd and Pipra villages followed by Mohim Buzurg and Ladiami villages. Sanauli, Badgaon and Bishariya villages are low priority villages. For fodder alternatives, Bairo, Laranch, Mahiri Dih, Bishariya, Sanauli and Ladiami villages are high priority villages followed by Mohim Khurd, Pipra and Mohim Buzurg (medium priority) villages. Reota, Pando, Hirni, Badgaon and Asman are low priority villages. For fuel extraction, emphasis should be given to Mahiri Dih and Ladiami villages as these are highly dependent followed by Pipra, Sanauli, Bairo, Laranch, Mohim Buzurg and Asman villages.

Reota, Pando, Mohim Khurd, Hirni, Badgaon and Bishariya villages are low priority villages. For the development of sustainable livelihood options, Mahiri Dih, Bairo and Laranch villages should be given high priority as these villages have higher number of dependent households followed by Ladiami and Mohim Buzurg villages.

Significance of the Kusheshwar Asthan Bird Sanctuary

- Every year more than 20000 water birds congregate in the sanctuary
- Total 80 species of birds were encountered in Kusheshwar Asthan *Chours*. Among these 3 are vulnerable and five are near threatened.
- The sanctuary is house of many fishes, amphibians, birds and other aquatic flora and fauna
- Ecosystem services such as Irrigation and ground water recharge

Sampling

A scientific exploration was carried out by a team from ICAR-CIFRI in the wetlands of Kusheshwar Asthan *Chours*, Darbhanga district, Bihar for addressing the issue of lack of baseline information on aquatic biodiversity in protected water bodies. Kusheshwar Asthan *Chaur* area under Kosi-Gandak basin has been highly significant from fisheries and biodiversity point of view and has been notified as a Bird Sanctuary by Govt. of Bihar

in 1994 under Wild life Protection Act, 1972. Monsoon run off and flow from a network of rivers like Kamala, Balan, Bagmati and Kareh are the prime source of water for the *chaurs*.

The seasonal sampling was scheduled during Wet season (November, 2021), and dry season (June, 2022) seasons for sample collection of fish fauna, water, sediment, plankton, macrophytes, benthos, etc. from different selected sampling stations in the two reservoirs. We have selected a total of 4 sampling sites *chaurs*-Narail *chaur* (East), Mahraila *chaur* (North), Barari *chaur* (West), and Manoria *chaur* (South) to get detailed information of habitat, ecology and fish diversity of these bird sanctuaries.

Table 1: Geographical details of sampling sites

Kusheswar Asthan Wetland complex		
Site 1	Narail <i>chaur</i> (East)	25°49'51.5" N 86°17'56.7"E
Site 2	Mahraila <i>chaur</i> (North)	25°49'23.2" N 86°18'27.0"E
Site 3	Barari <i>chaur</i> (West)	25°49'38.2" N 86°17'47.0"E
Site 4	Manoria <i>chaur</i> (South)	25°49'13.5" N 86°17'34.7"E

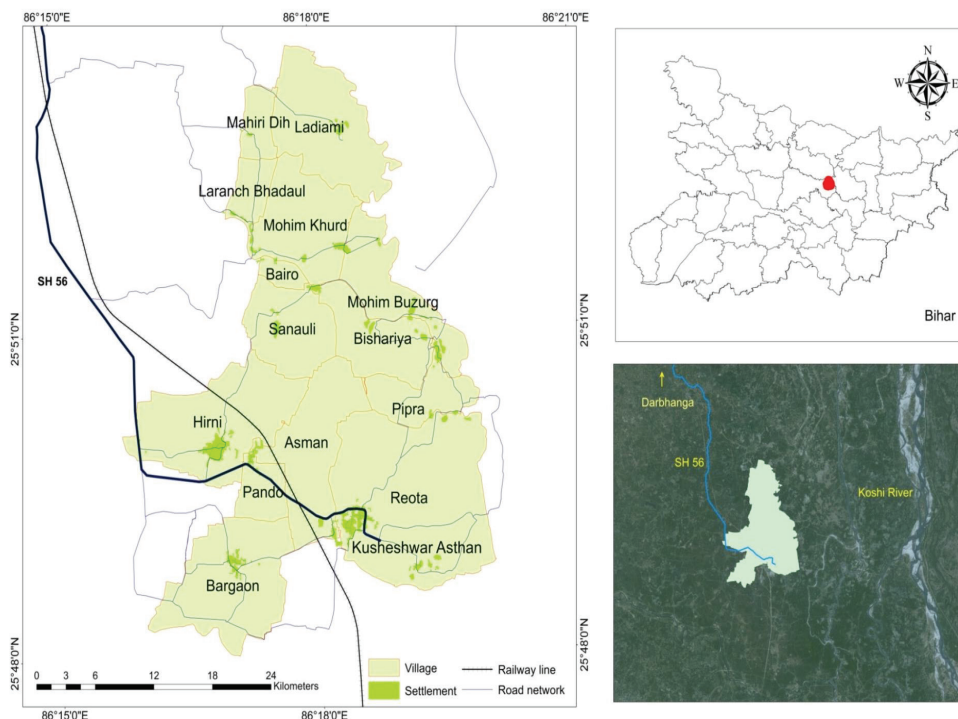


Figure 1: Map of Kusheswar Asthan Bird sanctuary (source: Forest department, Darbhanga)

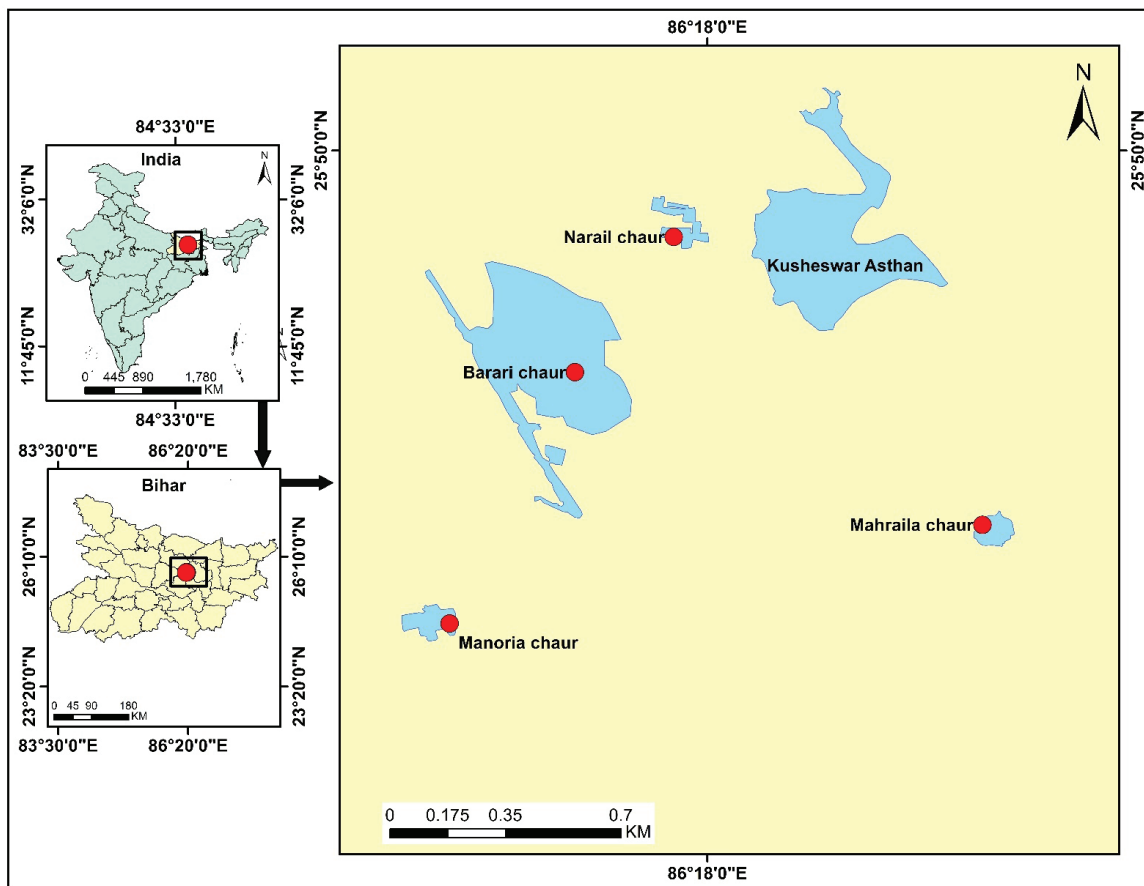


Figure 2: GIS map of Kusheswar Asthan Bird sanctuary



Figure 3: Kusheswar Asthan Bird sanctuary inundated during November

4. Hydrological and ecological parameters

The study on the important water quality attributes revealed that the water depth of wetlands is completely seasonal and a rain-fed inundation system. The dissolved oxygen level was above 5 in all sites during both sampling periods, indicating a favorable environment for fish. DO was assessed during the wet season from multiple locations, and an average value was calculated, but during the dry season, several deep pools were formed, and sapling was done from different deep pools. Water depth was not possible to figure out during the dry season because deep pools were totally based on the excavation done by private landowners on their own properties. During the wet season, Kusheshwar Asthan area gets inundated and no demarcation of private land owner is identified, and it becomes common property. Open-access fishing is practiced by fishermen and cooperatives. But when it gets dry in the dry season and the land becomes visible and demarcated by the land owner, they occupy it for their agricultural crop and auction the deep pools on payment for the complete harvest of fish. Fisheries growth and production in a 6-month period (late July to early February) is favorable because in February water gets dried up and the remaining water is stored in deep pools of private land and dried land or fields used for agriculture and horticulture crops. Fisheries are continuing until the deep pool has completely dried up.

Methodology followed:

Water quality parameters such as Depth (m) (digital depth sounder), Transparency (cm) (Secchi disc depth), Temperature of Water (°C) (graded centigrade mercury thermometer), pH (digital pH meter), Specific conductivity ($\mu\text{S}/\text{cm}$), Total Dissolved Solid (ppm), Dissolved Oxygen (ppm), Salinity (ppt) were assessed using a multiparameter digital probe (Eurotech), Free CO_2 (ppm), Chloride (ppm), Total Alkalinity (ppm), Total Hardness (ppm), Ca^{++} (ppm), Mg^{++} (ppm), Nitrate-N (ppm), Silicate-Si (ppm), Total Phosphorus (ppm) were assessed following Standard Methods (APHA, 2005, 2010; Welch, 1948). Water samples from all sites of Kusheshwar Asthan Bird Sanctuary were collected between 8 a.m. and 11 a.m. Parameters like temperature, pH, transparency, dissolved oxygen (DO), pH (digital pH meter), specific conductivity ($\mu\text{S}/\text{cm}$), total dissolved solids (ppm), dissolved oxygen (ppm), salinity (ppt), and free carbon dioxide (free CO_2) were estimated onsite immediately after the collection of water samples. Water samples from each site were brought to the laboratory for further analysis.

Water and soil quality parameters

The water and soil quality parameters of Mahrail, Manoria, Barari, and Larail were estimated from different sites, and these are represented in the average values in Table 2 and Table 3, respectively. Important parameters such as depth, DO, transparency, pH,

alkalinity, and phosphorus have shown differences between the seasons at the same sites of the bird sanctuary. In the month of June, water availability at each site was limited to patches. The measurement of water depth may not give the correct representation of the information. Migratory birds are very few in number. We have also discussed this with the local person regarding migratory birds; they opined that food for migratory birds is declining, so visits by migratory birds have decreased in Kusheswar Ashan Bird Sanctuary.

Table 2: Water quality parameter assessed during the wet (November) and dry season (June)

Water quality	Mahraila		Manoria		Barari		Larail	
Parameters	Nov	Jun	Nov	Jun	Nov	Jun	Nov	Jun
Depth (cm)	190.0	-	326.0	33	332.0	-	350.0	-
Transp. (m)	107.0	-	108.0	-	74.0	-	65.0	-
Temp Air (°C)	30	-	24.7	30.8	22.1	33.1	23	30.8
Temp Water (°C)	23.5	30.8	23.2	33.5	22.5	30.4	22.9	30.5
pH	6.72	7.91	6.81	-	6.77	7.74	6.85	7.6
Sp. cond. (µS/cm)	216.0	418.0	154.7	129.3	230.0	485.0	217	558
D.O. (ppm)	7.6	5.4	6.44	6.1	7.1	6.6	6.3	5.2
Free CO ₂ (ppm)	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
TDS (ppm)	154	310	110.0	91.8	161.0	343.0	153.0	395.0
Chloride (ppm)	42.0	-	25.2	-	44.0	-	42.0	-
Salinity (ppm)	105.0	0.2	75.5	0.1	109.0	0.2	104.0	0.3
Total Alkalinity (ppm)	112.0	200.0	76.0	76.0	100.0	236.0	108.0	272.0
Total hardness (ppm)	76.0	136.0	56.0	76.0	84.0	112.0	68.0	132.0
Ca ⁺⁺ (ppm)	14.4	37.7	12.8	15.2	24.0	27.3	17.6	36.9
Mg ⁺⁺ (ppm)	9.9	10.2	5.8	9.2	5.8	10.7	5.9	9.7
Nitrate-N (ppm)	0.25	0.53	0.51	0.18	0.45	0.14	0.37	0.10
Silicate-Si (ppm)	2.10	3.1	2.20	4.8	5.10	6.3	2.70	13.2
Total Phosphorus (ppm)	0.14	0.06	0.07	0.21	0.09	0.06	0.22	0.07



Figure 4 Sampling site of Kusheswar Asthan Bird Sanctuary in November



Figure 5. Same Sampling site of Kusheswar Asthan Bird sanctuary in June



Figure 6. Sampling site image in month of June: Patches of water found in deep pool at Barari and Maize harvest in Manoria

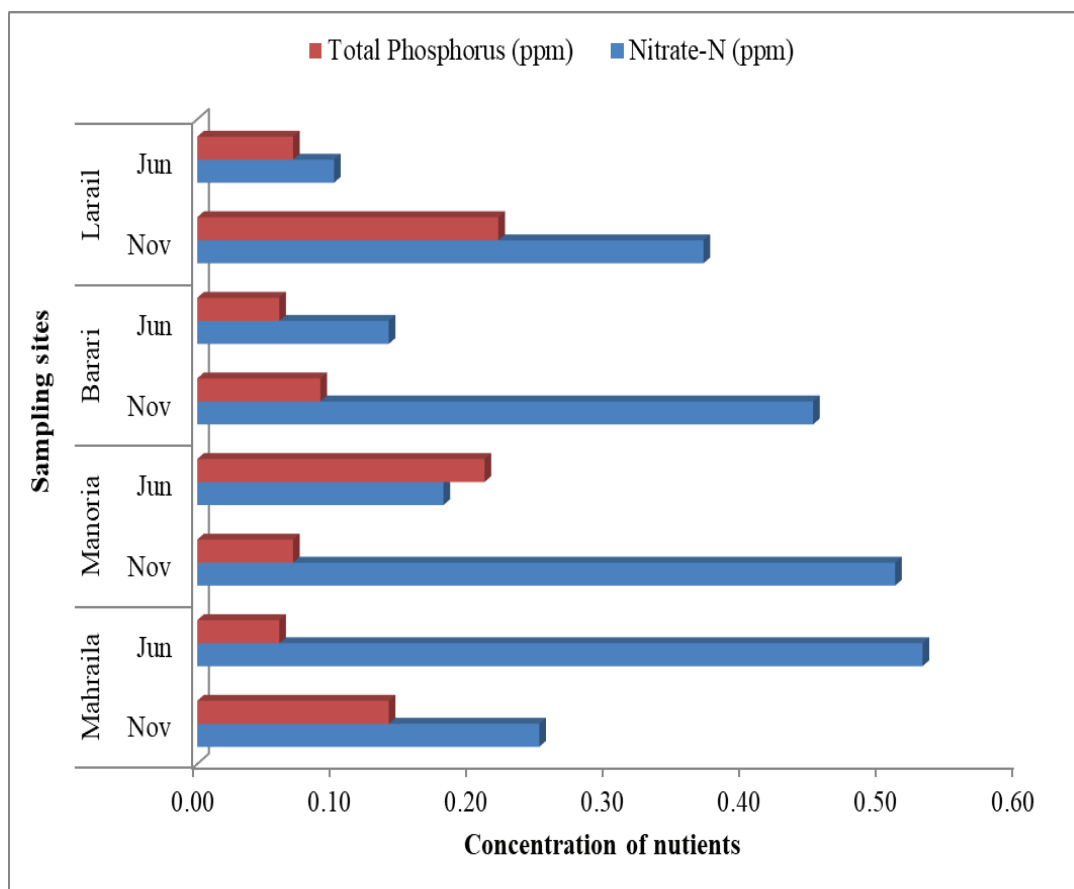


Figure 7. Seasonal variation in nitrate and total phosphorus concentration in Wet season (November) and in Dry season (June)

High levels of nitrate in water can be a result of runoff or leakage from fertilized soil, agricultural crops, wastewater, landfills, animal feedlots, septic systems, or urban drainage. The wetland complex of Kusheswar Asthan Bird Sanctuary has two cropping patterns: one is fisheries, and the other is agriculture, including vegetables and fodder for cattle farming. The most dominant farming in this area in Kharif season is maize. High concentrations of nitrate may be attributed to leaching from agriculture fields due to the application fertilizers.

Table 3: Soil quality parameter assessed during the wet (November) and dry season (June)

Soil quality	Mahraila		Manoria		Barari		Larail	
Parameters	Nov	Jun	Nov	Jun	Nov	Jun	Nov	Jun
pH	7.38	7.1	7.41	7.2	7.12	7.05	7.53	7.5
Sp. cond. ($\mu\text{S}/\text{cm}$)	319.0	430.0	245	275.0	292.0	264.0	545.0	220.0
Organic carbon (%)	1.94	3.31	1.45	3.2	1.32	2.6	1.7	2.44
AV. Phosphorus (mg/100gm)	1.8	1.57	0.8	1.7	1.6	1.76	2.8	1.72
Sand (%)	68.0	66.0	71	61.0	70.0	66	66.0	62.0
Silt (%)	8.0	13.0	9	9.0	10.0	11	8.0	12.0
Clay (%)	24.0	21.0	20	30.0	20.0	23	26.0	26.0

5. Plankton Diversity and Abundance

Phytoplankton

Phytoplankton are the foundation of the aquatic food web, the primary producers in aquatic ecosystems, and play an important role in overall wetland productivity, while zooplankton are recognized as the main primary consumers. Small fish and invertebrates also graze on the plant-like organisms, and then those smaller animals are eaten by bigger ones. As the base of the aquatic food web, phytoplankton plays a fundamental role in setting the productivity of the entire aquatic ecosystem. Specific phytoplankton groups also play key roles in the biogeochemical functioning of the wetlands, such as nitrogen fixation and oxygenation of the aquatic ecosystem. Due to their short life cycle and thus potentially rapid response to anthropogenic disturbances and environmental changes, planktonic organisms are also regarded as ideal bioindicators for assessing the environmental status of aquatic ecosystems.

The phytoplankton abundance and species diversity varied between the wetlands of Kusheshwar Asthan Bird Sanctuary; a total of 48 species of phytoplankton were recorded during the wet period and very few during the dry period. The highest abundance and diversity of phytoplankton were recorded in Manoria (47690 ± 2876 cells/Litre) and Mahraila (11560 ± 874 cells/Litre). Whereas in Larail and Baraila, there are 16605 ± 1142 cells/liter and 17695 ± 1563 cells/liter, respectively. Each individual plankton was counted separately under the inverted microscope using the Sedgwick rafter cell counting chamber. They can be classified into five groups. i.e., Chlorophyceae, Bacillariophyceae, Cyanophyceae, Dinophyceae, and Euglenophyceae. Among these groups, the most dominant group was Cyanophyceae, and the most dominant species was *Microcystis aeruginosa*, but little contribution to the total biomass indicated an organic load higher in the wetlands of Kusheshwar Asthan in the wet season, which may be attributed to runoff from agriculture land and domestic sewage.

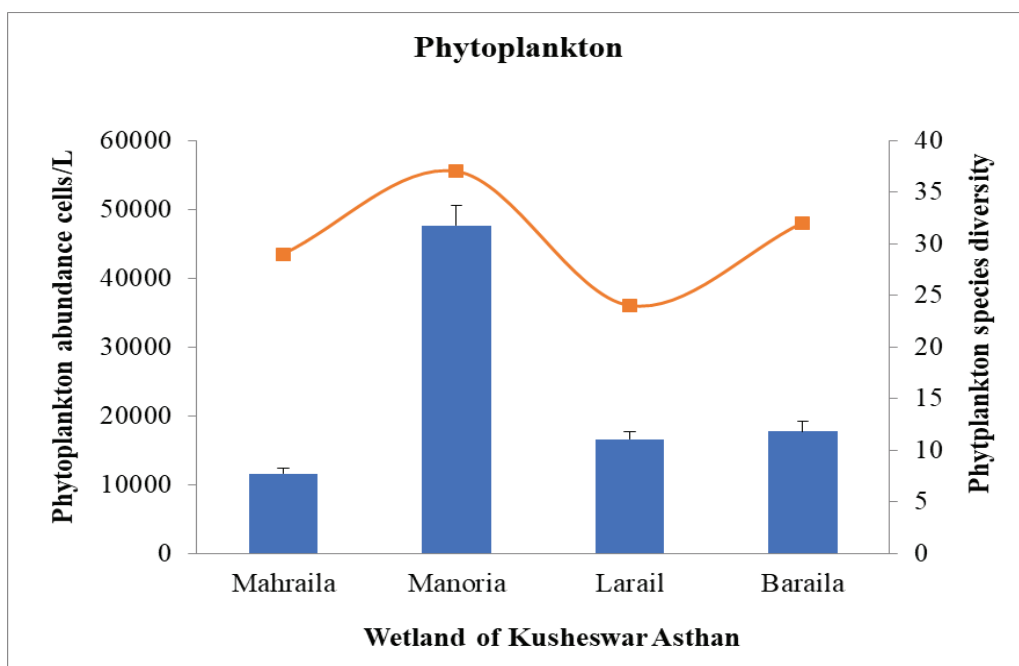


Figure 8. Wetland wise variation in phytoplankton abundance and diversity in Kusehswar Asthan Bird Sanctuary



Figure 9. Surface water plankton sample collection from wetland Manoria of Kusheshwar Asthan BS

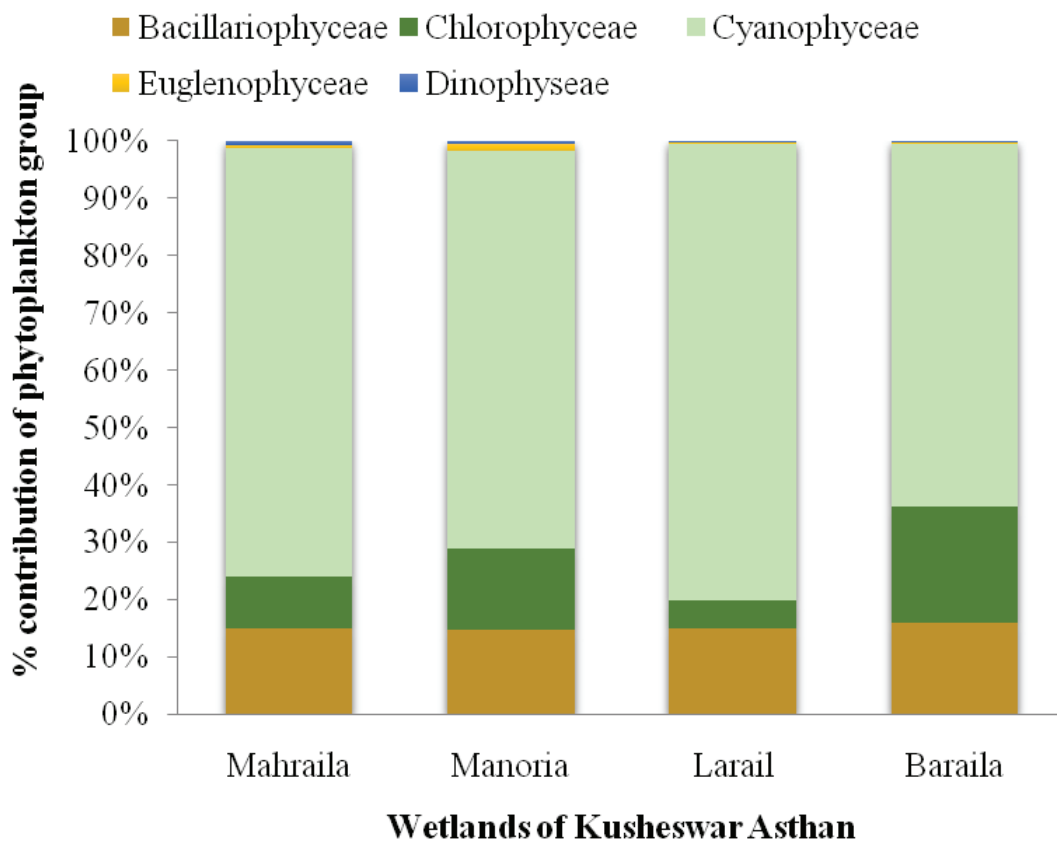


Figure 10. Group-wise phytoplankton variation in wetlands of Kusheshwar Asthan Bird sanctuary



Figure 11. Some of the abundant phytoplankton in Wetlands of Kusheshwar Asthan Bird sanctuaries; *Gomphonema*: Single cell diatom, asymmetrical valves, one end pointed and other end bluntly rounded, *Eudorina*: cells are loosely arranged in mucilage, *Pediastrum*: forms a larger coenobium with its cells arranged in circular plate



Surirella



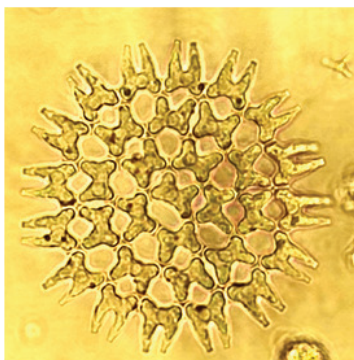
Aulacosira



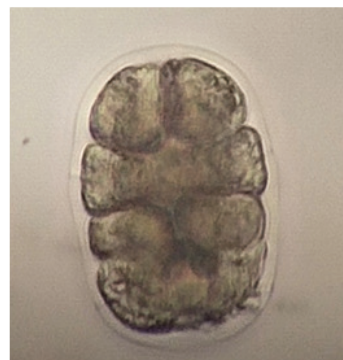
Navicula



Closterium



Pediatrum



Pandorina



Ceratium



Phacus



Euglena

Figure 12. Commonly found phytoplankton in the Kusheswar Asthan Bird sanctuaries. *Surirella*: Single cell, valves heteropolar, linear ovate, marginal folds strongly undulated with projections, *Aulacosira*: Centric diatom, unbranched filaments of cylindrical cells joined end to end, *Navicula*: elongated elliptical unicellular with rigid cell wall made up of silica, raphe lying within a thickened ridge, *Closterium*: Cells strongly curved, apices acutely rounded. *Pediatrum*: forms a larger coenobium with its cells arranged in circular plate, colonies with large intercellular space. *Pandorina*: cells have flattened where they make contact with other cells, spherical densely packed cells, *Ceratium*: contains armored plates. *Phacus*: cells ovoid or pyriform in shape, spirally twisted long straight sharp posterior caudus, *Euglena*: cells elongated fusiiform, long filaments in anterior part and posterior short tail point.

Table. 4 Phytoplankton species/texta reported from wetlands of Kusheshwar Asthan Bird Sanctuary

Phytoplankton	Kusheshwar Asthan Bird Sanctuaries			
	Mahraila	Manoria	Larail	Baraila
Bacillariophyceae				
1. <i>Cyclotella</i> sp.		+		+
2. <i>Navicula</i> sp.		+		+
3. <i>Nitzschia</i> sp.	+	+		+
4. <i>Synedra</i> sp.		+	+	+
5. <i>Fragillaria</i> sp.		+	+	
6. <i>Aulacosira</i> sp.	+	+	+	+
7. <i>Gomphonema</i> sp.	+	+	+	+
8. <i>Cymbella</i> sp.	+		+	+
9. <i>Gyrosigma</i> sp.		+		
10. <i>Achanthidium</i> sp.	+	+	+	
11. <i>Surirella</i> sp.	+	+	+	+
Chlorophyceae				
12. <i>Chloralla</i> sp.	+	+	+	+
13. <i>Pediastrum duplex</i>	+	+	+	+
14. <i>Pediastrum</i> sp.	+	+	+	+
15. <i>Closterium gracile</i>		+		+
16. <i>Closterium</i> sp.		+		
17. <i>Selenastrum</i> sp.		+		+
18. <i>Eudorina</i> sp.	+		+	+
19. <i>Pandorina</i> sp.	+	+	+	+
20. <i>Oocystis</i> sp.	+	+		+
21. <i>Tetraedron</i> sp.		+		
22. <i>Scenedesmus abundance</i>	+	+	+	+
23. <i>Scenedesmus quadricauda</i>		+	+	+
24. <i>Scenedesmus</i> sp.	+	+	+	+
25. <i>Crucigenia tetrapedia</i>	+	+	+	+
26. <i>Crucigenia crucifera</i>				+
27. <i>Mougeotia</i> sp.	+	+		+
28. <i>Euastrum</i> sp.		+		+
29. <i>Volvox</i> sp.	+	+		+
30. <i>Ankistrodesmus</i> sp.	+			

31.	<i>Westella</i> sp.		+		
32.	<i>Chroococcus</i> sp.	+	+	+	+
33.	<i>Staurastrum</i> sp.		+		+
34.	<i>Cosmarium</i> sp.		+		
35.	<i>Coscinodiscus</i> sp.		+		
Cyanophyceae					
36.	<i>Microcystis aeruginosa</i>	+	+	+	+
37.	<i>M. flosaquae</i>	+	+	+	+
38.	<i>Merismopedia</i> sp.	+	+		+
39.	<i>Phormidium</i> sp.	+	+		+
40.	<i>Oscillatoria</i> sp.		+	+	+
41.	<i>Anabaena</i> sp.	+	+	+	+
42.	<i>Lyngbya</i> sp.		+		
Euglenophyceae					
43.	<i>Trachelomonas</i> sp.	+	+		
44.	<i>Phacus</i> sp.	+	+		
45.	<i>Euglena gracile</i>	+	+		+
46.	<i>Euglena viridis</i>		+	+	+
Dinophyceae					
47.	<i>Peridinium</i> sp.	+	+	+	
48.	<i>Ceratium</i> sp.	+	+	+	+

Note: ‘+’ indicate presence of the species

Zooplankton

Zooplankton is considered as most important live food organism in larval stages of fish just after absorption of yolk sac in an aquatic ecosystem. Most of the small indigenous fish (SIF) in aquatic ecosystem depend on zooplankton for their survival. Many scientists attributed the ability of a fish population to outdistance through the larval period without vast mortality as one of the primary factors determining the size of the resulting year class and hypothesized that competition for food during the larval time might be a major factor affecting survival and subsequent year class strength.

Diversity and abundance of zooplankton of wetlands of Kusheshwar Asthan bird sanctuary were assessed using plankton net of 35 μm mesh size. a total of 50 Litre of water were filtered from each site across the transect to get maximum representative of zooplankton. The filtered zooplankton samples were collected in graduated 50ml transparent bottle and immediately preserved with 5% buffered formalin. The qualitative and quantitative assessment of zooplankton was done using Sedgwick rafter cell counting chamber and standard literature for identification. The community structure of zooplankton was the representative of Protozoa, Rotifera, Copepoda and Cladocera. Reproductive phase of zooplankton was observed during November month of study may be due to high food availability and conducive aquatic parameters of the bird sanctuaries. Of the 21 species and 14 taxa/species was identified as rotifers, *Brachionus*, *Lecane* and *Keratella* most abundant genera in Manoria wetlands. Seasonal variation in the abundance was significant in Kusheshwar Asthan BS. Only 8 species of zooplankton was recorded in Larail with dominance of large size zooplankton such as cladoceans and copepods. The mean abundance of zooplankton was recorded 2270 ± 426 ind./L, 720 ± 68 ind./L, 360 ± 24 ind./L and 265 ± 17 ind./L in Manoria, Baraila, Mahraila and Larail of Kusheshwar Asthan BS during wet season respectively. The increased plankton abundance noticed in wet season of sampling can be attributed to bird derived nutrients' input and also due to increase in primary productivity.



Figure 13. Some of the zooplankton which was abundant in the Wetlands of Kusheshwar Asthan Bird sanctuaries

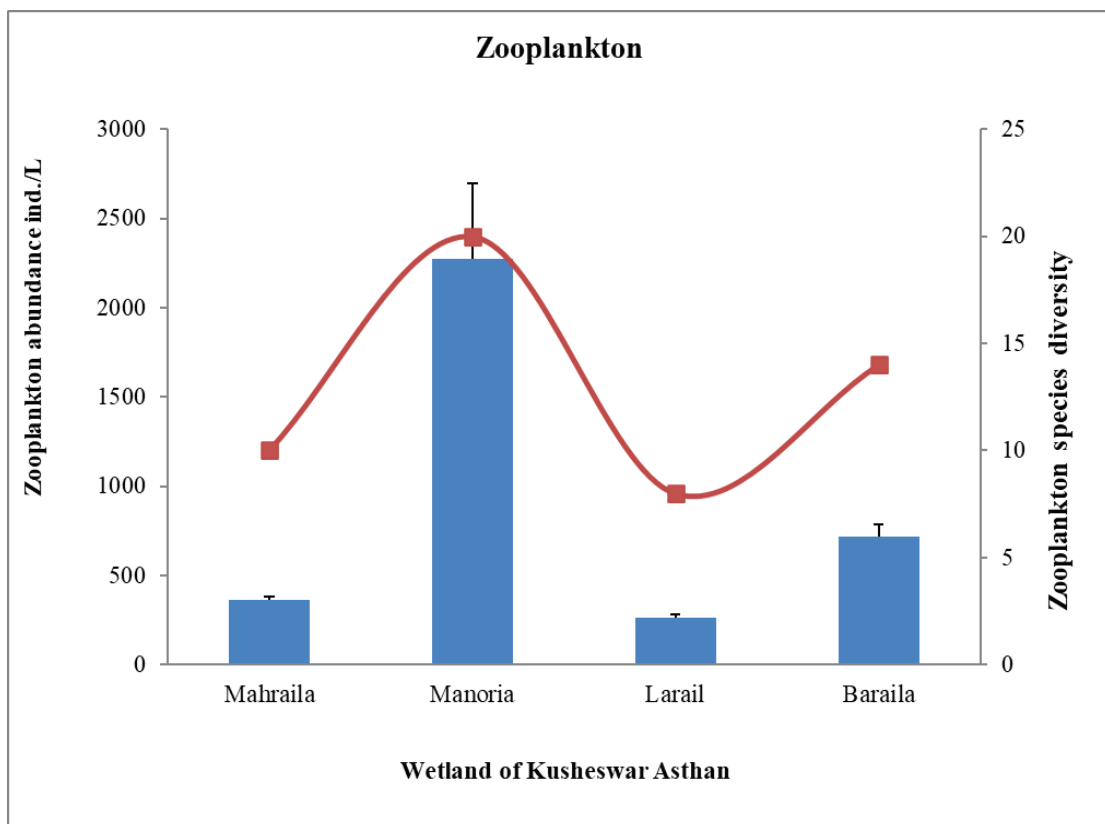


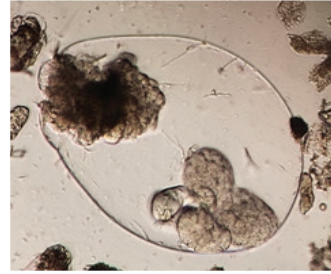
Figure 14. Seasonal variation in zooplankton abundance in four wetlands of Kusheswar Asthan Bird sanctuary



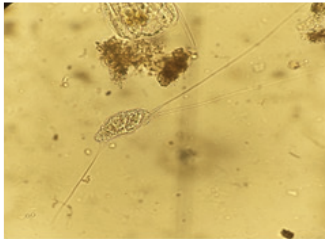
Keratella cochlearis



K. tropica



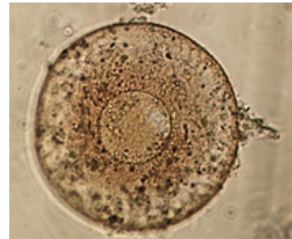
Asplanchna



Filinia



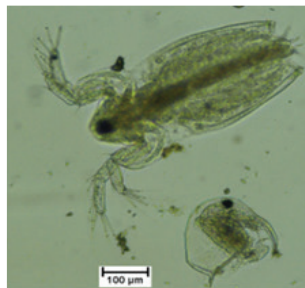
B. fulcatus



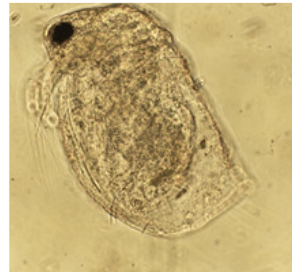
Arcella



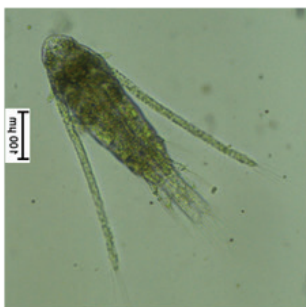
Bosmina



Diaphanosoma



Moina



Calanoid copepod



Cyclopoid copepod



Copepod Nauplii

Figure 15. Commonly found zooplankton in Wetlands of Kusheswar Asthan Bird sanctuaries

Table 5. Zooplankton species/texta recorded from wetland of Kusheswar Asthan Bird Sanctuary

Zooplankton	Kusheshwar Asthan Bird Sanctuary			
	Mahraila	Manoria	Larail	Baraila
Protozoa				
<i>Arcella</i> sp.		+	+	
Rotifera				
<i>Polarthra vulgaris</i>	+	+		+
<i>Keratella tropica</i>		+		
<i>Keratella cochlearis</i>	+	+	+	+
<i>Hexarthra mira</i>	+	+	+	+
<i>Brachionus calyciflorus</i>	+	+		+
<i>B. rubens</i>		+		+
<i>B. fulcatus</i>		+	+	+
<i>B. forficula</i>	+	+		+
<i>B. diversicornis</i>	+	+		
<i>Trichocerca Cylindrica</i>	+	+	+	+
<i>Lecane</i> sp.	+		+	+
<i>Asplanchna</i> sp.		+		
<i>Filinia longiseta</i>		+		+
<i>Filinia</i> sp.	+	+		
Cladocera				
<i>Bosmina</i> sp.	+	+		+
<i>Ceriodaphnia</i> sp.		+	+	+
<i>Moina</i> sp.	+	+		
Copepoda				
Copepod Cyclopoid		+		+
Copepod Calanoid		+	+	+
Nauplii		+		

Note: '+' indicate presence of the species

6. Macrophyte diversity

During the wet season, a significant proliferation of macrophytes was recorded in the Kusheshwar Asthan wetlands. This rapid growth of aquatic vegetation likely contributed to a decline in plankton abundance at the beginning of the wet season, as dense macrophyte cover can limit light penetration and nutrient availability for phytoplankton growth. Despite this, macrophytes play a crucial ecological role, particularly for the migratory birds that depend on them for food and habitat during their seasonal visits.

Among the dominant macrophyte species, the submerged and rooted aquatic plants such as *Potamogeton nodosus*, *Potamogeton wrightii*, and *Potamogeton natans* (locally known as Jheero) were found to be the most abundant, covering more than 70% of the total macrophyte area, including floating species like *Eichhornia crassipes* (water hyacinth). Other commonly observed macrophyte species included *Potamogeton*, *Najas*, and *Nymphaea*. *Potamogeton nodosus* thrives in a wide range of aquatic habitats, from floating to submerged conditions, shallow to deep waters (up to 6–8 feet), and across both lentic (still water) and lotic (flowing water) environments. Its long stalks and colonial growth nature make it a dominant species in these wetlands.

One of the most notable ecological functions of *Potamogeton nodosus* is its role in supporting migratory bird populations. The fruits (achenes) of the plant's flowering spikes form densely packed seed heads that are reddish-brown to red in color. According to local observations, these seeds are preferred by migratory birds, making this plant an essential food source during the birds' stay in the wetland. Similarly, *Nymphaea* produces fruits that are not only consumed by birds but are also traditionally eaten by local communities, indicating the plant's significance for both wildlife and human populations.

During winter, a steep decline in macrophyte coverage was observed in the wetland reservoirs. This seasonal reduction in aquatic vegetation may be directly linked to the congregation of migratory birds, as they rely on macrophytes for food and deplete the available vegetation through foraging. The shift in macrophyte abundance between seasons underscores the dynamic ecological interactions within the Kusheshwar Asthan wetlands, where bird migration patterns, hydrological changes, and plant life cycles are intricately connected. Maintaining a balance between macrophyte growth and wetland biodiversity is essential for sustaining the ecological integrity of this vital habitat.



Potamogeton wrightii



Potamogeton nodos



Potamogeton natans



Nymphaea



Eichhornia crassipes



Najas indica



Mangrove plants



Marginal aquatic plants



Nymphaea

Figure 16: Commonly available macrophytes in the wetlands of Kusheshwar Asthan BS



Figure 17. Harvest of macrophyte tubers for human consumption

7. Macro-invertebrate fauna

Macro-invertebrate fauna, also known as benthos, serves as an excellent bio-monitoring tool for assessing the health and ecological status of aquatic ecosystems. These organisms, which include various species of mollusks, annelids, and arthropods, are highly sensitive to environmental changes such as pollution, habitat alteration, and water quality fluctuations. The presence, abundance, and diversity of benthic organisms can provide valuable insights into water quality, sediment composition, and overall ecosystem stability.

To analyze the macro-invertebrate diversity in the Kusheshwar Asthan wetlands, Petersen Grab was used for sediment sampling across different study sites. This method allowed for the collection of standardized sediment samples from the bottom of the wetland, ensuring the retrieval of benthic organisms residing within the substrate. The collected sediment samples from each site were carefully sieved through a 500µm sieve, effectively separating finer particles while retaining macro-invertebrates for further examination. The sieved materials were then preserved in 4% formalin in plastic sample containers to maintain their integrity and prevent decomposition before detailed laboratory analysis.

In the laboratory, group-wise sorting of macro-invertebrates was conducted to categorize the collected specimens based on their morphological and taxonomic characteristics. The identification process was carried out using standard taxonomic literature, ensuring accurate classification of benthic organisms. Special attention was given to mollusks, as they play a crucial role in nutrient cycling, sediment stability, and serving as a food source for wetland birds. To supplement the sediment sampling, additional molluscan specimens were collected manually from the littoral zone of the bird sanctuary using hand-picking techniques. This approach allowed researchers to document the diversity of snails, bivalves, and other mollusks that inhabit the shallow areas of the wetland.

The study of macro-invertebrate communities in Kusheshwar Asthan wetlands provides critical baseline data for long-term monitoring of wetland health. Given their sensitivity to environmental disturbances, fluctuations in benthic populations can indicate changes in pollution levels, habitat degradation, and sediment quality. This research is vital for wetland conservation planning, helping to inform policymakers and conservationists about the ecological integrity of these water bodies and the need for sustainable management practices. By integrating macro-invertebrate assessments with other ecological indicators, a more comprehensive understanding of wetland dynamics can be achieved, ensuring the protection and conservation of Kusheshwar Asthan Bird Sanctuary as a thriving habitat for both aquatic and avian biodiversity.



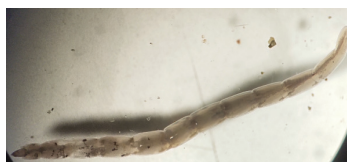
Figure 18: Collection of Benthos from Larail of Kusheshwar Asthan Bird sanctuar



Thiara tuberculata



Clinotanypus sp.



Dipteran larva



Bellamya bengalensis



Indoplanorbis exustus



Lamellidens marginalis



Bellamya dissimilis



Corbicula striatella

Figure 19: Commonly available Macro-invertebrate diversity of Kusheshwar Asthan Bird sanctuary

8. Fish diversity

The exploratory survey conducted in the protected wetlands of Kusheshwar Asthan Bird Sanctuary revealed a remarkably diverse aquatic fauna, highlighting the rich fish biodiversity of the region. A total of 72 fish species, 2 prawn species, and 2 crab species were recorded, emphasizing the ecological significance of these wetlands as critical breeding and feeding grounds for aquatic life.

Among the large-sized fish species observed in the capture landings, notable species included *Wallago attu* (giant catfish), murrels (*Channa marulius*, *Channa striatus*, *Channa punctata*), spiny eel (*Mastacembelus armatus*), and commercially valuable carps (*Labeo catla*, *Labeo rohita*, *Cirrhinus mrigala*, *Systomus sarana*). These fish contribute significantly to the local fisheries, supporting the livelihoods of the fishing communities residing around the wetland.

In addition to large fish species, the wetlands were found to be highly abundant in Small Indigenous Fish (SIF) species, which play a crucial role in nutritional security due to their high content of minerals, vitamins, and omega-3 fatty acids. The dominant SIF species included *Anabas testudineus* (climbing perch), *Macrornathus* spp. (spiny eels), *Puntius* spp., *Pethia* spp., *Chanda nama*, *Pseudambassis ranga*, *Salmophasia* spp., *Amblypharyngodon mola*, and *Rasbora* spp. These fish serve as an essential protein source for local populations and are also key components of the wetland food chain. However, despite their high ornamental value, species such as *Macrornathus* spp., *Trichogaster* spp., *Parambassis* spp., and *Puntius* spp. are largely undervalued, as they are indiscriminately harvested and sold for food at trash prices, rather than being utilized for aquarium trade and ornamental fish markets.

One of the most distinctive fishing techniques recorded in the region was the traditional ‘Jaing’ fishing practice, which is based on the use of Fish Aggregating Devices (FADs). This method is an age-old indigenous fishing technique used by local fishers to attract and capture fish in wetland environments. It demonstrates traditional ecological knowledge that has been passed down through generations and remains an integral part of local fishing practices in Kusheshwar Asthan.

The pre-monsoon survey indicated that while the *chaurs* (seasonal floodplain wetlands) were nearly dried up during this period, deep pools and ditches created by fishers served as crucial refuges for fish.



Figure 20: Collection of fish sample for diversity and abundance study from Experimental fishing with Gill net and bag net



Figure 21: Truss morphometry and biology study of fish from Kusheshwar Asthan BS on Field



Figure 22: Fish harvest of SIF in wet season and dominance of *Channa* spp. using different gear to get maximum diversity



Figure 23: Dominant commercial fishery of wetlands of Kusheshwar Asthan BS



Figure 24: Record of large size top predator fish *Wallago attu* of wetlands of Kusheshwar Asthan BS

Apart from being consumed locally, a significant portion of the fish harvested from these *chaurs* is transported to larger markets to meet the growing demand in different regions. The most crucial distribution hub for these fish is Ber Chowk, which serves as the primary marketplace for fish caught from Kusheshar Asthan *chaurs*. From Ber Chowk, a considerable quantity of fish is sent to Siliguri, a major trade center, where they are further processed and distributed to various states across India, particularly to West Bengal and Punjab, where the demand for freshwater fish remains consistently high. In addition to fresh fish sales, a substantial segment of the Small Indigenous Fish (SIF) catch is subjected to drying and preservation processes. These activities are primarily managed by fisherwomen, who operate dedicated fish drying units. These units play a crucial role in not only extending the shelf life of fish but also creating sustainable employment opportunities for numerous households. By engaging in fish drying and trading, fisherwomen contribute significantly to the local economy, ensuring a steady income stream while promoting traditional fish preservation methods.



Figure 25. Fish drying and sorting of high value fish *Mystus tengra* by a group of women for their livelihood

The team also explored, identified, and reported a large colony of freshwater sponges, *Ephydatia fluviatilis* (Linnaeus, 1759), covering fixed wooden structures across the *chaurs*. Additionally, various ecological services provided by the wetland system were studied, including fisheries, agriculture, aesthetic value, bird conservation, fuel and fodder

resources, and edible resources such as macrophyte tubers and seeds. These wetlands serve as vital climate and biodiversity regulators, supporting rich ecosystems while acting as significant carbon sinks, contributing to climate change mitigation. Furthermore, the *chaurs* exhibit remarkably high agricultural productivity, with corn being the predominant crop cultivated and harvested in the dried-up areas. This is followed by the extensive cultivation of vegetables, particularly different varieties of gourds, further enhancing the economic and nutritional benefits derived from these wetland ecosystems.



Figure 26. Freshwater sponge *Ephydatia fluviatilis* reported from Kusheshwar *Asthan chaur*s

Fish/ shellfish diversity of Kusheshwar Asthan bird sanctuary

Kusheshwar Asthan *Chaur* area under Kosi-Gandak basin has been highly significant from fisheries and biodiversity point of view and has been notified as a Bird Sanctuary by Govt. of Bihar in 1994 under Wild life Protection Act, 1972. Kusheshwar Asthan wetland system is a confluence of many big and small lakes (16) fed by river water (Aslam et al., 2021). The *chaurs* are rainfed wetland and monsoon run off with flow from a network of rivers like Kamala, Balan, Bagmati and Kareh are the prime source of water for the *chaurs*. The Kusheshwar Asthan *chaurs* is highly diverse and, are interspersed with 14 highly populated villages. The wetland system provides numerous ecological services and harbors a rich aquatic diversity. Kusheshwar Asthan along with Kanwar Jheel and Barailla wetlands were included in the list of National Wetland Conservation Programme, 2006 as these wetlands require urgent conservation and management interventions.

The fish faunal diversity of Kusheshwar Asthan has not been explored much by researchers. A study by Das and Koley (2014) reported 50 species under 27 genera from the wetland system and most of them were very common in other lentic and lotic water bodies of Darbhanga, represented by 9 orders, 18 families. Das et al. (2015) listed 35 fish species having ornamental value from the *Jhang*, fish aggregating system using aquatic plants installed in the Kusheshwar Asthan *chaurs* system.

Exploratory surveys were carried out in the wetlands of Kusheshwar Asthan Bird Sanctuary, Darbhanga district, Bihar for generating baseline information on aquatic biodiversity in protected water bodies. In the present exploratory study, the fish diversity in the Kusheshwar Asthan *Chaur*s system were studied through intensive sampling. In both pre-monsoon and post monsoon surveys, fish diversity was explored by analysing fishers' catch as well as through experimental fishing.

The present study recorded 72 species from the *chaur* system, falling under 28 families among which family Cyprinidae dominated with 25 species, Bagridae with 5 species, Ambassidae, Channidae, Mastacembelidae, Osphronemidae, Siluridae and Sisoridae with 3 species each. The most abundant species by number were *Amblypharyngodon mola*, *Macrognathus pancalus*, *Glossogobius giuris*, *Trichogaster fasciata*, *Lepidocephalichthys guntea*, *Trichogaster lalius*, *Puntius sophore*, *Macrognathus aral*, *Pethia conchonius* and *Salmostoma bacaila*. By weight, the most important species contributing to fish catch were *Wallago attu*, *Channa* spp, *Mastacembelus armatus*, *Labeo bata*, *Cirrhinus mrigala*, *Anabas testudineus*, *Systomus sarana*

Higher taxa diversity

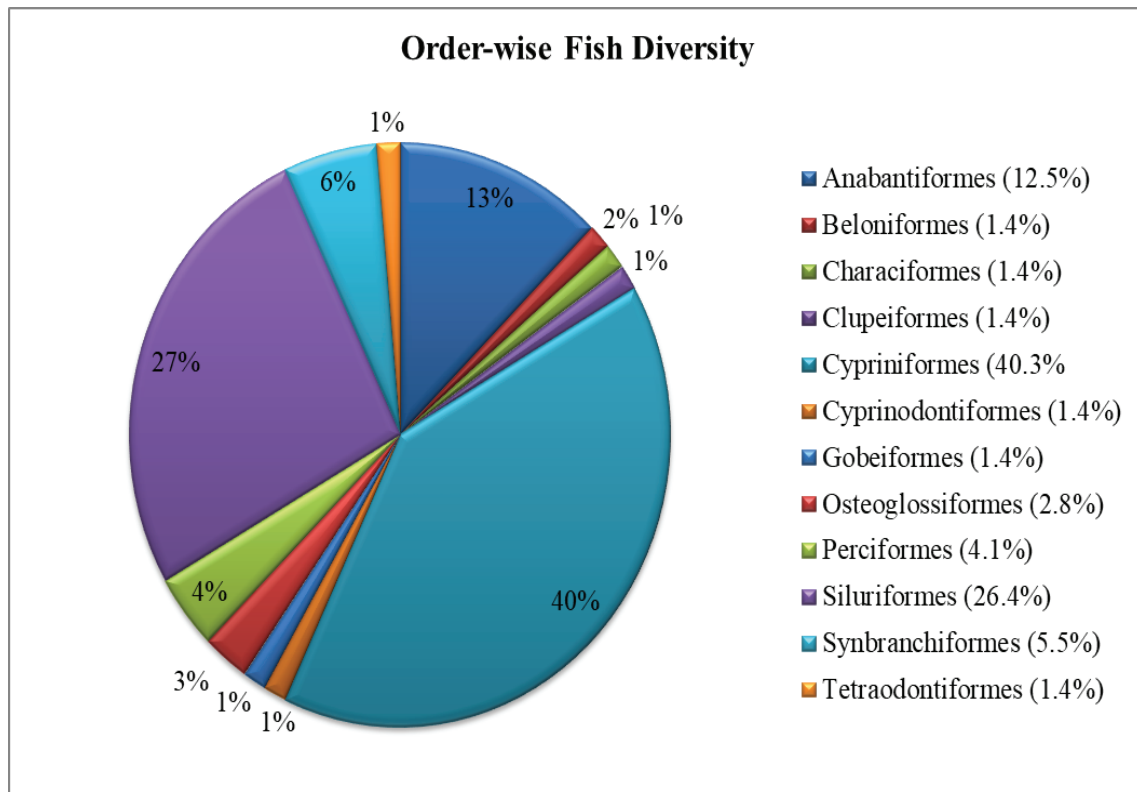


Figure 27. Order-wise fish diversity recorded in Kusheshwar Asthan bird sanctuary 2021-2023

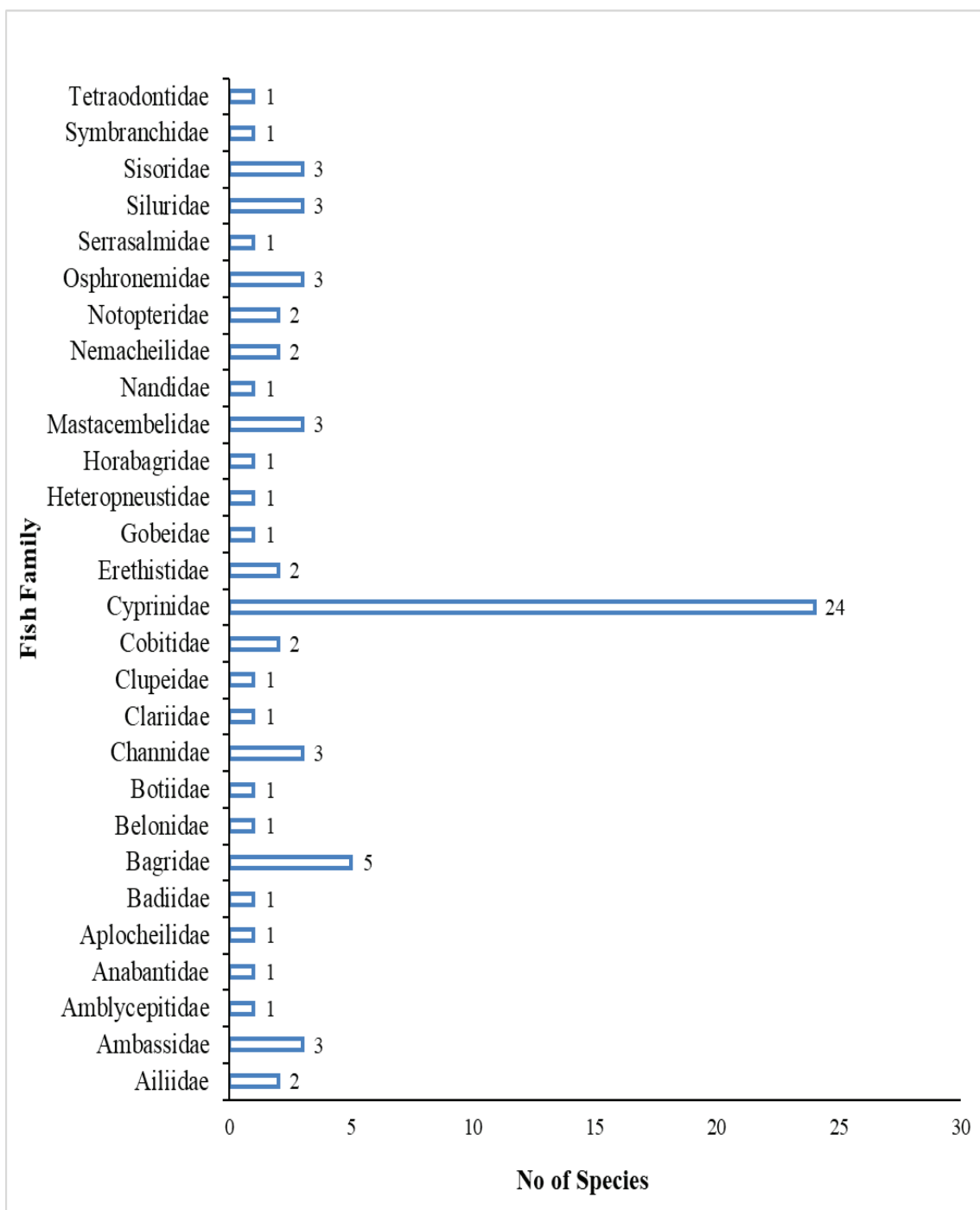


Figure 28. Family-wise fish diversity recorded in Kusheshwar Asthan bird sanctuary 2021-2023

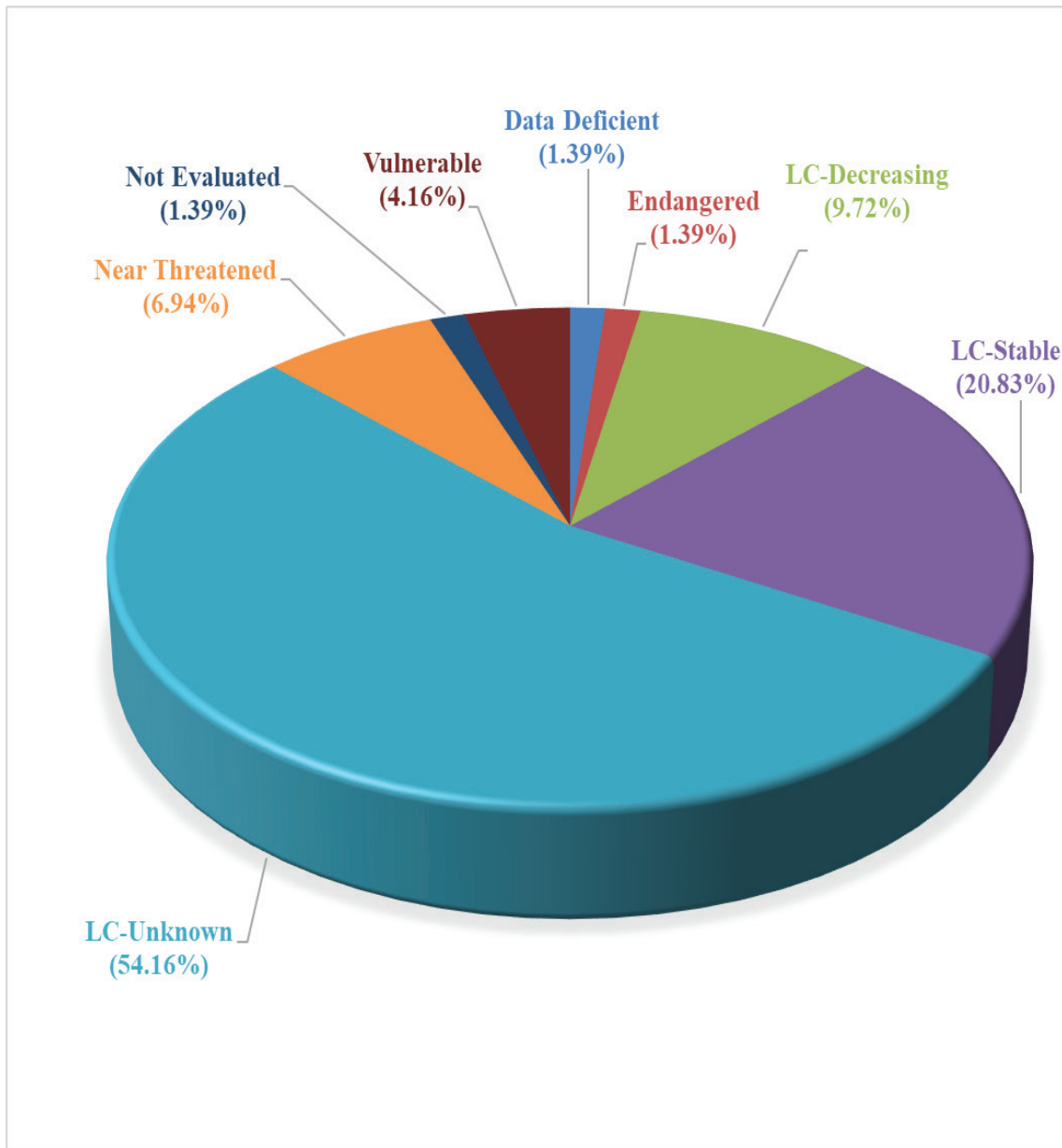


Figure 29. IUCN status of fish identified from Kusheshwar *Asthan Chaurs*

9. Systematic Account of fish species recorded and species description

Phylum CHORDATA

Class OSTEICHTHYES-bony fishes

Subclass ACTINOPTERYGII – ray-finned fishes

Superorder OSTEOGLOSSOMORPHA

Order OSTEOGLOSSIFORMES

Family NOTOPTERIDAE

1. *Chitala chitala* (Hamilton, 1822)

Common name:	Clown knifefish
Habitat:	Freshwater; demersal. Obligate air-breathing; Adults inhabit freshwater rivers, lakes, beels, nullahs in the plains, reservoirs, canals and ponds.
Distribution:	Asia: Indus, Ganges-Brahmaputra and Mahanadi river basins in India.
Food Habit:	Carnivorous. Feed on aquatic insects, molluscs, shrimps and small fishes
Reproductive Traits	Females lay eggs usually on stake or stump of wood, males fan them with tail, keep them aerated and silt-free, guard them against small catfish and other predators
Taxonomic description:	Dorsal spines (total): 0; Dorsal soft rays (total): 9; Anal spines: 0; Anal soft rays: 117 - 127. The only species in which subadults and adults have a series of transverse gold or silver bars on the dorsum, but this color feature is not always present
Species Prospects	Important food fish.



Chitala chitala

2. *Notopterus notopterus* (Pallas, 1769)

Common name:	Bronze featherback
Habitat:	Freshwater; brackish; demersal; potamodromous. Obligate air-breathing; Found in clear streams and enters brackish waters. Adults inhabit standing and sluggish waters of lakes, floodplains, canals and ponds.
Distribution:	Asia: Indus, Ganges-Brahmaputra, Mahanadi, Krishna, Cauvery, and other river basins in southern India; Irrawaddy, and Salween; Meklong, Chao Phraya, Mekong and virtually all coastal river basins of peninsular Thailand and Malaysia; Sumatra and Java.
Food Habit:	Carnivorous. Feed on insects, fish, crustaceans and also on some young roots of aquatic plants.
Reproductive Traits	Breeding takes place in stagnant or running waters in the rainy season. Eggs are laid in small clumps on submerged vegetation.
Taxonomic description:	Dorsal soft rays (total): 7-9; Anal soft rays: 97 - 111. Distinguishable by its plain brown adult coloration and the convex or only slightly concave dorsal head profile; juveniles (<5 cm SL) with dark bars on the whole body; preopercular scale rows 6-8; silvery-white with numerous fine grey spots on body and head
Species Prospects	Of high economic importance as food fish in South and Southeast Asia



Notopterus notopterus

Superorder CLUPEOMORPHA

Order CLUPEIFORMES

Family CLUPEIDAE

3. *Gudusia chapra* (Hamilton, 1822)

Common name:	Indian river shad
Habitat:	Freshwater; brackish; pelagic; potamodromous. Adults are found in middle and upper reaches of rivers. Also occur in ponds, beels, ditches and inundated fields
Distribution:	Asia: rivers of India and Bangladesh affluent to the Bay of Bengal (chiefly the Ganges and Brahmaputra systems and the Mahanadi River of Orissa). Reported from Nepal and Pakistan.
Food Habit:	Omnivorous. Mostly a plankton feeder with a preference for phytoplankton to zooplankton. Also feed on plant materials and detritus.
Reproductive Traits	The length at first maturity is about 8 cm. Absolute fecundity ranged from 749 to 15044, and ova diameter ranged from 0.10-2.00 mm. The spawning extended throughout the year with peak reproductive activity in some months.
Taxonomic description:	Dorsal spines (total): 0; Anal spines: 0. Body fairly deep; 26 to 29 scutes along belly. A single triangular pectoral axillary scale; depressed tip of dorsal fin to behind vertical from anal fin origin. Hind margin of scales smooth. Dark blotch behind gill opening, often followed by a series of spots along flank. Gill rakers fine and numerous, increasing with size of fish
Species Prospects	An important small indigenous fish which are rich in nutritive values, imperative to artisanal and subsistence small-scale inland fisheries of Indian reservoirs and wetlands.



Gudusia chapra

Superorder OSTARIOPHYSI

Order CYPRINIFORMES

Family CYPRINIDAE

4. *Amblypharyngodon mola* (Hamilton, 1822)

Common name: Mola carplet	
Habitat:	<i>Amblypharyngodon mola</i> is a freshwater species which is benthopelagic in nature. Adults are found in ponds, canals, beels, slow-moving streams, nullahs and paddy fields
Distribution:	The species is distributed in Asia, in countries like Pakistan, India, Bangladesh, Myanmar and Afghanistan.
Food Habit:	Planktivorous, feeding on Chlorophyceae, Bacillariophyceae, debris with mud etc. Incidentally consume zooplanktonic Rotifers and Crustaceans.
Reproductive Traits	Breeds twice a year, prolonged breeding season with two peaks. Asynchronous oocytes development and is a fractional spawner. Males mature earlier than females. Length at first sexual maturity for males fall in 5-5.5 cm and females 5.5-5 cm.
Taxonomic description:	Body is elongated. Presence of large eyes. Small scales with incomplete lateral lines which ceases after 9 to 18 scale, 65 to 91 scales along the lateral line. Presence of 9-10 scale rows between lateral line and pelvic fin base. Dark distinct marking on the dorsal, anal and caudal fins while pectoral and pelvic are hyaline.
Species Prospects	A popular food fish. This SIF (Small Indigenous Fish) species has great nutritional importance as a source of essential minerals and vitamins. Very rich in Vitamin A. It is used as a component in polyculture with Indian Major Carps. Also has ornamental value and kept in aquaria.



Amblypharyngodon mola

5. *Cirrhinus mrigala* (Hamilton, 1822)

Common name:	Mrigal
Habitat:	A freshwater, demersal species. Natural inhabitant of rivers and streams of South Asian countries
Distribution:	The species is distributed in Asia, in countries Pakistan, India, Nepal and Bangladesh. Introduced into Peninsular India.
Food Habit:	Herbivorous species. The fish feeds on blue-green algae, filamentous green algae, diatoms, and pieces of higher plants, form the bulk of food. Decayed vegetable matter, mud, and detritus, flagellates, rotifers, and small crustaceans are taken incidentally (Hora and Pillay, 1962).
Reproductive Traits	Attains reproductive maturity in 1-2 years.
Taxonomic description:	Body is elongated and highly compressed. Presence of single pair of rostral barbel. Mouth broad, upper lip entire, lower lip sharply defined. Lateral line with 40 to 50 scales. Pectoral fins shorter than head. Pelvic and anal fins are orange tipped with dusky caudal fins.
Species Prospects	A major candidate species for aquaculture and one among the three Indian Major Carps. Fast growing, attaining a marketable size of 800–1000 g in less than a year and are generally propagated on extensive and or intensive scale of polyculture system



Cirrhinus mrigala

6. *Cirrhinus reba* (Hamilton, 1822)

Common name:	Reba carp
Habitat:	Freshwater; benthopelagic. Inhabit large streams and rivers. Also found in tanks, canals, ponds, beels and inundated fields.
Distribution:	Asia: Pakistan, India, Nepal, Bangladesh, and Myanmar.
Food Habit:	Omnivorous bottom feeder. Primarily feed on plankton and detritus, but may also take in mud, vegetables, crustaceans and insect larvae
Reproductive Traits	An annual breeder with a single spawning period. The breeding season of this fish species extends for 2-3 months, mostly during the onset of rainy season. Length at first maturity falls between 11 to 14 cm for both males and females. A high fecund fish with fecundity range of 22,000 to 4.3 lakhs.
Taxonomic description:	Body is elongated and highly compressed. Mouth is widened with fringed upper lips. Single paired barbel. Caudal fin deeply forked. Pectoral fin as long as head. Scales are moderate and hexagonal shaped. Anal and pelvic fins are orange tipped.
Species Prospects	Food fish. Potential candidate for culture along with IMC.



Cirrhinus reba

7. *Ctenopharyngodon idella* (Valenciennes, 1844)

Common name:	Grass carp
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. occur in lakes, ponds, pools and backwaters of large rivers, preferring large, slow-flowing or standing water bodies with vegetation
Distribution:	Asia: Eastern China and Russia. Widely transported around the world for aquaculture.
Food Habit:	Herbivorous. Feed on higher aquatic plants and submerged grasses; takes also detritus, insects and other invertebrates.
Reproductive Traits	Do not breed in confined waters. Spawns in gravel bottomed areas of rivers. Eggs are pelagic and hatch while drifting downstream in 2-3 days
Taxonomic description:	Dorsal spines (total): 3; Dorsal soft rays (total): 7-8; Anal spines: 3; Anal soft rays: 7 - 11. No barbels. Snout very short, its length less than or equal to eye diameter. Postorbital length more than half head length. 18 soft rays for caudal fin. Diagnosed from rather similar species by having body olive to brassy green above, silvery white to yellow below; body cylindrical; pharyngeal teeth laterally compressed, serrated, with a groove along grinding surface, usually in two rows.
Species Prospects	An important candidate species in aquaculture, especially polyculture of carps.



Ctenopharyngodon idella

8. *Cyprinus carpio* Linnaeus, 1758

Common name:	Common carp
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. Inhabits warm, deep, slow-flowing and still waters such as lowland rivers and large, well vegetated lakes
Distribution:	Europe to Asia: introduced throughout the world.
Food Habit:	Omnivorous. feed on a variety of benthic organisms and plant material.
Reproductive Traits	Breeds along shores or in backwaters. Adults often undertake considerable spawning migration to suitable backwaters and flooded meadows. Larvae survive only in very warm water among shallow submerged vegetation.
Taxonomic description:	Dorsal spines (total): 3 - 4; Dorsal soft rays (total): 17-23; Anal spines: 2-3; Anal soft rays: 5 - 6; Vertebrae: 36 - 37. 2 pairs of barbels; dorsal fin with 15-20½ branched rays; caudal fin deeply emarginate. Scales large and thick. Very variable in form, proportions, squamation, development of fins, and colour. Caudal fin with 3 spines and 17-19 rays. Last simple anal ray bony and serrated posteriorly; 4 barbels; 17-20 branched dorsal rays; body grey to bronze
Species Prospects	An important candidate species in aquaculture, especially polyculture of carps.



Cyprinus carpio

9. *Danio devario* (Hamilton, 1822)

Common name:	Giant danio, Devario
Habitat:	Freshwater; benthopelagic. Inhabits rivers, canals, ponds, beels and inundated fields
Distribution:	Asia: Pakistan, India, Nepal, Bangladesh and Afghanistan
Food Habit:	Carnivorous. Feeds on worms, small crustaceans and insects
Reproductive Traits	Easy to breed in aquariums. Spanish moss is the best spawning medium; parents should be removed after spawning and infusoria and brine shrimp should be supplied to young as soon as they are free swimming
Taxonomic description:	Body rhomboidal and compressed. Ventral profile more convex than that of dorsal. Longer lower jaw with a symphyseal prominence and upper with a notch. Mouth small, obliquely directed upwards with no barbells. Dorsal fin inserted slightly to anal fin and caudal fin emarginated to lunate. Lateral line complete with 34-38 moderate sized scales.
Species Prospects	Used as food fish, but more popular as aquarium fish with good ornamental value.



Danio devario

10. *Hypophthalmichthys molitrix* (Valenciennes, 1844)

Common name:	Silver carp
Habitat:	Freshwater; brackish; benthopelagic; potamodromous.
Distribution:	Asia: Native to most major Pacific drainages of East Asia from Amur to Xi Jiang, China and Hanoi, Vietnam. Introduced around the world for aquaculture and control of algal blooms.
Food Habit:	Herbivorous. Adults feed only on phytoplankton while larvae and small juveniles prey on zooplankton.
Reproductive Traits	Breed in rivers or tributaries over shallow rapids with gravel or sand bottom.
Taxonomic description:	Dorsal spines (total): 1 - 3; Dorsal soft rays (total): 6-7; Anal spines: 1-3; Anal soft rays: 10 - 14. Body olivaceous to silvery. Barbels absent. Keels extend from isthmus to anus. Edge of last simple dorsal ray not serrated. Branched anal rays 12-13.5. Differs from <i>H. nobilis</i> by having sharp scaleless keel from pectoral region to anal origin
Species Prospects	An important candidate species in aquaculture, especially polyculture of carps. Introduced to many countries where its ability to clean reservoirs and other waters of clogging algae is appreciated even more than its food value.



Hypophthalmichthys molitrix

11. *Hypophthalmichthys nobilis* (Richardson, 1845)

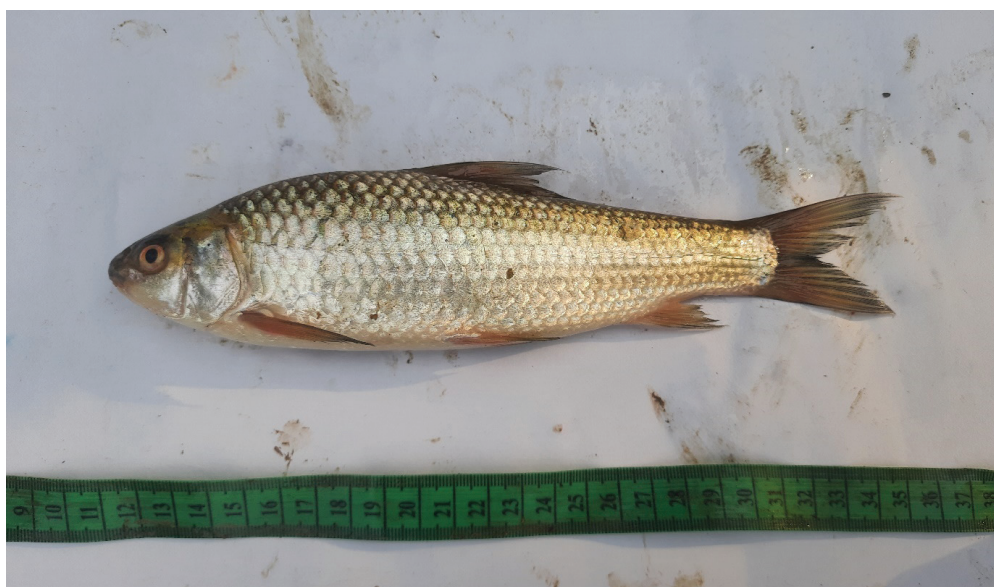
Common name:	Bighead carp
Habitat:	Freshwater; brackish; benthopelagic; potamodromous.
Distribution:	Asia: China. Introduced to numerous countries and has achieved a near global distribution.
Food Habit:	Bottom feeding fish, feeds mainly on zooplankton, but also takes algae as food.
Reproductive Traits	Breeding requirements are very specialized and stocks are maintained by artificial reproduction. Undertakes long distance upriver migration at start of a rapid flood and water-level increase. Spawns in upper water layer or even at surface during floods. After spawning, adults migrate for foraging habitats, Larvae drift downstream and settle in floodplain lakes, shallow shores and backwaters with little or no current.
Taxonomic description:	Dorsal spines (total): 3; Dorsal soft rays (total): 7; Anal spines: 1-3; Anal soft rays: 12 - 14. Body with numerous scattered small black blotches. Keels extend from pelvic base to anus. Barbels absent. Posterior margin of last simple dorsal ray not serrated. Branched anal rays 13-14.5. Differs from <i>H. molitrix</i> by having scaled keel from pelvic to anal, 240-300 long gill rakes, head length 27-35% SL, dark overall coloration, flank with dark, large, very irregularly shaped blotches, fin bases and inferior parts of head and belly yellowish.
Species Prospects	An important candidate species in aquaculture, especially polyculture of carps.



Hypophthalmichthys nobilis

***12.Labeo bata* (Hamilton, 1822)**

Common name:	Bata
Habitat:	Freshwater; benthopelagic; potamodromous.
Distribution:	Asia: India, Bangladesh and Pakistan
Food Habit:	Herbi-omnivorous. A bottom feeder, feeding mainly on algae, higher plant parts, protozoans, crustaceans and also detritus.
Reproductive Traits	It breeds in floodplains during rainy season. Spawns only once in a year. The average fecundity is around 20, 000.
Taxonomic description:	Body elongate, ventral profile quite less convex than dorsal profile. Eyes large and mouth inferior. Dorsal fin originated nearby snout - tip. Pectoral fins as long as head, extending to pelvic fins. Scales
Species Prospects	One of the important minor carps with great demand as good table fish.



Labeo bata

***13.Labeo calbasu* (Hamilton, 1822)**

Common name:	Kalbasu, Black rohu
Habitat:	Freshwater; brackish; demersal; potamodromous. Occur in rivers and ponds; in slow-moving waters of rivers.
Distribution:	Asia: Pakistan, India, Bangladesh, Myanmar, Nepal, Thailand and South Western China.
Food Habit:	Herbivorous. Feed on plants, filamentous algae and diatoms.
Reproductive Traits	Length at first maturity for riverine population is 32 to 34 cm. Fecundity ranged from 1.3 to 5.07 lacs in a total length range of 30 to 60 cm. A short seasonal breeder, breeds normally once in a year in lacustrine habitat during rainy months. Breeding takes place in the river in a sandy stretch after a short migration of 12-25 Km
Taxonomic description:	Body strongly thick and fairly deep. Barbels two pairs, eyes moderate. Dorsal fin with a quite long base., originated mid point between snout – tip and base of caudal fin. Caudal fin deeply forked; scales moderate; 40 to 44 scales in lateral line. Blackish green color but lighter below, fins black, upper lobe of caudal fin tipped with white.
Species Prospects	An important food fish. Also used in aquaculture.



Labeo calbasu

***14. Labeo catla* (Hamilton, 1822)**

Common name:	Catla
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. Occur in rivers, lakes and culture ponds.
Distribution:	Asia: Pakistan, India, Bangladesh, Nepal and Myanmar.
Food Habit:	Surface and mid-water feeders, mainly omnivorous with juveniles feeding on aquatic and terrestrial insects, detritus and phytoplankton.
Reproductive Traits	Mature individuals breed in rivers
Taxonomic description:	Dorsal soft rays (total): 17; Anal spines: 0; Anal soft rays: 7 - 8. Body deep, with depth 2.5 to 3 times in standard length. Has a large, upturned mouth, with a prominent protruding lower jaw. Pectoral fins long, extending to pelvic fins; scales conspicuously large.
Species Prospects	One of the Indian major carps, of great importance in aquaculture.



Labeo catla

15. *Labeo dyocheilus* (McClelland, 1839)

Common name:	<i>Ghora mach</i>
Habitat:	Freshwater; benthopelagic; potamodromous. Live in clear active currents of large rivers
Distribution:	Asia: Pakistan, India, Bangladesh and Nepal
Food Habit:	Herbi-omnivorous, column feeder. Primarily feed on green algae and diatom, and occasionally on zooplankton along with insects and macrophytes.
Reproductive Traits	Fecundity ranged between 3, 000 to 32, 000 eggs.
Taxonomic description:	Body elongate with conical snout, projecting beyond mouth, with a distinct lateral lobe. Small eyes, nearly invisible from underside of head. Mouth wide and inferior. Dorsal fin originated midway between snout – tip and base of caudal fin. Scales moderate with 43 scales in lateral line. Caudal fin deeply forked.
Species Prospects	A medium sized major carp fish. It is a highly valued food fish.



Labeo dyocheilus

16. *Labeo gonius* (Hamilton, 1822)

Common name:	<i>Khursa, Kuria labeo</i>
Habitat:	Freshwater; benthopelagic; potamodromous
Distribution:	Asia: Pakistan, India, Bangladesh, Myanmar and Afghanistan
Food Habit:	Herbivorous. Feed on diatoms, green algae and decayed organic matter.
Reproductive Traits	Spawn during the southwest monsoon. Do not normally breed in ponds. Artificial breeding done through hypophysation. Length at maturity is about 17-18 cm TL. The ovary contained a single batch of ova and spawn only once during the year. The fecundity ranged from 18,000 to more than 2 lakhs.
Taxonomic description:	Body elongated, dorsal more curved outward than ventral profile. Mouth narrow and sub inferior with thick and fringed lips. Two pairs of small barbells, dorsal fin originated nearer to snout than to base of caudal fin. Caudal fin deeply forked along with pointed lobes. Scales small; 71 to 84 scales in lateral line. Greenish – black on back, dull white in flanks and belly.
Species Prospects	One of the important medium size freshwater carps of India. Cultured in ponds along with other carp species.



Labeo gonius

17. *Labeo rohita* (Hamilton, 1822)

Common name:	Rohu
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. Inhabit rivers
Distribution:	Asia: Pakistan, India, Bangladesh, Myanmar and Nepal.
Food Habit:	Herbivorous. Feed on plants.
Reproductive Traits	Spawning occurs in flooded rivers. Spawns in middle reaches of rivers, where flood water spreads in more or less limpid shallows over fertile flats, well above tidal reaches; also in reservoirs and bundh-type tanks. Fecundity varies from 226,000 to 2,794,000 depending upon the length and weight of the fish
Taxonomic description:	Body moderately elongated, ventral profile more arched than dorsal profile. Mouth small and inferior, thick and fringed lips with a distinct inner fold to each lip. Dorsal fin originated mid point between snout – tip and base of caudal fin. Pectoral fins shorter than head. Caudal fin deeply forked. Scales moderate, lateral line with 40 to 44 scales.
Species Prospects	One of the Indian major carps, of great importance in aquaculture. Widely introduced outside its native range for stocking reservoirs and aquaculture.



Labeo rohita

18. *Pethia conchonius* (Hamilton, 1822)

Common name:	Rosy barb/ Shinning barb
Habitat:	inhabit lakes and fast flowing hill streams
Distribution:	Asia: Afghanistan, Pakistan, India, Nepal, Bangladesh and Myanmar.
Food Habit:	Feed on worms, crustaceans, insects and plant matter. Feeding habit changes from carni-omnivorous to herbi-omnivorous and again to carni-omnivorous with growth.
Reproductive Traits	Prolific spawners
Taxonomic description:	Body deep and compressed. Mouth small and barbels absent. Dorsal fin placed in equidistance between tip of snout and base of caudal fin. Lateral line incomplete which ceases after 10 th to 13 th scale.
Species Prospects	Popular ornamental fish. impressively colored during the mating period.



Pethia conchonius

19. *Pethia phutunio* (Hamilton, 1822)

Common name:	Rosy barb/ Shinning barb
Habitat:	inhabit lakes and fast flowing hill streams
Distribution:	Asia: Afghanistan, Pakistan, India, Nepal, Bangladesh and Myanmar.
Food Habit:	Feed on worms, crustaceans, insects and plant matter. Feeding habit changes from carni-omnivorous to herbi-omnivorous and again to carni-omnivorous with growth.
Reproductive Traits	Prolific spawners
Taxonomic description:	Body deep in shape. mouth small and barbel absent. Eyes large and diameter about 2.5 times in head. Large scales, lateral line incomplete that ceases after 3 to 4 scales. Longitudinal scales 20-23.
Species Prospects	Popular ornamental fish. impressively colored during the mating period.



Pethia phutunio

20. *Pethia ticto* (Hamilton, 1822)

Common name:	Ticto barb
Habitat:	Found in still, shallow, marginal waters of tanks and rivers, mostly with muddy bottoms.
Distribution:	Asia: Pakistan, India, Nepal, Sri Lanka, Bangladesh, Myanmar and Thailand. Also occurs in the upper Mekong, Salween, Irrawaddy, Meklong and upper Chao Phraya basins
Food Habit:	Column feeder; omnivore. Feed on crustaceans, insects and plankton.
Reproductive Traits	High fecund fishes with 2200-8500 eggs. About 150 eggs are laid in batches of about 20 at a time; eggs hatch in about a day, and fry are free-swimming the next day.
Taxonomic description:	Mouth terminal and small; barbels absent. Posterior to pelvic fin origin dorsal fin fixed, last ray is unbranched, osseous strong and serrated. Scales medium ; lateral line usually complete, often ceases after six to eight scales. 23-25 scales in longitudinal series; predorsal scales 9-11.
Species Prospects	A popular aquarium species.



Pethia ticto

21. *Puntius chola* (Hamilton, 1822)

Common name:	Swamp barb/ Chola punti / Green barb
Habitat:	Freshwater; benthopelagic; potamodromous. Inhabits streams, rivers, canals, beels, haors, ponds and inundated fields. Occurs mainly in shallow water
Distribution:	Asia: Pakistan, India, Nepal, Bangladesh, Sri Lanka and Myanmar. Also reported from Bhutan
Food Habit:	Omnivorous. Feeds on worms, crustaceans, insects and plant matter
Reproductive Traits	Absolute fecundity varied from 200-500 with an average of about 1200 eggs.
Taxonomic description:	Body deep and compressed; single maxillary pair of barbels present; last simple dorsal ray moderately strong and smooth; lateral line complete with 24-28 scales; scales from dorsal fin origin to lateral line 6 and those from lateral line to pelvic fin origin 4; predorsal scales 11, circumpeduncular scales 14, pre-pelvic scales 11, pre-anal scales 19
Species Prospects	An SIF with good nutritive value. Also kept in aquaria.



Puntius chola

22. *Puntius sophore* (Hamilton, 1822)

Common name:	Pool barb
Habitat:	Freshwater; benthopelagic; amphidromous. Inhabits streams, rivers, canals, beels, haors, ponds and inundated fields. Occurs mainly in shallow water
Distribution:	Asia: Pakistan, India, Nepal, Bangladesh, Myanmar and Yunnan, China, Bhutan and Afghanistan
Food Habit:	Omnivorous. Feeds on worms, crustaceans, insects and plant matter
Reproductive Traits	sophore from March to July
Taxonomic description:	Body deep and compressed; single maxillary pair of barbels present; last simple dorsal ray moderately strong and smooth; lateral line complete with 24-28 scales; scales from dorsal fin origin to lateral line 6 and those from lateral line to pelvic fin origin 4; predorsal scales 11, circumpeduncular scales 14, pre-pelvic scales 11, pre-anal scales 19
Species Prospects	An important food fish and an ornamental fish



Puntius sophore

23. *Puntius terio* (Hamilton, 1822)

Common name:	Onespot barb, teri barb
Habitat:	Freshwater; benthopelagic. Found in rivers, canals, ponds, ditches and inundated fields.
Distribution:	Asia: Pakistan, India, Bangladesh and Myanmar
Food Habit:	foraging omnivore feeding on worms, insects and other small invertebrates, as well as plant material and organic detritus.
Reproductive Traits	March to July
Taxonomic description:	24-26 scales on lateral line. 9-11 scales on transverse series. 9 scales before dorsal fin base. 3.5 scales between origin of pelvic fin and lateral line.
Species Prospects	SIF



Puntius terio

24. *Rasbora daniconius* (Hamilton, 1822)

Common name:	Slender rasbora/ Blackline rasbora
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. Occurs in a variety of habitats: ditches, ponds, canals, haors, streams, rivers and inundated fields. Inhabits mainly sandy streams and rivers
Distribution:	Asia: Mekong, Chao Phraya and Salween basins, northern Malay Peninsula, westwards to the Indus and Sri Lanka.
Food Habit:	Feeds mainly on aquatic insects and detritus. A surface feeder. Active predator type.
Reproductive Traits	breed during the rainy season.
Taxonomic description:	Body elongated, mouth obliquely directed upward. Dorsal fin inserted behind origin of pelvic fins. Lateral line completes with 26 to 29 scales. Black lateral stripe present between eye to caudal fin.
Species Prospects	Hardy and adaptable in the aquarium.



Rasbora daniconius

25. *Rasbora rasbora* (Hamilton, 1822)

Common name:	Gangetic scissortail rasbora
Habitat:	Freshwater; brackish; benthopelagic;
Distribution:	Asia: Pakistan, India, Bangladesh, Myanmar and Thailand.
Food Habit:	Feeds mainly on aquatic insects and detritus.
Reproductive Traits	An egg-scattering species, continuous spawner that exhibits no parental care. Can be bred in planted aquaria
Taxonomic description:	Body elongate, compressed. Abdomen rounded. Head large, pointed. Snout slightly pointed. Lateral line with 28 to 31 scales. Caudal fin with well defined blackish hind – border.
Species Prospects	Have high ornamental value and popular aquarium fish



Rasbora Rasbora

26. *Salmophasia bacaila* (Hamilton, 1822)

Common name:	Large razorbelly minnow/ Chela
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. Occur in rivers, ponds, beels and inundated fields. Usually found in slow running streams
Distribution:	Asia: Pakistan, India, Bangladesh and Nepal and Afghanistan
Food Habit:	Surface feeders , predate on larvae and adults of insects
Reproductive Traits	Size at first maturity is about 7 cm TL.
Taxonomic description:	Strongly compressed and elongated body. Mouth oblique. Dorsal fin attached well in advance of anal fin. Small scales, bearing 86 to 110 scales, 17-19/ 4-6 rows of scales in lateral transverse side. Gray green on upper side. a broad gleaming white green band along flank.
Species Prospects	An SIF with nutritive value



Rasbora Rasbora

27. *Salmophasia phulo* (Hamilton, 1822)

Common name:	Finescale razorbelly minnow
Habitat:	Freshwater; benthopelagic. Occurs in the lower reaches of rivers, ponds, beels, ditches and canals
Distribution:	Asia: India and Bangladesh.
Food Habit:	Omnivorous feeding habit
Reproductive Traits	Once in a year June/July extending until October
Taxonomic description:	Body elongated and compressed. mouth oblique in nature. Dorsal fin attached to opposite to origin of anal fin. The length of pectoral fin is about 3.5 times in standard length. Small scales, lateral line curves gently downward, having 99 to 112 scales ; lateral transverse scale rows 12-15/16
Species Prospects	An SIF with good source of protein, vitamins and minerals. Co-cultured with Indian major carps and exotic carps



Salmophasia phulo

28. *Systemus sarana* (Hamilton, 1822)

Common name:	Olive barb
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. Occur in rivers, streams, lakes and backwaters.
Distribution:	Asia: Afghanistan, Pakistan, India, Nepal, Bangladesh, Bhutan and Sri Lanka
Food Habit:	Omnivorous. Feed on aquatic insects, fish, algae and shrimps.
Reproductive Traits	Spawn in running waters among submerged boulders and vegetation
Taxonomic description:	Dorsal spines (total): 3; Dorsal soft rays (total): 8; Anal spines: 2; Anal soft rays: 5. Body oblong, head, small, barbels 2 pairs. Maxillary pair longer than orbit, rostral pair shorter.
Species Prospects	Food fish. Small fish have limited demand in the aquarium trade.



Systemus sarana

29. *Botia dario* (Hamilton, 1822)

Common name:	Bengal loach, Queen loach
Habitat:	Freshwater; demersal. Occurs in clear mountain streams
Distribution:	Asia: India and Bangladesh
Food Habit:	Omnivorous. Feed on algae, aquatic molluscs, insects, worms, and other invertebrates.
Reproductive Traits	The fecundity ranged from 13,000 to 28,000 eggs. The average fertilization rate was found to be 82.09 %. It can be easily matured and bred successfully undercaptive conditions
Taxonomic description:	With yellow golden stripes on a black background. Body is elongated and laterally compressed. Large eyes situated on posterior part of the head. Mouth is small with four pairs of barbells. Dorsal fin is located exactly at equidistance from the tip of the snout to the caudal fin base. Caudal fin with two to three black bars. Seven to eight inclined greyish coloured band descending from dorsal side to ventral side.
Species Prospects	An important ornamental fish. A vulnerable species having both ornamental as well as edible value.



Botia dario

30. *Canthophrys gongota* (Hamilton, 1822)

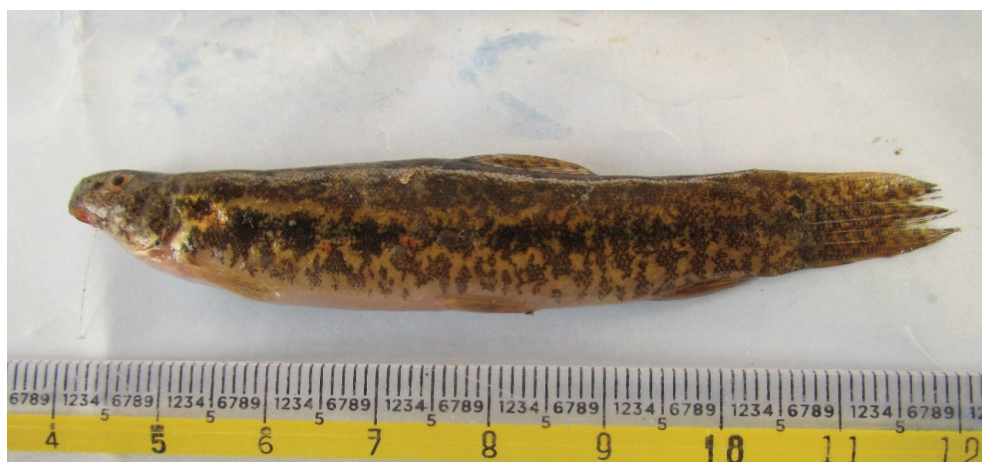
Common name:	Gongota loach
Habitat:	Freshwater; demersal. Inhabits streams and rivers. Occurs in shallow slow-moving streams with sandy, muddy or gravelly bottom.
Distribution:	Asia: India, Bangladesh and Nepal
Food Habit:	A bottom-dwelling filter feeder. A micro-predator, sifting mouthfuls of substrate through the gills from which insect larvae, small crustaceans and likes are extracted.
Reproductive Traits	Induced breeding using pituitary gland extract successful.
Taxonomic description:	Broader abdomen. Pectoral and pelvic fins thick and rounded. Paired fins having greater distances between bases of two fins. Projection of operculum on dorsal profile.
Species Prospects	Consumed fresh and also have ornamental value.



Canthophrys gongota

31. *Lepidocephalichthys guntea* (Hamilton, 1822)

Common name:	Guntea loach
Habitat:	Freshwater; brackish; demersal; potamodromous. Facultative air-breathing; Found in flowing or even clear standing waters.
Distribution:	Asia: Pakistan, northern India, Bangladesh, Nepal, Myanmar and Thailand.
Food Habit:	Feed on insects larvae and bottom detritus
Reproductive Traits	A seasonal spawner in nature. Artificial spawning using pituitary gland successful.
Taxonomic description:	Dorsal spines (total): 0; Dorsal soft rays (total): 8; Anal spines: 0; Anal soft rays: 7. Pectoral fin with an osseous spine in males.
Species Prospects	Used as food and also found in the aquarium trade



Lepidocephalichthys guntea

32. *Acanthocobitis botia* (Hamilton, 1822)

Common name:	Mottled loach, Zipper loach
Habitat:	Freshwater; demersal. Inhabit clear water, swift flowing streams with rocky, pebbly and sandy bottoms.
Distribution:	Asia: Indus basin in Pakistan to the Mae Khlong basin in Thailand through Ganges, Chindwin, Irrawaddy, Sitang and Salween basins.
Food Habit:	They are micro predators and will feed on insects, larvae, and plant matter.
Reproductive Traits	Induce breeding using synthetic hormone successful. About 100-150 eggs.
Taxonomic description:	Dorsal soft rays (total): 14-17; Anal soft rays: 8. Distinguished from its congeners by the absence of a suborbital flap in male, the flap being replaced by a suborbital groove; lateral line reaches at least to anus
Species Prospects	SIF, used as food fish and also high ornamental value



Acanthocobitis botia

33. *Paracanthocobitis* sp.

Common name:	Zipper loach
Habitat:	Freshwater
Distribution:	Widespread - India, Pakistan, Nepal, Sri Lanka, Bangladesh, Butan, Thailand, Burma and Myanmar.
Food Habit:	Herbivorous
Reproductive Traits	In the wild, Zipper Loaches spawn from May to June and up to 150 eggs are scattered per spawning.
Taxonomic description:	Body slender. Eyes moderate invisible from underside of head. Barbels well developed. nasal barbels short. Dorsal fin fixed near to snout tip. Caudal fin emarginated. Lateral lin eusually complete and often ending far away from base f anal fin.
Species Prospects	Used as food and ornamental fish



Paracanthocobitis sp

Order CHARACIFORMES

Family SERRASALMIDAE

34. *Priaractus brachypomus* (Cuvier, 1818)

Common name:	Red-bellied Pacu, Rup chanda
Habitat:	Freshwater; potamodromous.
Distribution:	Native to the Amazon basin in tropical South America. Introduced to other regions for aquaculture.
Food Habit:	It mainly feeds on fruits, seeds, and nuts, but it is opportunistic and will also take zooplankton, insects, crustaceans and small fish
Reproductive Traits	Spawning occurs at the beginning of the flood season
Taxonomic description:	They have small eyes and an arched back. The body is dark below and lighter above. They have an adipose fin (a small, fleshy dorsal fin) located behind the dorsal fin.
Species Prospects	Widely used in aquaculture.



Priaractus brachypomus

Order SILURIFORMES

Family SILURIDAE

35. *Ompok bimaculatus* (Bloch, 1794)

Common name:	Butter catfish
Habitat:	Freshwater. Found in quiet, shallow, often muddy water, in sandy streams, rivers and tanks. Also occur in canals, beels and inundated fields.
Distribution:	Asia: Bangladesh, India, Pakistan, and Sri Lanka.
Food Habit:	Carnivorous; Cannibalistic. feeds on the crustacean larvae, algae, and protozoans.
Reproductive Traits	They breed throughout the year with peak spawning activity during the months of October and August and September.
Taxonomic description:	Elongate body is strongly compressed. Head depressed and snout rounded. Mouth is superior. Lower jaw is longer than upper. Two pairs of barbels are present. Maxillary barbels extend posterior to (or slightly beyond) anal fin base. Nostrils widely separated from each other. Teeth found on jaws and vomer. Caudal fin is deeply forked and its upper lobe long. Dorsal side grey, a transverse blackish spot present, behind the operculum on the lateral line, caudal stripped with black spots; besides, there are purple and yellowish spots throughout the body. Anal fin with 57 or 58 branched rays
Species Prospects	A fish with good market demand as food fish. Aquaculture is in practice.



Ompok bimaculatus

36. *Ompok pabda* (Hamilton, 1822)

Common name:	Pabdah catfish
Habitat:	Freshwater
Distribution:	Asia: Afghanistan, Pakistan, India (West Bengal, North Eastern States, Uttar Pradesh, Odisha, Indus Ganga and Brahmaputra river systems), Bangladesh and Myanmar.
Food Habit:	Omnivorous
Reproductive Traits	once a year during the monsoon season (June – August) with a peak in July.
Taxonomic description:	Moderate eyes. Mouth large and oblique. Rayed dorsal fin short, no spine. Maxillary pair extended usually to as far as middle of pectoral fin. Anal fin long separated from caudal by notch. Caudal fin forked and both lobes pointed.
Species Prospects	A fish with good market demand as food fish (SIF). Aquaculture practice



Ompok pabda

37. *Wallago attu* (Bloch & Schneider, 1801)

Common name:	<i>Wallago attu</i> (buari)
Habitat:	Freshwater
Distribution:	Asia: Pakistan to Vietnam, Indonesia, Afghanistan and India.
Food Habit:	Feeds mainly on insects; adults feed on smaller fish , crustaceans.
Reproductive Traits	The rainy season is the breeding period of Wallago Attu fish. They generally lay eggs in July to August. They lay eggs in both bound and open water reservoir.
Taxonomic description:	Body colour darker in above and lighter in lower part. Pectoral fin extending beyond pelvic fin, adipose fin absent. Pelvic fin extending up to the base of anal fin, adipose fin absent rounded.
Species Prospects	Highly predatory fish, high commercial demand in eastern India



Wallago attu

38. *Eutropiichthys murius* (Hamilton, 1822)

Common name:	Murius vacha
Habitat:	Freshwater
Distribution:	Asia: North India, Bangladesh and Pakistan, Typical location Mahananda river basin
Food Habit:	Omnivorous, feeds mainly on insects
Reproductive Traits	April to August with peak spawning in June to late July
Taxonomic description:	Body is elongated and laterally compressed. Mouth is broad, and cleft extending anterior to the upper jaw with villiform teeth. Four pair of barbells and maxillary stretching beyond base of the pectoral fin and nassal barbell beyond the eye orbit. Short dorsal fin placed anterior to the pelvic fin. Dorsal, pectoral and caudal fin are with dusky tips.
Species Prospects	Food fish - caught mainly for human consumption due to their excellent flesh quality



Eutropiichthys murius

39. *Eutropiichthys vacha* (Hamilton, 1822)

Common name:	Batchwa vacha
Habitat:	Freshwater
Distribution:	Asia: India, Pakistan, Bangladesh, Nepal, Myanmar and Thailand
Food Habit:	Primarily feeds on small fish and insects.
Reproductive Traits	Spawning season April to august (peak breeding June to July)
Taxonomic description:	Body is enlarged and compressed. Mouth is widened and the cleft extends beyond the eye orbit. Four pair of barbells, maxillary barbells exceeding the orbit and nasal barbells exceeding the posterior edge of the head. The mandibular barbels are shorter in length. Caudal fins is blackened at the tip.
Species Prospects	Used as a excellent food fish in Uttar Pradesh, Bihar and West Bengal.



Eutropiichthys vacha

40. *Pachypterus atherinoides* (Bloch 1794)

Common name:	Indian potasi
Habitat:	Freshwater
Distribution:	Distributed mainly in Asia: Pakistan, India, Bangladesh, Nepal and Myanmar.
Food Habit:	Omnivorous
Reproductive Traits	Breeding period from May to August
Taxonomic description:	Body is elongated and laterally compressed. Upper jaw elongated and projecting considerably beyond the lower jaws.
Species Prospects	Used as food and ornamental fish.



Pachypterus atherinoides

41. *Mystus bleekeri* (Day, 1877)

Common name:	Days mystus
Habitat:	Freshwater
Distribution:	This species distributed in Asia: Pakistan, India, Bangladesh, Nepal, Myanmar, Bhutan and Indonesia
Food Habit:	Omnivorous
Reproductive Traits	<i>Mystus bleekeri</i> spawns twice in April-August and October-November.
Taxonomic description:	Body is elongated and compressed. Mouth is terminal, eyes diameter 4 to 5 times. Barbels 4 pairs; maxillary barbels extends to anal fin. Dorsal spine is rarely serrated and smooth. Just behind the rayed dorsal fin, large adipose fin is present.
Species Prospects	Used as food fish (SIF).



Mystus bleekeri

42. *Mystus cavasius* (Hamilton, 1822)

Common name:	Gangetic mystus
Habitat:	Freshwater
Distribution:	Thailand, Asia: lowland rivers in most major basins of the Indian subcontinent includes Pakistan, Nepal, India, Sri Lanka and Myanmar.
Food Habit:	Omnivorous
Reproductive Traits	Breeding season for this fish species extended from May to September Body is elongated and compressed. Maxillary barbells extend to beyond caudal fin base in adults but not in young ones. Dorsal spine weakly serrated. At anterior to the first dorsal spine, a dark spot high lightened by a white or pale area along the ventral margin.
Taxonomic description:	
Species Prospects	Used as food fish.



Mystus cavasius

43. *Mystus tengara* (Hamilton, 1822)

Common name:	Striped dwarf catfish
Habitat:	Freshwater, in flooded canals, beels, paddy and jute fields, streams, haors, oxbow lakes and rivers in swarms during rainy season.
Distribution:	Asia: Indian subcontinent, including Pakistan, India, Sri Lanka, Nepal, Bangladesh, probably Myanmar and Thailand.
Food Habit:	Feeds on plants, shrimps insects, molluscs and fish.
Reproductive Traits	Breeding period is extended from May to September with single peak breeding month July Rayed dorsal fin inserted above half of pectoral fin with strong spine. Barbells four pair. Maxillary pair extending to the base of pelvic fin. Adipose dorsal fin short with long interspace from rayed dorsal fin. Pectoral fin not reaching pelvics ,spine strong. Anal fin not reaching caudal base.
Taxonomic description:	
Species Prospects	SIF, high value food fish, both in dry and fresh in demand



Mystus tengara

44. *Mystus vittatus* (Bloch, 1794)

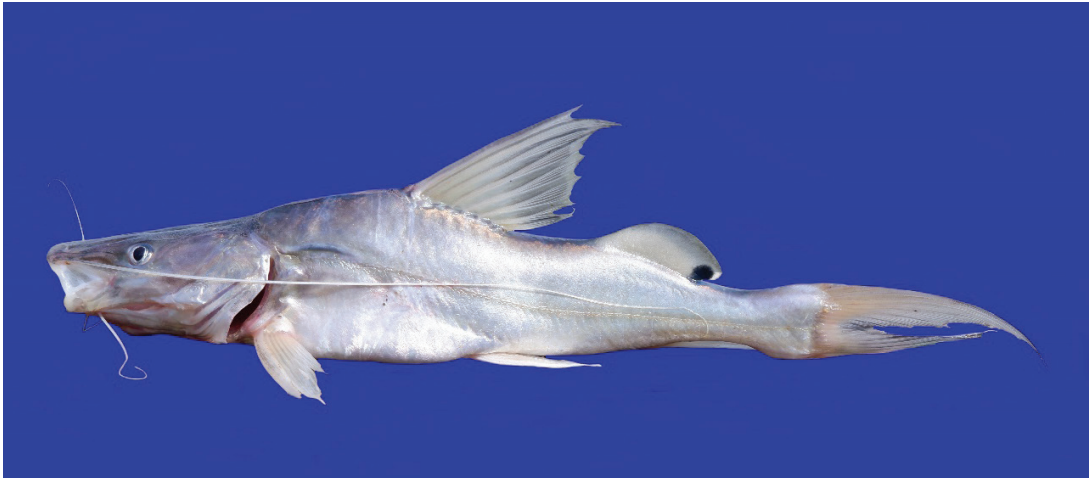
Common name:	Striped dwarf catfish
Habitat:	Freshwater, in flooded canals, beels, paddy and jute fields, streams, haors, oxbow lakes and rivers in swarms during rainy season.
Distribution:	Asia: Indian subcontinent, including Pakistan, India, Sri Lanka, Nepal, Bangladesh, probably Myanmar and Thailand.
Food Habit:	Feeds on plants, shrimps insects, molluscs and fish.
Reproductive Traits	This species short breeding period from September to October with Peak spawning in October
Taxonomic description:	Rayed dorsal fin inserted above half of pectoral fin with strong spine. Barbells four pair. Maxillary pair extending to the base of pelvic fin. Adipose dorsal fin short with long interspace from rayed dorsal fin. Pectoral fin not reaching pelvics, spine strong. Anal fin not reaching caudal base.
Species Prospects	High value SIF



Mystus vittatus

45. *Sperata aor* (Hamilton, 1822)

Common name:	Long whiskered catfish (gamefish)
Habitat:	Freshwater
Distribution:	Southern Asia: India, Pakistan, Nepal, Bangladesh and Myanmar, Lives in wide range of habitat such as ponds, channels, rivers, canals and reservoirs
Food Habit:	Feeds on small fishes and worms.
Reproductive Traits	Extended breeding period from April to August and peak in July to August
Taxonomic description:	Elegant body elongated and compressed. Snout broad and round. Maxillary barbels extends to the base of caudal fin. Pelvic fin not reaching anal fin. Mouth sub terminal; 4 pair barbels. Serration occurs on posterior edge of dorsal spine. long adipose fin base.
Species Prospects	Used as food fish.



Sperata aor

46. *Amblyiceps mangois* (Hamilton, 1822)

Common name:	Indian torrent catfish
Habitat:	Freshwater
Distribution:	Global distribution, Bangladesh, Myanmar, Nepal, Pakistan, India, Thailand and local distribution Northeastern India, Ganga and Padma river
Food Habit:	Feeds on aquatic insects.
Reproductive Traits	Breeding period is in summer June-July
Taxonomic description:	Elongated body with small depressed head covered by thick layer of skin. Mouth is wide consisting of four pair of barbels. Weak and concealed dorsal spine with concealed pectoral spine. Caudal fin is truncated or emarginated. Olive brown in colour with dark lateral band
Species Prospects	SIF



Amblyiceps mangois

47. *Bagarius bagarius* (Hamilton, 1822)

Common name:	Goonch
Habitat:	Freshwater
Distribution:	This species have wide range of distribution from South to Southeast Asian countries including Bangladesh
Food Habit:	Feeds on insects, small fish frog and shrimps.
Reproductive Traits	Breeding extended from April to July
Taxonomic description:	Body is elongated and deepened. Presence of crescent shaped inferior mouth with four pair of barbels. Adipose fin originates from the base of the anal fin while the pelvic fin originates from the base of dorsal fin. Olive green colouration of the body with the three dark pigmented bands. Caudal fin is yellowish grey.
Species Prospects	Food fish



Bagarius bagarius

48. *Gagata cenia* (Hamilton, 1822)

Common name:	Indian gagata
Habitat:	Freshwater
Distribution:	Distributed along Ganga and Padma river of Indian and Bangladesh
Food Habit:	Feeds on crustaceans, insects and their larvae and aquatic plants.
Reproductive Traits	Not reported
Taxonomic description:	Body compact and slender with constricted head. Barbels are four paired, maxillary barbels are strong , nasal barbels very small. Dorsal spine is tiny but stiff and minutely serrated. Pelvic fin exceeds till the vent. Gray coloured body with dusky pelvic fins and caudal fins with black band on each lobe.
Species Prospects	Used as food fish.



Gagata cenia

49. *Gagata sexualis* Tilak, 1970

Common name:	kenyakatta
Habitat:	North Koel River at Daltonganj, Chotanagpur, southern Bihar, Assam, India. Species of sisorid catfish endemic to India. Preferred habitat is rivers, flowing water
Distribution:	India : U.P, Bihar, West Bengal, Assam, Orissa. Bangladesh. Burma.
Food Habit:	Bottom dwelling fish, feed on benthic plant and animals
Reproductive Traits	Not available
Taxonomic description:	Body moderately elongate, compressed. Abdomen flat. Head small. Eyes small dorso lateral. Lips thick, fleshy papillated. Anal fin short, with 8-10 rays. Lateral line complete, simple. Occipital process reaching basal bone of dorsal fin.
Species Prospects	SIF



Gagata sexualis

50. *Erethistes jerdoni* Day, 1870

Common name:	Dwarf Anchor Catfish
Habitat:	Prefer hilly region with sandy bottom, sluggish fish slow moving
Distribution:	India: U.P, Bihar, West Bengal, Assam, Orissa. Bangladesh. Burma.
Food Habit:	Feed on bottom dwelling worms and zooplankton such as daphnia, cyclops etc.
Reproductive Traits	Breeding in Monsoon season with single peak
Taxonomic description:	Body moderately elongate, compressed. Abdomen flat. Head small. Eyes small dorso lateral. Lips thick, fleshy papillated. Anal fin short, with 8-10 rays. Lateral line complete, simple. Occipital process reaching basal bone of dorsal fin.
Species Prospects	SIF



Erethistes jerdoni

***51. Clarias magur* (Hamilton, 1822)**

Common name:	High fin glassy perchlet/ dwarf glass perch
Habitat:	Freshwater; brackish; demersal. Found in ponds, ditches and pools. Enters brackish waters
Distribution:	Asia: India, Bangladesh and Myanmar.
Food Habit:	Herbivorous
Reproductive Traits	Length at first maturity is 25 mm TL
Taxonomic description:	Body elongated and compressed. Mouth oblique. Second spine of dorsal fin very elongated. Small scales, lateral line having about 90 scales. Body with 3 longitudinal dusky bands moving dorsoventrally. Operculum with dark stripes.
Species Prospects	Used as food fish.



Clarias magur

52. *Heteropneustes fossilis* (Bloch, 1794)

Common name:	High fin glassy perchlet/ dwarf glass perch
Habitat:	Freshwater; brackish; demersal. Found in ponds, ditches and pools. Enters brackish waters
Distribution:	Asia: India, Bangladesh and Myanmar.
Food Habit:	Herbivorous
Reproductive Traits	Length at first maturity is 25 mm TL Body elongated and compressed. Mouth oblique. Second spine of dorsal fin very elongated. Small scales, lateral line having about 90 scales. Body with 3 longitudinal dusky bands moving dorsoventrally. Operculum with dark stripes.
Taxonomic description:	
Species Prospects	Used as food fish.



Heteropneustes fossilis

Superorder ACANTHOPTERYGII

Order GOBIIFORMES

Family GOBIIDAE

53. *Glossogobius giuris* (Hamilton, 1822)

Common name:	Tank goby
Habitat:	Marine; Freshwater; brackish; benthopelagic; amphidromous. Found mainly in freshwater and estuaries, but also enter the sea. Also occur in canals, ditches and ponds
Distribution:	Africa to Oceania: Red Sea and East Africa and most inland freshwater bodies over the Indian Ocean and western Pacific. Common in coastal and estuarine waters
Food Habit:	Carnivorous. Predate on fishes and insects
Reproductive Traits	The fish exhibits clear sexual dimorphism with shape and structure of genital papilla. It has a prolonged breeding period. Great variation in reported fecundity, from 7000 to 88, 000 eggs.
Taxonomic description:	Dorsal spines: 7; Dorsal soft rays: 8-9; Anal spines: 1; Anal soft rays: 8 - 9. Head flattened, lower jaw projecting; body pale without longitudinal lines. Dorsal fins with small spots forming longitudinal stripes. Pelvic fins jointed but attached to the body only from their anterior part. The body is brownish yellow with 5 to 6 dark and rounded spots on its sides.
Species Prospects	Food fish.



Glossogobius giuris

Subseries OVALENTARIA

Family AMBASSIDAE

54. *Chanda nama* Hamilton, 1822

Common name:	Elongate glass-perchlet
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. Found in standing and running waters; clear streams, canals, beels, ponds, and inundated paddy fields.
Distribution:	Asia: Pakistan, India, Nepal, Bangladesh, and Myanmar.
Food Habit:	Carnivorous; feed on zoobenthos, zooplankton and small fishes
Reproductive Traits	Length at first maturity is 25 mm SL or 40 mm TL. A highly fecund fish, having an average fecundity of 3000 eggs.
Taxonomic description:	Body is strongly compressed and laterally almost flat. The dorsal and abdominal profiles are equally convex; a considerable rise from the occiput to the base of the first dorsal fin; lower jaw is much longer than the upper jaw; Pre-orbital with three denticulations along its posterior-superior margin; vertical limb of pre-opercle is entire except near its angle; two or three large and crooked canines directed forwards on either side of the symphysis of the lower jaw
Species Prospects	SIF with high nutritional value. Popular for aquarium purposes. Exported from India to other countries as indigenous ornamental fish



Chanda nama

55. *Parambassis lala* (Hamilton, 1822)

Common name:	High fin glassy perchlet/ dwarf glass perch
Habitat:	Freshwater; brackish; demersal. Found in ponds, ditches and pools. Enters brackish waters
Distribution:	Asia: India, Bangladesh and Myanmar.
Food Habit:	Herbivorous
Reproductive Traits	Length at first maturity is 25 mm TL
Taxonomic description:	Body elongated and compressed. Mouth oblique. Second spine of dorsal fin very elongated. Small scales, lateral line having about 90 scales. Body with 3 longitudinal dusky bands moving dorso-ventrally. Operculum with dark stripes.
Species Prospects	Used as food fish, it can be a beautiful ornamental fish



Parambassis lala

56. *Parambassis ranga* (Hamilton, 1822)

Common name:	Indian glassy fish
Habitat:	Inhabitant of sluggish and standing waters. Occur in rivers, streams, canals, ditches, beels, ponds and derelict waterbodies.
Distribution:	Asia: India, Bangladesh, Pakistan, Nepal, Myanmar, Malaysia and Thailand. Introduced in Japan and Philippines.
Food Habit:	Carnivorous fish. Feeds on crustaceans, insects, larvae including mosquito larvae
Reproductive Traits	fecundity range of 500-6,500. 2.58 cm has been reported as length at first maturity for female Body is stout and deeply compressed. Dorsal and abdominal profiles both are very convex, but the profile over the eyes is slightly concave. The maxilla is used to reach below the middle of the orbit. The double margin of horizontal limb of the pre-opercle is serrated; sub and inter-opercles are entire. Lower jaw is comparatively elongated than the upper jaw. Lateral line is partly distinct and partly absent. Body is transparent olive in color, a silvery gloss is present on dorsum; a silvery broad lateral stripe can be seen on side of body; a dark mark composed of spots is present on the shoulder.
Taxonomic description:	
Species Prospects	SIF species which has high nutritional value. Popular ornamental fish



Parambassis ranga

Order BELONIFORMES

Family BELONIDAE

57. *Xenentodon cancila* (Hamilton, 1822)

Common name:	Blue panchax
Habitat:	Freshwater
Distribution:	The freshwater garfish is widely distributed across South and Southeast Asia from India, Bangladesh, Hawaian Islands, Malaysia, Myanmar, Pakistan, Thailand and Sri Lanka and locally distributed: Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Assam (Brahmaputra and Barak drainages), Gonga basin, North Bihar
Food Habit:	Feeds on insects and benthic organisms. Preferred carvivorous
Reproductive Traits	Breeding season extended from April to September Body is elongated and compressed posteriorly.
Taxonomic description:	Presence of large eyes and terminal mouth with villiform teeth. Caudal fin round in shape. Yellowish fins while dorsal fin is having a big black blotch at the base.
Species Prospects	Used as food and ornamental fish.



Xenentodon cancila

Order CYPRIONODONTIFORMES

Family APLOCHEILIDAE

58. *Aplocheilus punchax* (Hamilton, 1822)

Common name:	Blue panchax
Habitat:	Freshwater pools, pond ditches, wetlands, waterlogged area, they also reported from Brackish water
Distribution:	Global distribution from Asia: Pakistan, India, Bangladesh, Myanmar and the Indo-Malaysian archipelago. Also reported from Nepal Cambodia, Viet Nam and Sri Lanka
Food Habit:	Feeds on insects and benthic organisms.
Reproductive Traits	Breed through out year
Taxonomic description:	Body is elongated and compressed posteriorly. Presence of large eyes and terminal mouth with villiform teeth. Caudal fin round in shape. Yellowish fins while dorsal fin is having a big black blotch at the base.
Species Prospects	Used as food and ornamental fish.



Aplocheilus punchax

Order SYNBRANCHIFORMES

Family SYNBRANCHIDAE

59. *Monopterusuchia* (Hamilton, 1822)

Common name:	Striped spiny eel/ Barred spiny eel/ Indian spiny eel
Habitat:	Freshwater; brackish; benthopelagic. Inhabits slow and shallow waters of rivers of plains and estuaries; also found in canals, streams, beels, ponds and inundated fields.
Distribution:	Asia: Pakistan, India, Bangladesh and Nepal.
Food Habit:	Carnivorous. Feed on fishes, crustaceans and other zoobenthos.
Reproductive Traits	Length at first maturity is about 11 cm TL. Absolute fecundity varied from 200 to 8500 eggs.
Taxonomic description:	Dorsal spines (total): 24 - 26; Dorsal soft rays (total): 30-42; Anal soft rays: 31 - 46
Species Prospects	Important food fish. Also kept in aquaria.



Monopterusuchia

60. *Macrognathus aral* (Bloch & Schneider, 1801)

Common name: One-stripe spinyeel

Habitat: Freshwater; brackish; benthopelagic. Occurs in running and stagnant waters. Inhabits still waters with silt or mud substrate. Believed to be common in rice paddy fields.

Distribution: Asia: Pakistan, India, Sri Lanka, Bangladesh, Nepal and Myanmar.

Food Habit: Nocturnal feeder, on insects and worms.

Reproductive Traits Deposits eggs on algal masses.

Taxonomic description: Dorsal spines (total): 16 - 23; Dorsal soft rays (total): 44-45. Caudal fin rays 15 and caudal fin distinctly separated from dorsal and anal fins (Ref. 97143).

Species Prospects SIF, food as well as ornamental value



Macrognathus aral

61. *Macrognathus pancalus* (Bloch & Schneider, 1801)

Common name:	Striped spiny eel/ Barred spiny eel/ Indian spiny eel
Habitat:	Freshwater; brackish; benthopelagic. Inhabits slow and shallow waters of rivers of plains and estuaries; also found in canals, streams, beels, ponds and inundated fields.
Distribution:	Asia: Pakistan, India, Bangladesh and Nepal.
Food Habit:	Carnivorous. Feed on fishes, crustaceans and other zoobenthos.
Reproductive Traits	Length at first maturity is about 11 cm TL. Absolute fecundity varied from 200 to 8500 eggs.
Taxonomic description:	Dorsal spines (total): 24 - 26; Dorsal soft rays (total): 30-42; Anal soft rays: 31 - 46
Species Prospects	Important food fish. Also kept in aquaria.



Macrognathus pancalus

62. *Mastacembelus armatus* (Lacepede, 1800)

Common name:	Zig-zag eel/ Marbled spiny eel
Habitat:	Freshwater; brackish; demersal; potamodromous.
Distribution:	Asia: Pakistan to Viet Nam and Indonesia.
Food Habit:	Carnivorous. Forages at night on benthic insect larvae, worms and some submerged plant material.
Reproductive Traits	The length at first maturity for the female and male are about 360 and 380 mm TL. Peak breeding occurring in the rainy season (July–October), even though females with matured gonads were observed in most months
Taxonomic description:	Elongated cylindrical snake like body with prominent and conical head. Mouth terminal with sharp teeth, thick lips, snout was pointed with fleshy appendages. Upper jaw was longer than lower.
Species Prospects	Important food fish.



Mastacembelus armatus

Order ANABANTIFORMES
Family ANABANTIDAE

63. *Anabas testudineus* (Bloch, 1792)

Common name:	Climbing perch
Habitat:	Freshwater.; Amphibious.
Distribution:	Distributed in Asian countries: India to Wallace line including China.
Food Habit:	Feeds on macrophytic vegetation, shrimps and fish fry.
Reproductive Traits	Breeding periodicity: May to August with peak season in June and July
Taxonomic description:	Body is moderately deep and elongated. Mouth is fairly large with villiform teeth. Large scales, 21-29 present on the lateral series. Greenish to dark grey colouration on the dorsal side which fades near the belly giving a yellow colour. Dorsal and caudal fins are dark grey, pectoral and anal fins are pale yellow and pelvic fins are pale orange.
Species Prospects	Very high demand in Bihar as food fish



Anabas testudineus

64. *Trichogaster fasciata* (Bloch & Schneider, 1801)

Common name:	Banded gourami
Habitat:	Freshwater; benthopelagic. An air-breathing fish, occurs in large rivers, estuaries, ditches, ponds and lakes, generally preferring weedy environment
Distribution:	Asia: Pakistan, India, Nepal, Bangladesh and upper Myanmar.
Food Habit:	Omni-carnivorous fish and feeding on small invertebrates, algae etc. Also feed on mosquito larvae.
Reproductive Traits	Bubble nest builder and male defends the bubble-nest.
Taxonomic description:	Dorsal spines (total): 15 - 17; Dorsal soft rays (total): 9-14; Anal spines: 15-18; Anal soft rays: 14 - 19; Vertebrae: 27. Body elongate and strongly compressed. Mouth small, slightly protrusible; upper lip papillose, especially in old males. Preorbital serrate in young specimen. Color greenish with oblique orange or bluish bars descending downwards and backwards from the back to the anal fin.
Species Prospects	Very high ornamental value



Trichogaster fasciata

65. *Trichogaster lalius* (Hamilton, 1822)

Common name:	Dwarf gourami
Habitat:	Freshwater; benthopelagic. Inhabits slow moving streams, rivulets and lakes with plenty of vegetation.
Distribution:	Asia: Pakistan, India and Bangladesh.
Food Habit:	Omni-carnivorous fish and feeding on small invertebrates, algae etc. Also feed on mosquito larvae.
Reproductive Traits	A bubble nest maker. Male guards the floating bubble-nest where the eggs are laid, about 600 in number. Hatching takes place in 12 to 24 hours while the male parent continues to protect the nest.
Taxonomic description:	Dorsal spines (total): 15 - 17; Dorsal soft rays (total): 9-14; Anal spines: 15-18; Anal soft rays: 14 - 19; Vertebrae: 27. Body elongate and strongly compressed. Mouth small, slightly protrusible; upper lip papillose, especially in old males. Preorbital serrate in young specimen. Color greenish with oblique orange or bluish bars descending downwards and backwards from the back to the anal fin.
Species Prospects	An air-breathing species. This is the smallest and most popular of the small gouramis in the ornamental trade.



Trichogaster lalius

66. *Trichogaster chuna* (Hamilton, 1822)

Common name:	Honey Gourami and Sunset gourami, Chunakhalisa (West Bengal) and Kholisa (Bihar)
Habitat:	Freshwater: river, canal, ponds, ditches, inundated wetlands, beels, Jheels
Distribution:	Bangladesh and India (Gangetic provinces and Assam) (Talwar and Jhingran, 1991)
Food Habit:	Omnivorous, feed on plankton, vegetation and detritus (Siddique, 200
Reproductive Traits	Breeding period from June to August
Taxonomic description:	Body oblong and compressed. Small and protractile mouth present. Preorbital serrated. Dorsal spine posteriorly increasing. Caudal fin slightly emarginated. Dorsal soft and pointed. A filiform ray present at the pelvics which is extended to the caudal. Lateral line incomplete, interrupted and sometimes absent.
Species Prospects	Good ornamental value



Trichogaster chuna

67. *Channa marulius* (Hamilton, 1822)

Common name:	Great snakehead
Habitat:	Freshwater; benthopelagic; potamodromous. Occurs in sluggish or standing water in canals, lakes, and swamps and inhabit waters with submerged aquatic vegetation.
Distribution:	Asia: India to China, south to Thailand and Cambodia.
Food Habit:	Predatory behavior hunt on crustaceans, molluscs, insects, small fishes
Reproductive Traits	Builds floating nest of weeds and leaves where the orange-yellow eggs are deposited. Eggs hatch in 36 to 48 hours and fry remain in the nest for about 10 days after hatching. Parents guards the fry for about a month.
Taxonomic description:	The fish has an elongated, anteriorly sub-cylindrical body with rounded abdomen. The head is large and depressed with plate like scales. Snout somewhat obtuse and mouth fairly large, opening moderate to wide that may extend to below orbit. An accessory respiratory organ in the form of a thin bony lamina present in a cavity in gill chamber. Both dorsal and anal fins free from caudal. A black white-edged ocellus presents on basal portion of caudal fins. 15-16 pre-dorsal scales and 10 scales between orbit and angle of preopercle present.
Species Prospects	Food fish



Channa marulius

68. *Channa punctata* (Bloch, 1793)

Common name:	Spotted snakehead
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. Obligate air-breathing; Found in ponds, swamps, brackish water (Ref. 6028), ditches and beels.
Distribution:	Asia: Afghanistan, Pakistan, India, Sri Lanka, Nepal, Bangladesh, Myanmar and Yunnan in China.
Food Habit:	Carnivorous. Feed on worms, insects and small fish
Reproductive Traits	Spawning usually takes place at night in shallow water with a silty substrate. Eggs are laid in nests through elaborate tunnels in vegetated areas. Eggs are guarded by one or both parents.
Taxonomic description:	Body is elongated and fairly rounded. Mouth is large with 3-6 canine teeth. Caudal fin rounded. Scales are larger on head. Colour varies from black to light green. Anal and caudal fins are dark grey in colour. Body colour black to light green.
Species Prospects	Food fish



Channa punctata

69. *Channa striata* (Bloch, 1793)

Common name:	Striped snakehead (Sauri in Bihar)
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. inhabit ponds, streams and rivers, preferring stagnant and muddy water of plains.
Distribution:	Asia: Pakistan to Thailand and south China.
Food Habit:	Highly carnivorous. Feed on fish, frogs, snakes, insects, earthworms, tadpoles and crustaceans.
Reproductive Traits	Breeds in ditches, ponds and flooded paddy fields. Young shoal at the surface and are guarded by the male parent
Taxonomic description:	Dorsal spines (total): 0; Dorsal soft rays (total): 38-43; Anal spines: 0; Anal soft rays: 23 - 27. Body sub-cylindrical; head depressed; caudal fin rounded. The dorsal surface and sides is dark and mottled with a combination of black and ochre, and white on the belly; a large head reminiscent of a snake's head; deeply-gaping, fully toothed mouth; very large scales
Species Prospects	Very good food fish.



Channa striata

70. *Nandus nandus* (Hamilton, 1822)

Common name:	Gangetic leaffish, Bheda (Bihar), Nadosh (WB)
Habitat:	Freshwater; brackish; benthopelagic. Found most commonly in standing or sluggish waters of lakes, reservoirs or canals. Also occur in tanks, beels, bheries, ditches and inundated fields.
Distribution:	Asia: Pakistan to Thailand.
Food Habit:	Carnivorous. Feed on aquatic insects and fishes
Reproductive Traits	The fecundity reported varied between 1,000 to 50, 000 numbers of eggs. The length at first maturity is 9-10 cm, and mature within the first year of life. The species is reported to be a single spawner.
Taxonomic description:	A deep laterally compressed body with nearly straight belly and arched back. Head is large and compressed. Snout is pointed. Eyes are comparatively large in smaller specimens. Body colour is greenish brown. Three yellow-green or olive green coloured vertical patchy bands at sides. Fins greenish to yellowish, some narrow dark bands radiate from eye. Scales number above lateral line is 8. Lateral line interrupted at 39-41 scales. Lateral line continued below for 14-16 scales. Scales number in longitudinal series is 48 to 50.
Species Prospects	A high-priced fish and sold fresh as food fish.



Nandus nandus

Family BADIDAE

71. *Badis badis* (Hamilton, 1822)

Common name:	Badis
Habitat:	Freshwater; benthopelagic. Occurs in rivers, ponds and ditches. Also found in swamps.
Distribution:	Asia: Ganges River drainage in India, Bangladesh, and Nepal, from Himachal Pradesh (Yamuna River) to the estuary; the Mahanadi River drainage; Assam lowlands close to Brahmaputra.
Food Habit:	Carnivorous. Feeds on worms, crustaceans and insects.
Reproductive Traits	Produces 30-100 eggs. Distinct pairing with embrace
Taxonomic description:	Dorsal spines (total): 15 - 17; Dorsal soft rays (total): 7-10; Anal soft rays: 6 - 8; Vertebrae: 26 - 28. The species has conspicuous dark blotch covering superficial part of cleithrum above pectoral fin base. Lacks a dark caudal peduncle blotch. Body depth 30.7-38.9%SL; interorbital width 6,5-8,3% SL; scales in lateral row 25-27; circumpeduncular scales 19-20; pectoral rays usually 12. Has a series of prominent dark blotches along dorsal fin base and/or a series of dark blotches along middle of dorsal fin; and has indistinct bars on side.
Species Prospects	Nutrient rich SIF and important as ornamental fish in planted aquarium tank

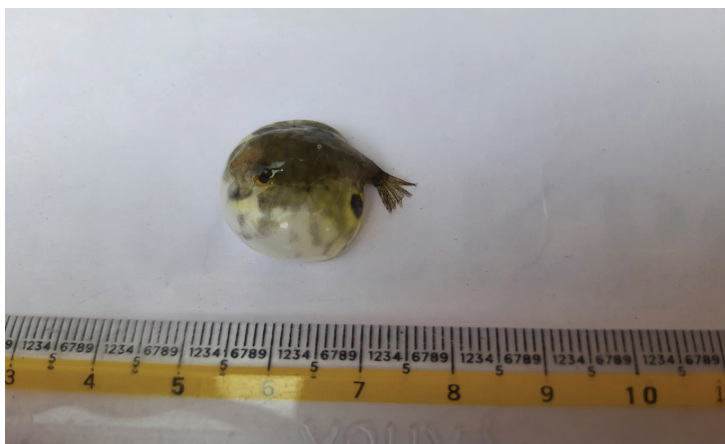


Badis badis

Order TETRAODONTIFORMES
Family TETRAODONTIDAE

72. *Leiodon cutcutia* (Hamilton, 1822)

Common name:	Ocellated pufferfish
Habitat:	Freshwater; brackish; demersal; potamodromous
Distribution:	Asia: India, Bangladesh, Sri Lanka and Myanmar
Food Habit:	Carnivorous.
Reproductive Traits	Shows sexual dimorphism during breeding season. Breed once in a year during summer season. The absolute fecundity ranged from 400 to 1500 eggs. Body is short with rounded abdomen and blunt snout. Mouth is small and terminal; both jaws with a median suture. One or two nostrils are present on each side in the form of short tube.
Taxonomic description:	Body covered with fine dermal spines. The upper lateral line is not reaching the tail, curved down above anal fin. Ventral fin is absent. All fins are rounded. Body colour is greenish above and whitish below. A light band is present across eyes. Greenish reticulations are on the back of body and a red spot is on the throat
Species Prospects	Of no interest to fisheries.



Leiodon cutcutia

Shellfishes

Phylum Arthropoda

Class Malacostraca

Order Decapoda

Family Potamidae

73. *Acanthopotamon martensi* (Wood-Mason, 1875)

Common name	crab
Habitat:	They live on the bottom of a water body and abundant in shallow water bodies, such as beels, canals, etc during the summer. To escape from the dry season, they construct burrows in clay soil, which they seal with mud. They create burrow closer to water level. The humid air trapped inside the burrows give crabs enough moisture to survive until the wet weather returns.
Distribution:	In India, they are distributed throughout the Gangetic valley, reported from states of Assam, Meghalaya, Arunachal Pradesh, Bihar, Uttar Pradesh, Uttarakhand, West Bengal and Rajasthan. Also distributed widely in Bangladesh and Myanmar.
Food Habit:	Nocturnal and omnivorous and feed on remains of other crabs, molluscs, insects, vegetation and detritus materials. Actually, predator for small aquatic animals.
Reproductive Traits	They start to populate at the beginning of the rainy season when water remains turbid and then a large number of juveniles are found. Before breeding moulting occurs when their body colour becomes glossy. After that they increase in length up to December. During the winter they become slightly darker in colour.
Taxonomic description:	Squarish carapace convex, surface smooth but uneven except some fin ripples near the postero-lateral edge; front robust; H-shaped gastric grooves on carapace. Outer epibranchial, meso and metabranchial regions with obliquely placed carinae. Antero-lateral sides of carapace equal to the well-defined posterolateral sides and armed with three spines, other than the blunt, angular, outer orbital angle. Eye stock moderate. Outer margin of orbit 'U' to 'V'shaped incision. Cheliped markedly unequal in both sexes, surface usually smooth; upper distal corner of arm with spine, inner corner of wrist present. Colour: dorsal surface of carapace and cheliped greenish to grey; ventral surface of cheliped, periopod, and carapace light brown; abdomen lighter.
Species Prospects	No commercial value. Some places, they are fished for human and aquaculture feed. Some predatory animals, such as fish, birds, mongoose, etc feed on it. Nowadays, also used in poultry industries and as a fertilizer
Ecological role	It plays an important ecological role in maintaining the balance in aquatic ecosystem, especially by scavenging, predating and hunting aquatic organism.



Acanthopotamon martensi

Order Decapoda

Family Palaemonidae

74. *Macrobrachium equidens* (Dana, 1852)

Common name:	Rough river prawn
Habitat:	Occurs in low parts of streams, river mouths, estuaries and brackish waters of high salinity, and is rarely found in pure freshwater but often in sea water to a depth of 30 meters.
Distribution:	Indo-West Pacific.
Food Habit:	The adult prawn is a bottom, omnivorous feeder preferring a diet of animal origin, thus exhibiting predatory feeding habit. The juveniles prefer diatoms and algae.
Reproductive Traits	Mating behavior: Precopulatory courtship ritual is common (through olfactory and tactile cues); usually indirect sperm transfer. Most females probably produced only a single brood of 20-75 eggs each breeding season. They showed no size-specific fecundity
Taxonomic description:	Rostrum elongate, curved slightly upwards, reaching or surpassing the distal extremity of the scaphocerite; superior margin with 9-12 teeth irregularly distributed, of which the proximal teeth are distributed almost uniformly (2-4 behind the orbit) and the distal teeth, more widely spaced in comparison with the other.
Species Prospects	It is marketed fresh or dried



Macrobrachium equidens

75. *Macrobrachium lamarrei* (H. Milne Edwards, 1837)

Common name:	Indian whisker shrimp, Kuncho river prawn
Habitat:	The species is usually found in big water bodies like beels, swampy area, moderate sized river towards bank side. They like to stay in the turbid water with sparsed distribution of aquatic vegetation.
Distribution:	India, Nepal, Bangladesh, Pakistan
Food Habit:	This species is naturally omnivorous. They are nocturnal species feed voraciously on planktonic organisms, algae, muscles pieces of their own kind or fish etc.
Reproductive Traits	In north and northeast India, these prawns attain sexual maturity during late part of rainy season and larval stages are completed during winter.
Taxonomic description:	It is a medium-sized prawn ranging from 75-80 mm in length rostrum bears 7-9 teeth dorsally and 5-8 ventrally. Teeth on the dorsal edge present throughout the rostrum. Rostrum shows convexity towards base, concavity at the middle and generally inclined. Body colouration is creamy white to light brownish white with greenish brown pigmentation all over the cephalothorax.
Species Prospects	It is a small sized prawn with high population densities in the distributed waters. Used as fresh and dried for human consumption.



Macrobrachium lamarrei

10. Ecosystem Services

Wetlands are a ubiquitous ecosystem, found in all regions and climatic conditions across the globe. Wetlands deliver many ecosystem services but are under continuous threat due to various anthropogenic activities. North Bihar (northern side of the River Ganges) is blessed with plenty of wetlands locally known as *chaur*s (natural depressions), *moin*s (oxbow lakes), and *pokhar*s (natural or artificial ponds) that are lifelines by serving the community for irrigation, fishing, foxnut (makhana) and water chestnut (singhara) cultivation. Kusheshwar Asthan wetland is one of the important wetlands in Gangetic plains of Mithilanchal in North Bihar and is situated in the Darbhanga district of Bihar (India). The wetland has been considered a wetland of international importance (MoEF & CC 2020).

It is a bird sanctuary and habitat for a variety of endemic birds and migratory birds of other countries. Besides that, the Kusheshwar Asthan wetlands are a religious place. Still, Kusheshwar Asthan wetlands are struggling with agriculture encroachment, railway-track construction and lesser inflow of water due to the construction of flood control embankments (bunds) on the Koshi and Kamla rivers (WII 2017). The Kusheshwar Asthan wetlands have an unconsolidated boundary without clear-cut demarcations, which results in conflict in land usage. Approximately 78% of the land is government-owned and the rest is private land. The land settlement rights are still pending since it was designated as a bird sanctuary in 1994. Such conflicts have resulted in encroachment of land for agriculture and are responsible for the shrinkage of wetlands and change in land use. The present study has been carried out to examine the suitability of Kusheshwar-Asthan wetland's water for fisheries and fish diversity conservation.

1. Bird conservation

One can meet several species of birds in this sanctuary and some of the local birds of this region are Mail, Lalshar, Dighouch, Nakta, Adhani, Chaha, Silli, Harial, Karan, Gaiber (White and Black) and Ratwa which can be found in Kusheshwar Asthan Bird Sanctuary. Gairi and Gagan both are rare species of birds which can be seen in this bird sanctuary. Apart from local birds of the region, a large number of migratory birds also come here as 'Winged Guests' for stay in winter season during November to March. That is the reason why Kusheshwar Asthan Bird Sanctuary is also known as Winter Capital of migratory birds. During winter, these birds take rest in vast water bodies located in 8100 ha area of this bird sanctuary. Almost 15 species of these migratory birds are of rare and endangered birds. Some of the major species of migratory birds seen in Kusheshwar Asthan Bird Sanctuary are Dalmatian Pelican, Indian Skimmer, Siberian Crane, Indian Darter, Oriental Quosande, Marbled Teal and more (Source: <https://wildtrails.in/kusheshwar-asthan-bird-sanctuary/>). But in the present study, exploratory survey during November, 2021, we have not recorded any birds. As per the information collected by local fisherman, the

birds population has drastically decrease due to poaching, killing and reduction in water residential period, shrinking of wetland area, competition for same food resources with the human.

2. Fish and Fisheries

Fish and Fisheries is one of most important ecological services provided by the Kusheshwar Asthan *Chaur* as livelihood for fishers and dependent. Fishing is done throughout the year but main fishing period in open access mode if November to June till the water completely dried up and rest of the period fish captured in deep pools. June to October almost lean period due to flood but from last few years there was much infrastructure development such as roads, rails bund has reduced the water feeding into these wetlands. No proper maintenance of catch information maintained by state government of cooperative society. However, questionnaire-based discussion with the fishermen and office bearer of cooperative society it was figure out that the fishing is done throughout the year but main fishing period is (November to June). The study was conducted by Jha and Chandra (1997) has also been reported similar pattern of fishing season but comparatively low daily fish catch. Ber Chowk, the most important market for the fishes caught from Kusheshwar Asthan *chours*.

The wetlands of Kusheshwar Asthan are hotspot of freshwater fish diversity but less explored, also support artisanal fisheries and livelihood for many families. The present investigation was carried out to assess the fish diversity of KAW and their dominance pattern in wet and dry seasons of 2021-2022. The wetland (*chaur*) is rainfed wetland and monsoon run off with flow from a network of rivers like Kamala, Balan, Bagmati and Kareh are the prime source of water. Distinct seasonality has been observed and also shifting of cropping pattern from fisheries to agriculture (Maize). A total of 72 species of fin fish and 3 shell fish was recorded during the study of which near threatened (6.94%), vulnerable (4.16%), and endangered (1.39%) categories based on IUCN Red data list). Total fish production (thousand metric tonnes) of Darbhanga district is 53.8 and demand is 42.54 in 2021-2022. Kusheshwar Asthan *Chaur* is major contributor of total fish production of Darbhanga district. Most dominant fish diversity in Kusheshwar Asthan wetland complex catch is Cypriniformes (40.3%) followed by Siluriformes (26.4%) and Anabantiformes (12.5%). Fisheries dominated by % of total fish catch (Kg) by single species *Wallago attu* (7%) in wet season and *Channa striatus* (13%) in dry season. The dominance of predatory fish in these wetlands due high amount of available fish food. The SIFs (small indigenous fish) is contributing subsistence amount to the total fisheries in spite of presence of large predators. It indicates that, this wetland highly suitable of breeding and larval rearing of fishes during water residential period. If provision for water retention period extension can create good habitat for enhancement of biodiversity and its conversation.



Figure. 30 Heap of SIFs sorted *Mystus* sp. and *Puntius* sp. used for fresh transport to West Bengal (Siliguri)



Figure 31: Prawn is high price shell fish sorted; size grading is done and large size used for fresh local consumption and small size transported to West Bengal



Figure 32. Harvest of tubers of macrophytes for human consumption

3. Environmental and cultural significance

The Kusheshwar Asthan wetlands are home to plenty of winter migratory birds besides the resident water birds. Due to its importance for water birds, the wetland was declared a bird sanctuary in 1994. It was classified as an Important Bird Area (A1 category) by Bird Life International and the Royal Society for Protection of Birds, UK (Ranjan et al. 2017). IUCN red-listed species like avian fauna (*Anhinga melanogaster*, *Ciconia episcopus*, *Mycteria leucocephala*, *Aythya nyroca*, *Numenius arquata*) and reptiles (*Python molurus*) were reported in the wetland area (WII 2017). The major aquatic vegetation communities include *Alternanthera*, *Eichhornia*, *Ottelia*, *Nymphoides*, *Ipomea* and *Vallisneria* (WII 2017). Having a rich repository of flora, fauna, and fishes, the wetland is recognized as a wetland of national importance under the National Wetland Conservation and Management Programme by the Government of India (<https://indianwetlands.in/>). The wetland absorbs the excessive flood water from adjoining rivers and protects the area from complete inundation. Furthermore, wetland supports the livelihood of the local people. These people depend on the wetland for agriculture, fisheries, and fodder mainly. Besides this, the Kusheshwar Asthan temple of Lord Shiva popularly known as ‘Kush Mahadev’ adds religious and cultural importance to the wetland area. The temple is visited by thousands of pilgrims every year.





Figure 33. Kusheshwar Asthan temple of Lord Shiva and a pond cemented dykes for performing many rituals like chhath puja.

4. Agricultural

The Kusheshwar Asthan *Chaur* is utilized for cultivation of Agriculture and horticulture crops such as rice, Maize, corn and vegetables during November to early June. Rabi crop is cultivated in this region. Rabi Crops are harvested in the spring season, preferably April-May, while it is sown in winter. The rabi crops are sown around mid-November, preferably after the monsoon rains are over. Presently Maize is major rabi crop in Kusheshwar Asthan *Chaur*. After harvesting maize the rest part shown in the figure is left into the field itself and this is continued from many years. Due to their continuous deposition of half of the maize plan the Kusheshwar Asthan *Chaur* is becoming shallow.



Figure 34. Maize (corn) farming at Kusheshwar Asthan Wetland in low water period



Figure 35. Post harvest of Maize (corn) farming at Kusheshwar Asthan Wetland in low water period.

11. Stakeholder's interactive meeting

Exploratory survey of Kusheshwar Asthan *Chaur*s and interactive meeting with stakeholder's was done regarding history of Kusheshwar Asthan fisheries and bird sanctuary. According to the perceptions of fisheries the fish production has been declining in last 7 years. Declining fisheries and changed in stalk structure has been noticed due to infrastructure development such as construction of road, railway line, bundh to prevent flood and most important conflict among the ownership rights of fishers and non-fishers.



Figure 35: Stakeholder's meet before initiation of sampling at Kusheshwar Asthan Bird Sanctuary



Figure 37: Stakeholder's meeting regarding fish and fisheries and migratory birds with fishers, panchayat office, local dependent fishers and owner of land under Kusheshwar Asthan Bird sanctuary.

12. Challenges in the protected habitat of Kusheshwar Asthan Bird sanctuary

Kusheshwar Asthan wetlands is complex ecosystem are in verge of extreme threat due to anthropogenic and environmental pressure. There is hardly any fish left in the lake as most of the area has been encroached on or transformed into agricultural land. There is no water even during the monsoons. Water retention period is only 6-7 months including deep pools. Deep pools are constructed by the land owner in their own land, which is claimed to be a part of Kusheshwar Asthan Bird sanctuary under protected area. Mass constructions and other infrastructure development have blocked the entry points of water into the lake, which has led to the destruction of biodiversity and loss of livelihood of many stakeholders.



Figure 38. Issues and challenges are observed in protected area of Kusheshwar Asthan

The Kusheshwar Asthan wetland, a crucial ecological zone, is facing a multitude of environmental and anthropogenic challenges that threaten its sustainability. A dedicated team conducted an in-depth exploration of the wetland's changing ecology, seasonal variations, and overall ecological vulnerability. Their findings highlight the pressing threats that this *chaur* system encounters, primarily due to both natural factors and human activities.

One of the most alarming issues is the increasing siltation of the wetland, which has significantly diminished its water retention capacity. This, in turn, has exacerbated the frequency and intensity of floods, affecting the local communities and biodiversity. Additionally, the wetland is witnessing rising conflicts among various stakeholder groups, particularly between fishing and non-fishing communities, due to competing interests over resource utilization.

Another major concern is the prevalence of destructive and unregulated fishing practices, which not only deplete fish populations but also disturb the delicate aquatic ecosystem. The declining number of bird sightings further indicates ecological distress, likely stemming from habitat degradation and human encroachment.

Moreover, poor governmental interventions and the absence of proactive policy measures have left the wetland management in a state of neglect. The lack of community involvement in conservation efforts has further exacerbated the situation, leading to ineffective governance and mismanagement of resources. The ineptitude of fisheries cooperatives has also contributed to the deteriorating condition of the wetland, preventing sustainable fishery practices from being implemented.

Addressing these challenges requires a comprehensive conservation strategy that includes scientific interventions, policy reforms, active community participation, and sustainable management practices to restore and protect the ecological integrity of the Kusheshwar Asthan wetland.

13. Recommendations

1. *Demarcation of protected area and removal of conflict of ownership rights*

Protected area need to demarcated in three zones viz. (i) core zone: where limited access for harnessing ecosystem services, protection of biodiversity fish or plant in these zones, Bird's feeding ground, may be protected as actual sanctuaries (ii) Buffer zone: where access of fishers with permission or only to catch fish without using destructive fishing gears, may be gill nets and trap used in the fishing for livelihood (iii) Sustainable use zone: fishing recreation, tourism can be promoted for economic and societal benefit of the stakeholders. Periodic ecological restoration for the area facing challenges in self-restoration through Integrated wetland management method. Public awareness about the conservation plan for protecting the flora and fauna of Kusheshwar Asthan Bird Sanctuary. Kusheshwar Asthan chaur has witnessed lot of conflicts between private owners and state government including forest department. It is essential, therefore, that the entire Kusheshwar sthan chaur area be brought under ownership of State Government to make the development of fisheries more effective.

2. *Link channel restoration*

Periodic restoration of link channel for continuous water availability for proper functioning of ecological wellbeing of the sanctuary.

3. *Ecosystem based fisheries management*

From age old practice in Darbhanga region, wetlands are rain fed or seasonal fishes are not cultured only capture fisheries. Fishes including all life history traits are enter in the inundated wetlands of Darbhanga region through flood or river flow and intensive fish capture is continued till last fish get capture by digging deep pools in order to reduce water depth or drying inside the wetlands (controlled under individual land owner). This had led to the continuous declining in the fish stock of indigenous fish and declining fish diversity and its population. Many fishes have tendency to reach in less disturbed, low depth and lower flow region for breeding, among these *Clarias magur* (state fish of Bihar), *Anabas testudeni* (Kawai) and *Heteropneustis fossilis* (Singhi) are highly priced fish breed in wetlands. Protection of breeding ground and maintenance of minimum water depth in core zone of protected area may help in establishing of self-recruitment of indigenous fish species and with Bird fish also can be protected.

4. *Awareness and campaign*

Frequent awareness among the local stakeholders, students and manager of this ecosystem are essential for proper functioning and protection of resources. Routine campaign is required with suitable quotation and circulation of information with different audio-visual aids and electronic media for protection and sustainable utilization of resources.

5. *Pollution abatement plan*

There two source of pollution i) Point source: this source can be easily identified and suitable measures can be taken and complete control can be achieved, ii) non-point source: the pollutant in different form are entering to the protected habitat, suitable management plan by creating artificial habitat using macrophyte to filter large plastic products etc.

6. *Strengthening of fishermen's Cooperative /Marketing System*

The Kusheshwar Asthan Fishermen's cooperative society is poorly managed. The documentation of fish produced in maintained by individual fishermen and that is confidential for their own purpose. Marketing is done in three locations onsite, Kusheshwar Asthan market and Ber chawk. 80% of fish harvest come at Ber chawk for marketing, unhygienic fish market, fish kept on floor sometimes on plastic sheet. The cooperative society should take lead in managing and marketing of fish and its sale.

7. *Creation of Infrastructure for fish drying and icing*

The most of the SIF fish, which is not fresh has observed been used for drying in traditional way. Which is unhygienic. Infrastructure for icing facility by constructing ice plant and fish drying unit may help in fetching higher price than the present traditional way of preserving to avoid fish spoilage.

It has been observed that drying of fish, specially forage fishes, is done in the area crudely. It is proposed therefore, that processing facilities be created in the area for better marketing of processed fish. It has also, been observed and reported by the local fisherman that a good percentage of fish catch gets spoiled at times, in absence of ice for preservation and proper transport to export the fish in time. Arrangements need be made for efficient transportation, Insulated carrier may be arranged under the Cooperative Society to avoid spoilage of fish catch.

8. *Stocking in Chours*

The chours in the area have high infestation of weeds as such have very rich periphytons and detrital load at the column and bottom respectively. These important components of the food chain largely remain under-utilized. It is suggested, therefore, that the waterbodies be stocked with IMC with Grass carp will increase the carp contribution in catch. It is suggested that a stocking density of 1000 numbers per ha of advanced fingerlings (80-100 cm size) need to be followed.

9. *Removal of macrophytes*

The massive infestation of aquatic weeds in these chauris is a serious threat to the fish and fisheries. It is highly essential to reduce the macrophyte infestation to 20-30% of surface area. Removal of macrophytes manual or biological by introducing fish such as Grass carp (*Ctenopharyngodon idella*).

10. *Enclosure (Pen) culture*

Pen culture is highly promising technology for seed raising and table fish production from wetlands. Peripheral area of wetland and the stagnant zone of Kamala River channel is good habitat for pen culture practice. Pen culture is efficient low-cost technology can effectively utilize the marginal area for seed raising and stocking material for wetlands.

11. *Strict regulations for Bird Trapping*

The migratory and resident variety of birds are the important component of the chaur ecosystem as they help in maintaining ecological balance by consuming the forage fishes. It is proposed that killing of birds be banned by enforcing suitable measures. The above suggested recommendations would also need some additional measures for proper development.

Exploration of ecology and fish diversity of Nagi & Nakti Ramsar Site

1. Executive Summery

- The influx of migratory birds at Nagi compared to Nakti is an interesting observation. Bird populations can serve as indicators of ecosystem health, and differences in bird abundance may reflect variations in habitat quality, food availability, and other ecological factors.
- The decline in Transparency during the dry season at Nagi Bird Sanctuary is indeed intriguing. Algae concentrations can significantly affect water clarity, and their proliferation in warmer, nutrient-rich environments can reduce transparency. Algae thrive in such conditions, and their presence can alter the light penetration through the water column.
- The maximum water depth of 10.4 meters at Nagi during the wet season suggests a strongest habitat for aquatic life. Deeper water provides additional niches for various species, including fish, aquatic plants, and invertebrates. It's essential to consider these factors when assessing the overall ecological value of these sanctuaries.
- Planktonic organisms, due to their short life cycles, serve as rapid indicators of environmental health in aquatic ecosystems, with the dry season showing significantly higher phytoplankton abundance and diversity, particularly in Nagi and Nakti Bird Sanctuaries, where 53 species were observed, indicating a notable increase in abundance compared to the wet season.
- The study identified *Brachionus*, *Lecane*, and *Keratella tropica* as the most abundant genera among the 28 species and 20 genera of rotifers in Nagi Bird Sanctuary, with significant seasonal variations in zooplankton abundance observed in Nakti Bird Sanctuary but not in Nagi Bird Sanctuary, where Cladocera and Copepoda dominated among the 16 species recorded, showing increased abundance during the dry season compared to the wet season in both sanctuaries.
- Submerged macrophytes like *Potamogeton nodosus*, *Potamogeton wrightii*, and *Potamogeton natans* dominated the observed species, comprising over 70% of macrophyte coverage, with additional species such as *Chara*, *Najas*, and *Nymphaea* also present but to a lesser extent, while *Potamogeton nodosus*, characterized

by its submerged, long, rooted plants with elongated leaves and colonial nature, occupies a wide ecological range and produces densely packed seed heads favored by visiting birds.

- The study revealed significant seasonal variations in benthic organism abundance, identifying eight macro-benthic species with *Bellamya dissimilis* and *Bellamya bengalensis* as the most dominant, with Nagi Bird Sanctuary showing higher densities during the dry season and Nakti Bird Sanctuary exhibiting the same trend, highlighting the dynamic response of benthic communities to seasonal changes in aquatic ecosystems.
- The Twin Bird sanctuaries: Study recorded 29 fish and 2 prawn species. Other than the stocked species, most native species were small sized fishes, and many of them have ornamental value. The highest taxonomic contribution from Cypriniforms (55%), followed by Anabantiformes (17%), Perciformes (14%), Synbranchiformes (7%), and Gobiiformes (3.5%).
- The conservation status of the recorded fish species from Nagi and Nakti indicates that 3.4% of species are under the near-threatened category, 6.9% are categorized as LC-decreasing, 34.5% as LC-Stable, and 55.1% as LC-Unknown.
- The introduction of Tilapia fish into the Nagi reservoir through stocking has led to its proliferation and establishment of breeding populations within the sanctuary. This highlights the dynamic interactions between introduced and native species within these protected ecosystems, underscoring the need for monitoring and management to maintain ecological balance and preserve biodiversity.
- Addressing the proliferation of Tilapia in Nagi Bird Sanctuary requires careful management strategies, including monitoring and control measures to mitigate their impact on native biodiversity. This may involve implementing measures to control Tilapia populations, restoring habitat for native species, and raising awareness among stakeholders about the importance of preserving biodiversity in the sanctuary.

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Principal Chief Conservator of Forest, Bihar

Chief Wildlife Conservator, Wildlife, Jamui district

Forest ranger and other officials of Nagi and Nakti Bird sanctuary

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2. Introduction

The declaration of protected areas (PAs) is increasing globally to conserve natural flora and fauna and associated ecosystem services (Lehikoinen et al., 2021). Between 2010 and 2019, protected areas expanded from covering 14.1% to 15.3% of global land (Maxwell et al., 2020) and freshwater environments (excluding Antarctica) and from 2.9% to 7.5% of the marine realm (UNEP-WCMC, 2019). Protected area, most widely used tools for conservation of biodiversity are using mandatory legal procedures for strict implementation of limited human interference in defined geographical space to enhance diversity. There are a total of 18,075 freshwater fish species in the world, accounting for 51 percent of all fish species and 25 percent of all vertebrates, provide irreplaceable goods and services but are increasingly affected by human activities. They are an important food source for 200 million people and provide work for 60 million. But their numbers are in decline. The IUCN Red List of Threatened Species has declared 80 to be extinct, 16 of those in 2020 alone. In fact, freshwater biodiversity is plummeting at twice the rate of biodiversity in the oceans and forests.

The State Bihar is situated at along the Ganga River basin, includes 38 districts of which 21 districts in North Bihar and 17 districts in south Bihar. The state of Bihar is endowed with a variety of natural water resources viz. Rivers and associated water bodies like floodplain wetlands (Oxbow Lake, meanders, seasonal floodplain), Reservoirs, Ponds and Tanks. Despite abundant aquatic resources in terms of about 2800 km of rivers, 43500 hectares *chaurs* and floodplain wetlands, 9,000 hectares of oxbow lakes or *mauns*, 7,200 hectares of reservoirs and 68,050 hectares of ponds and tanks, fish supply is short of demand in the State of Bihar. Apart from Ganga river system, 15 rivers and rivulets such as Koshi, Gandak, Budhi Gandak, Kareh, Kamla, Bagmati etc.

Protected Areas are the principal mechanism of conservation of biodiversity on Earth and serves as the most important units for in-situ biodiversity conservation. Globally, wetland conservation mainly focusses on conservation of aquatic birds and most times, the fish diversity in those protected waterbodies are not explored or documented. Although the Ramsar Convention which came to existence in 1971 adopted fish criterion to designate wetlands as Ramsar sites in 1996 and necessitated an assessment of fisheries contribution in Ramsar sites, adequate relevance has not been given to fisheries and fish diversity assessments in many such designated wetlands. The project was formulated with an aim to explore the status and diversity of fish fauna in some of the protected waters of India.

Objective:

- To develop biological inventory of fish and shell fish in selected protected water bodies
- To identify priority habitat of fish and shellfish in the protected water bodies

Possible outcome

- Inventory and database of fish and shellfish diversity of selected protected water bodies
- Identification of priority habitat for recorded fish and shellfish species
- Documentation of conservation status of fishes found in studied protected area

Study period: April, 2021-March, 2023

3. Background of Project site

In the 21st century, establishing protected areas has become a crucial strategy globally for conserving and restoring biodiversity. One such initiative took place in the Sanctuary region, where policymakers and managers utilized protected area declarations as vital tools. This effort included the Nagi and Nakti Dams, constructed in the early 1960s by the irrigation department along the Nakti River in Jamui district, South Bihar, near the Jharkhand border.

The Nagi and Nakti bird sanctuaries emerged as significant sites selected for exploration and study under this project. These twin sanctuaries, situated close to each other in Jamui district, Bihar, are essentially small reservoirs created by damming the Nagi and Nakti Rivers in 1958 and 1983, respectively. Surrounding these dams are rocky hills and downstream farmlands, creating a unique ecosystem.

Despite primarily serving irrigation purposes for nearby villages, these reservoirs were declared protected sites in 1987, with the implementation finalized in 2009. Interestingly, fishing activities are prohibited within these sanctuaries, which were once infested with submersed macrophytes. Occasionally, fish stocking was carried out to sustain migratory bird populations.

Spanning over 791 hectares for Nagi Dam and 332 hectares for Nakti Dam, these sanctuaries are so closely located that they are often regarded as one bird area. Over the years, Nagi-Nakti Bird Sanctuaries have become home to a diverse range of indigenous and migratory bird species. During winters, migratory birds from various regions including Eurasia, Central Asia, the Arctic Circle, Russia, and Northern China flock to these sanctuaries, highlighting their importance as vital habitats within the global ecosystem.

History and Purpose of Nagi Dam and Nakti Dam, Jamui, Bihar

Nestled amidst the serene landscape of Jamui district in Bihar, the Nagi Dam and Nakti Dam stand as monuments of human ingenuity and environmental conservation. These dams, constructed in the early to mid-20th century, have not only facilitated agricultural development but have also evolved into vital sanctuaries for avian biodiversity.

The history of Nagi Dam and Nakti Dam dates back to the mid-20th century when the region witnessed significant infrastructural development aimed at harnessing water resources for irrigation purposes. The construction of Nagi Dam commenced in 1958, followed by the development of Nakti Dam in 1983. These projects were spearheaded by the irrigation department, reflecting the government's commitment to enhancing agricultural productivity in the region.

Purpose and Functionality

The primary purpose of Nagi Dam and Nakti Dam was to regulate the flow of the Nagi and Nakti Rivers, respectively, thereby facilitating irrigation for the surrounding agricultural lands. The reservoirs created by these dams served as crucial water sources for local farmers, enabling them to cultivate crops even during dry spells. However, beyond their utilitarian function, Nagi Dam and Nakti Dam assumed a more significant role in environmental conservation. The surrounding areas, characterized by rocky hills and fertile farmlands, provided an ideal habitat for a diverse range of flora and fauna. Recognizing the ecological importance of these ecosystems, efforts were initiated to declare Nagi and Nakti as protected areas.

Evolution into Bird Sanctuaries

The transformation of Nagi Dam and Nakti Dam into bird sanctuaries marked a significant milestone in their history. Over the years, these reservoirs attracted a plethora of avian species, both indigenous and migratory, owing to their pristine surroundings and abundant food sources. In 1987, Nagi and Nakti were officially designated as bird sanctuaries, reflecting the government's commitment to biodiversity conservation. Subsequent efforts were made to implement conservation measures, including the prohibition of fishing activities within the sanctuaries and occasional fish stocking to support migratory bird populations.

Conservation Efforts

Today, Nagi Dam and Nakti Dam serve as crucial habitats for a wide variety of bird species, attracting migratory birds from distant corners of the globe. During the winter months, these sanctuaries come alive with the sights and sounds of winged visitors, making them a haven for birdwatchers and nature enthusiasts.

Conservation efforts within Nagi and Nakti sanctuaries continue to evolve, with stakeholders working tirelessly to preserve their ecological integrity. Initiatives such as habitat restoration, community engagement, and scientific research play a vital role in safeguarding the rich biodiversity of these wetland ecosystems.

In conclusion, the history and purpose of Nagi Dam and Nakti Dam exemplify the intricate relationship between human development and environmental conservation. From their humble beginnings as irrigation reservoirs to their current status as vibrant bird sanctuaries, these dams stand as testaments to the power of collective action in preserving our natural heritage for future generations.

Significance of the twin Bird Sanctuary

Nestled in the picturesque landscape of Jamui district, Bihar, the Nagi-Nakti Bird Sanctuaries stand as vibrant ecosystems teeming with life and vitality. Spanning over these sanctuaries are narratives of ecological significance, avian diversity, and the invaluable services they provide to both wildlife and human communities.

Avian Spectacle

Each year, a remarkable phenomenon unfolds as more than 20,000 water birds congregate in the Nagi-Nakti Bird Sanctuaries. These avian visitors, hailing from distant corners of the globe, transform the tranquil waters into a bustling haven of activity and sound. Among these visitors, approximately 2,000 Bar-headed geese make a breathtaking appearance, representing 3% of their total global population. Their majestic presence adds to the allure of these sanctuaries, highlighting their importance as critical habitats for migratory birds.

Resident Terrestrial Birds

While migratory birds take centre stage during the winter months, the rocky terrain of the Nagi-Nakti sanctuaries also provides a haven for many resident terrestrial birds. These feathered inhabitants, adapted to the rugged landscape, find refuge and sustenance amidst the rocky outcrops and verdant vegetation, contributing to the rich biodiversity of the region.

Rich Aquatic Life

Beyond its avian residents, the sanctuaries harbor a diverse array of aquatic life forms, including fishes, amphibians, and other aquatic flora and fauna. The pristine waters of Nagi and Nakti reservoirs support thriving ecosystems, where each organism plays a vital role in maintaining ecological balance and resilience.

Ecosystem Services

The Nagi-Nakti Bird Sanctuaries are not only havens for wildlife but also serve as providers of essential ecosystem services. The water stored in these reservoirs serves agricultural irrigation needs, ensuring the sustenance of local farming communities. Additionally, the sanctuaries play a crucial role in groundwater recharge, replenishing aquifers and supporting water security in the region.

Tourism and Education

Beyond their ecological significance, the Nagi-Nakti Bird Sanctuaries offer a tranquil and picturesque environment for tourism and education. Visitors are afforded the

opportunity to immerse themselves in the wonders of nature, observing birds in their natural habitat and gaining insights into the intricate dynamics of wetland ecosystems. Educational programs conducted within the sanctuaries provide valuable learning experiences, fostering environmental stewardship and appreciation for biodiversity conservation.

The Nagi-Nakti Bird Sanctuaries represent not only a sanctuary for avian diversity but also a testament to the interconnectedness of ecosystems and human well-being. As stewards of these precious habitats, it is incumbent upon us to ensure their preservation for generations to come, safeguarding their ecological integrity and nurturing their potential for both wildlife and human communities alike.

4. Sampling

In order to comprehensively study the habitat, ecology, and fish diversity within the Nagi and Nakti Bird Sanctuaries, a meticulous seasonal sampling plan was devised. The sampling strategy aimed to capture the nuances of these ecosystems across varying climatic conditions, thereby providing a holistic understanding of their ecological dynamics.

The sampling plan was structured to cover both wet and dry seasons, reflecting the seasonal variability inherent in these ecosystems. Specifically, sampling was conducted during the wet season in 2021 and the dry season in 2022, allowing for the collection of data under contrasting hydrological conditions.

Various environmental parameters and biological components were targeted for sampling, including fish fauna, water quality, sediment characteristics, planktonic organisms, macrophytes, and benthic communities. This multi-faceted approach enabled researchers to assess the ecological health and functioning of the reservoirs from diverse perspectives.

A total of seven sampling sites were strategically selected across the Nagi and Nakti reservoirs to capture the spatial heterogeneity within these ecosystems. Four sampling sites were designated within the Nagi reservoir, while three sites were identified within the Nakti reservoir. This spatial distribution ensured adequate coverage of different habitat types and ecological gradients present within the sanctuaries.

At each sampling site, a suite of sampling techniques and equipment was employed to collect data and specimens representative of various ecological compartments. This included methods such as water sampling for physicochemical analysis, sediment coring for sediment characterization, plankton netting for planktonic community assessment, and visual surveys for macrophyte and benthic community documentation.

The data collected through these rigorous sampling efforts will serve as invaluable resources for assessing the habitat suitability, ecological dynamics, and fish diversity within the Nagi and Nakti Bird Sanctuaries. By documenting seasonal variations and spatial patterns across a range of ecological parameters, this study contributes to our understanding of these vital ecosystems and informs conservation and management efforts aimed at preserving their biodiversity and ecological integrity.

Table 1: Geographical details of sampling sites

Nagi Dam		
Site 1	Littoral: Between Dam site and Lotic sites	N24°49'29.7": E086°24'06.4"
Site 2	Lotic: River-Reservoir inter phase	N24°49'00.3": E086°24'28.8"
Site 3	Transitional: At the Centre; more than 1 km from dam site	N24°49'06.3": E086°24'39.3"
Site 4	Dam site: Near overflow point	N24°48'58.4": E086°24'03.2"
Nakti Dam		
Site 1	Lotic site: small rivulet Kubri joins reservoir here	N24°50'58.4": E086°26'13.5"
Site 2	Dam site	N24°50'58.9": E086°26'30.5"
Site 3	Lotic site: near river Katara	N24°51'08.9": E086°26'37.5"

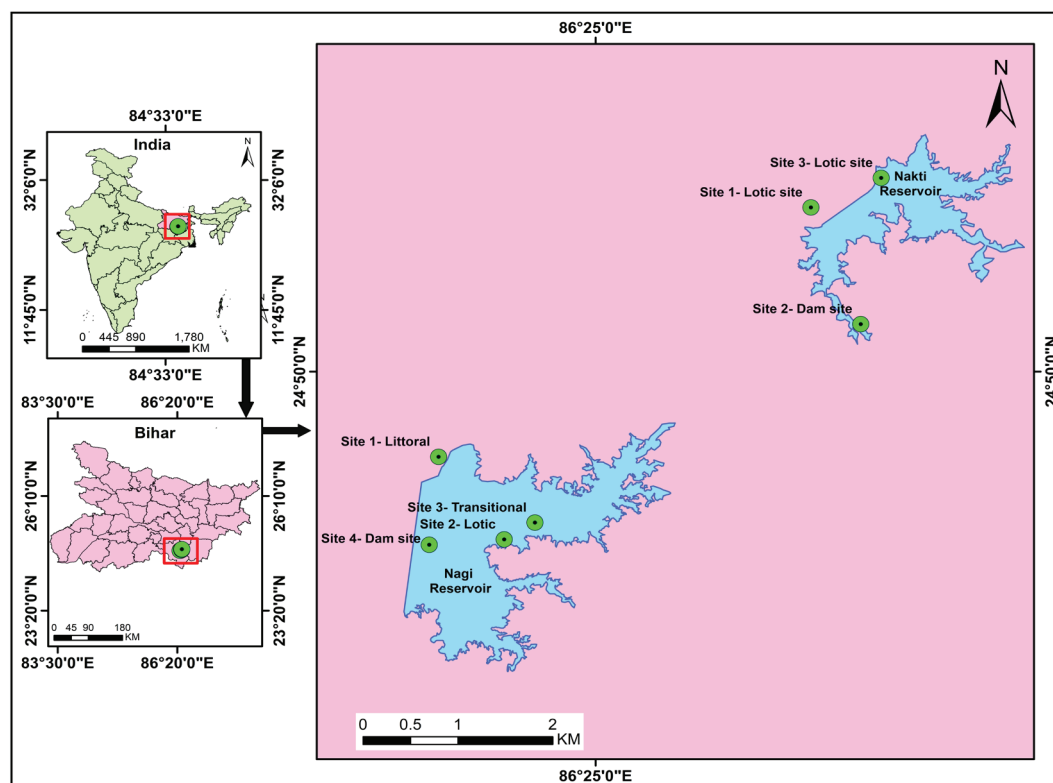


Figure 1: GIS map Nagi and Nakti Bird sanctuary



Figure 2: The littoral zone of Nagi Bird sanctuary

The littoral zone, often described as the shallow down-sloping shelf of a lake where water meets land, is a vital component of aquatic ecosystems. This transitional area serves as a dynamic interface between aquatic and terrestrial environments, harboring a rich diversity of plant and animal life.

Plants that thrive in the littoral zone play a crucial role in supporting wildlife populations, providing habitat and food sources for a variety of species. Wading birds, such as herons and egrets, find ample foraging opportunities amidst the dense vegetation of the littoral zone, preying on fish, amphibians, and invertebrates that inhabit these waters. Turtles and crabs also rely on the littoral zone for shelter, breeding sites, and food resources. These lush vegetated areas not only support diverse wildlife communities but also contribute to the overall health and functioning of aquatic ecosystems.

Littoral plants help stabilize shorelines, prevent erosion, and filter pollutants from entering the water, thus improving water quality and clarity. Additionally, the intricate root systems of littoral plants provide habitat and refuge for juvenile fish and aquatic invertebrates, contributing to the productivity and biodiversity of freshwater habitats. Recognizing the ecological importance of littoral zones, they are often protected by law to ensure their preservation and conservation. Regulatory measures may include restrictions on shoreline development, prohibitions on habitat destruction, and the establishment of protected areas or buffer zones along lake shores.

One notable aspect of littoral zones is their role in supporting the life cycles of various aquatic organisms. Mollusks, for example, often lay their eggs in the sheltered confines of the littoral zone, where the shallow, nutrient-rich waters provide optimal conditions

for larval development. By providing suitable breeding grounds for mollusks and other aquatic species, littoral zones contribute to the overall biodiversity and resilience of freshwater ecosystems.



Figure 3: The littoral zone of Nakti Bird sanctuary



Figure 4. Snail eggs in the littoral zone of Nagi Bird sanctuary

Snail eggs, often referred to as snail egg masses or clusters, are fascinating structures produced by freshwater and terrestrial snails as part of their reproductive process. These eggs are typically laid in gelatinous masses, which serve to protect and nourish the developing embryos until they hatch. Visually, snail egg masses vary in appearance depending on the species of snail. They can range in color from translucent to opaque and may be spherical, elongated, or irregular in shape. The texture of the egg mass is usually gelatinous or jelly-like, providing a protective matrix that helps retain moisture and shield the developing embryos from predators and environmental stressors.

The development of snail embryos within the egg mass typically proceeds over a period of days to weeks, depending on factors such as temperature, humidity, and availability of food resources. As the embryos mature, they undergo a series of developmental stages before eventually hatching as miniature versions of the adult snail.

5. Hydrological and ecological parameters

The investigation into the critical water quality attributes of the reservoirs yielded insightful findings, shedding light on the overall environmental conditions within these aquatic habitats. Across all seasons, the water reaction of the reservoirs was predominantly alkaline, indicating a favorable and conducive environment for aquatic life. This alkaline nature of the water reflects the overall health and stability of the reservoir ecosystems. Furthermore, the levels of Dissolved Oxygen (DO) in the water were consistently above 5 ppm (parts per million) across all sampling sites and durations. This high level of Dissolved Oxygen suggests an environment conducive to the thriving of fish populations. Adequate oxygen levels are essential for the survival of aquatic organisms, and the presence of sufficient Dissolved Oxygen indicates a healthy and oxygen-rich aquatic habitat.

Methodology followed:

The methodology employed in the study involved a comprehensive assessment of various water quality parameters using state-of-the-art equipment and standardized procedures. A range of parameters including Depth, Transparency, Water Temperature, pH, Specific Conductivity, Total Dissolved Solids, Salinity, Free Carbon Dioxide, Chloride, Total Alkalinity, Total Hardness, and concentrations of various ions and nutrients were meticulously measured.

Water samples were collected from both Nagi and Nakti dams during the morning hours, between 8 AM to 11 AM, to ensure consistency and minimize temporal variations in water quality. On-site measurements of key parameters such as temperature, pH, transparency, Dissolved Oxygen, Specific Conductivity, Total Dissolved Solids, Salinity, and Free Carbon Dioxide were promptly conducted immediately after sample collection. These real-time measurements provided valuable insights into the immediate conditions of the water at each sampling site.

Subsequently, water samples were transported to the laboratory for further analysis, where additional parameters were assessed using established standard methods. These laboratory-based analyses allowed for a more comprehensive understanding of the water quality characteristics and enabled researchers to evaluate the overall health and integrity of the reservoir ecosystems.

Overall, the study's methodology combined rigorous field measurements with precise laboratory analyses to provide a thorough assessment of the water quality attributes of the Nagi and Nakti reservoirs. By systematically evaluating a range of parameters, the study contributes valuable insights into the environmental conditions of these aquatic habitats and informs future conservation and management efforts aimed at preserving their ecological integrity.

Water and Soil quality parameters

The water and soil quality parameters of Nagi and Nakti were assessed across various sites, and the findings are summarized in Table 2 and Table 3, respectively. Notably, significant differences were observed in key parameters such as Dissolved Oxygen (DO), pH, Alkalinity, and Transparency between Nagi and Nakti Bird Sanctuaries.

One notable disparity was observed in Transparency, with Nagi Bird Sanctuary exhibiting a decrease from the monsoon to the dry season. This decline in Transparency during the dry season can be attributed to higher concentrations of algae, which tend to proliferate in warmer, nutrient-rich environments. Conversations with the authorities responsible for managing Nagi and Nakti Bird Sanctuaries revealed that Nagi receives a greater influx of migratory birds compared to Nakti. This disparity in bird populations is mirrored in the water quality parameters observed at both sanctuaries.

Further comparison of water quality parameters highlighted differences between the two sanctuaries. For instance, Nagi Bird Sanctuary recorded a maximum water depth of 10.4 meters during the wet season, indicating a more expansive and potentially more suitable habitat for aquatic life compared to Nakti.

Moreover, observations suggest that Nagi Bird Sanctuary is more meticulously organized and managed as a bird sanctuary compared to Nakti. This enhanced organization may contribute to differences observed in water quality parameters and overall ecological health between the two sites. Temperature measurements conducted simultaneously at both sanctuaries revealed slightly lower water temperatures in Nagi compared to Nakti, indicating a comparatively colder environment in Nagi Bird Sanctuary.

Despite variations in environmental conditions, pH levels remained predominantly alkaline throughout the study period in Nagi Bird Sanctuary, except during the dry season. This consistency in pH suggests relatively stable environmental conditions conducive to the health and well-being of aquatic life.

Overall, Dissolved Oxygen levels were found to be within favorable ranges for fisheries and aquatic life in both Nagi and Nakti Bird Sanctuaries, indicating healthy and oxygen-rich aquatic environments conducive to the survival and proliferation of aquatic species.

Table 2: Water quality parameter assessed during the wet (July) and dry season (February)

	Nagi Bird sanctuary		Nakti Bird Sanctuary	
	Wet Season	Dry Season	Wet Season	Dry Season
Water quality				
Depth (m)	1.5-10.4	1.87-7.37	1.9-7.9	1.96-6.12
Transparency (cm)	210-230	152-199	165-180	201-336
Temp Water (°C)	31.8-32.4	20.7-21.5	32.6-33.8	20.1-20.8
pH	8.95-9.17	7.05-7.7	7.7-8.5	7.26-7.85
Specific conductivity (µS/cm)	210-226	242-248	233-238	271-276
Dissolved Oxygen (ppm)	7.2-8.8	8.5-8.7	6.6-8.1	5.2-7.2
Free CO₂ (ppm)	Nil	Nil	Nil	Nil
TDS (ppm)	149-154	170-191	165-169	191-195
Chloride (ppm)	20-22	42-56	20-22	54-60
Salinity(ppt)	0.09-0.1	0.112-0.127	0.106-0.108	0.127-0.136
Total Alkalinity (ppm)	88-94	108-112	100-108	132-136
Total hardness (ppm)	68-72	88-104	68-80	96-104
Ca ++ (ppm)	11.2-14.4	19.2-20.8	12.8-14.4	17.6-20.8
Mg ++(ppm)	7.8-10.7	9.7-13.1	8.8-10.7	10.7-13.6
Nitrate-N (ppm)	0.27-0.4	0.21-0.28	0.32-0.43	0.2-0.46
Silicate-Si(ppm)	10.2-12.7	0.61-4.27	8.4-12.1	1.72-3.77
Total Phosphorus(ppm)	0.09-0.33	0.16-0.92	0.06-0.11	0.11-0.34

Water depth fluctuates within both bird sanctuaries. Transparency levels in Nagi Bird Sanctuary decreased notably during February, whereas in Nakti, there was an increase. This fluctuation in transparency is indicative of the migratory birds' residential period, with Nagi boasting a higher abundance compared to Nakti Bird Sanctuary. This observation finds support in the higher phosphorus concentration observed in Nagi compared to Nakti. Additionally, the appearance of the water's color was transparent during July but pale green in February, as illustrated in Figure.

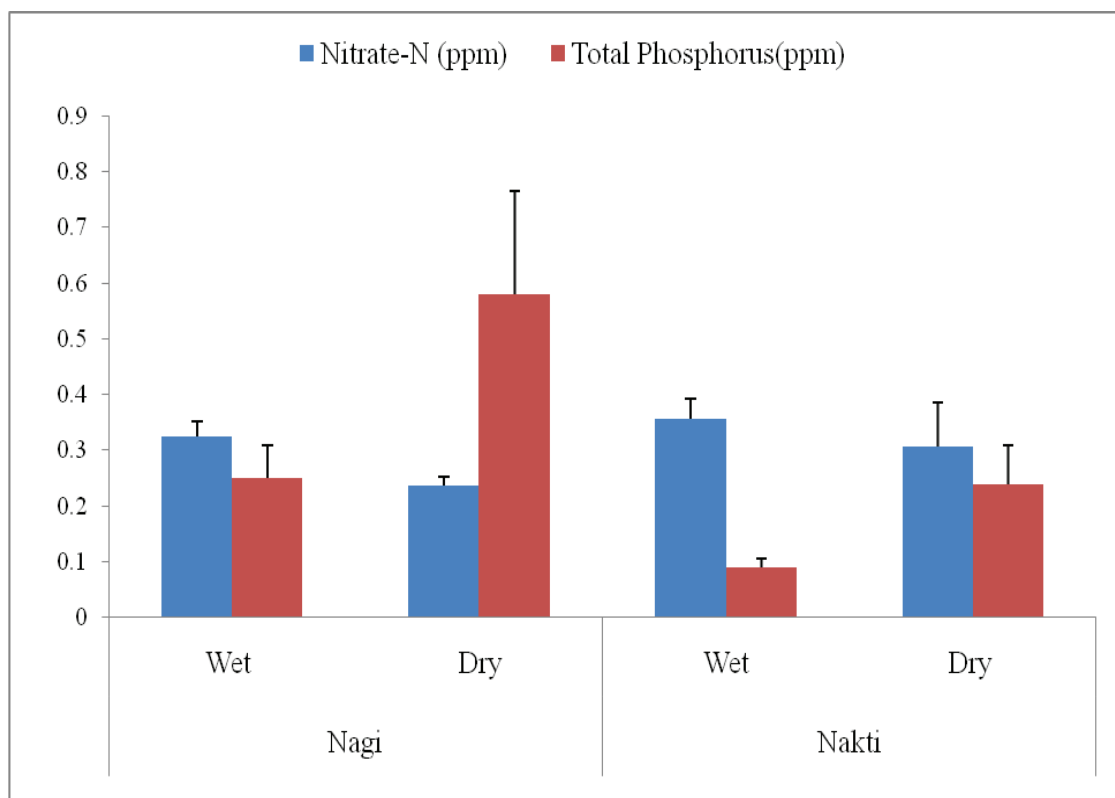


Figure 5. Seasonal variation in nitrate and total phosphorus concentration in Wet season (July) and in Dry season (end of February)

Table 3: Soil quality parameter assessed during the wet (July) and dry season (February)

	Nagi Bird sanctuary		Nakti Bird Sanctuary	
	Wet Season	Dry Season	Wet Season	Dry Season
Water quality				
pH	7.74-8.66	7.37-8.2	7.8-8.1	7.4-7.9
Specific conductivity ($\mu\text{S}/\text{cm}$)	175-740	188-589	130-586	260-673
Organic carbon (%)	0.17-3.76	1.41-2.95	0.1-1.65	1.9-2.75
Av.Phosphorus (mg/100gm)	0.96-9.2	0.26-1.2	0.8-2.0	0.3-0.96
Sand (%)	70-92	71-81	71-89	79.5-88
Silt (%)	3-16	6-15	5-12	4.5-11
Clay (%)	4-16	5-20	6-20	1-15.5



Figure 6. Sampling of water and soil quality collection and analysis



Water color transparent during July



Water color pale green during February
Figure 7. The appearance of water color between the wet and dry seasons

6. Plankton Diversity and Abundance

Phytoplankton

Phytoplankton, the cornerstone of the aquatic food web, serve as primary producers in aquatic ecosystems, driving overall wetland productivity. Conversely, zooplankton act as primary consumers, while small fish and invertebrates graze on these plant-like organisms, forming a crucial link in the food chain. With phytoplankton at the base, these organisms fundamentally dictate the productivity of the entire aquatic ecosystem. Certain phytoplankton groups also contribute significantly to the biogeochemical processes of wetlands, including nitrogen fixation and oxygenation.

Given their short life cycles, planktonic organisms exhibit rapid responses to anthropogenic disturbance and environmental changes, making them ideal bioindicators for assessing the environmental health of aquatic ecosystems. During the Dry season, a substantial diversity of phytoplankton species was observed, with particularly high abundances recorded in Nagi and Nakti Bird Sanctuaries. In the Dry season, 53 species of phytoplankton with very high abundance 118900 ± 4768 cells/Litre and 64500 ± 16450 cells/Litre were recorded from different sampling sites of Nagi and Nakti Bird sanctuary, respectively, whereas in wet season 12315 ± 268 cells/Litre and 17043 ± 3450 cells/Litre for Nagi and Nakti Bird sanctuary, respectively. The abundance levels were notably higher during the dry season compared to the wet season. Phytoplankton enumeration was conducted using the Sedgwick rafter cell counting chamber under an inverted microscope, revealing a classification into five distinct groups: Chlorophyceae, Bacillariophyceae, Cyanophyceae, Dinophyceae, and Euglenophyceae.

Among these groups, Cyanophyceae emerged as the most dominant, with *Microcystis* sp. being the predominant species. This dominance of Cyanophyceae suggests a higher organic load during the dry season, potentially attributable to bird roosting activities occurring from December to January. These findings underscore the dynamic interplay between biological and environmental factors in shaping the composition and abundance of phytoplankton communities in aquatic ecosystems.

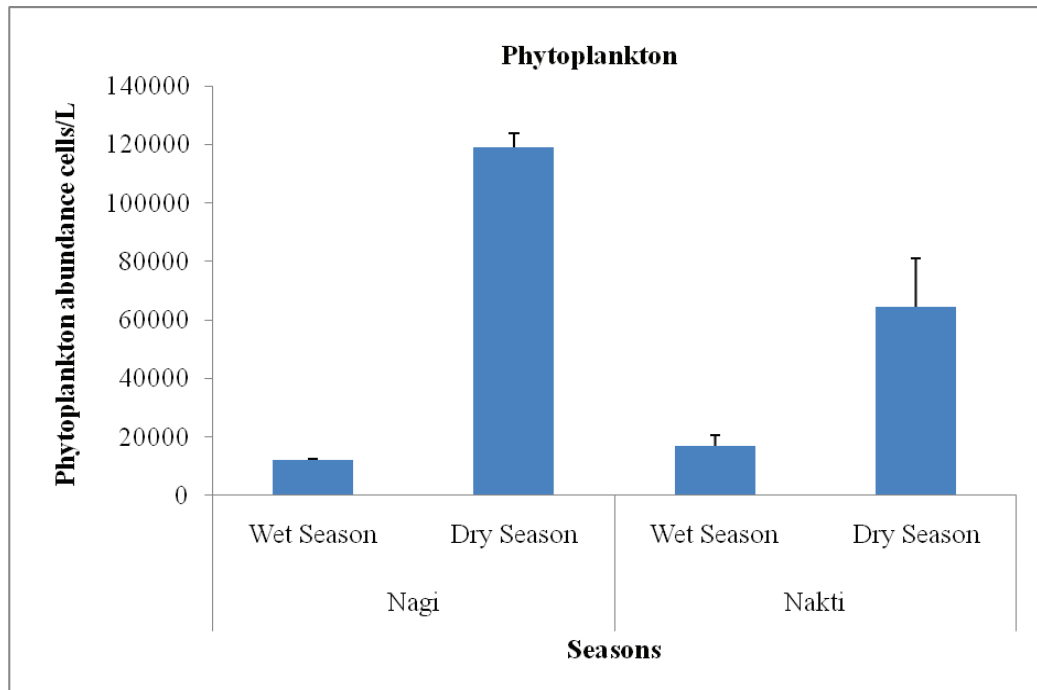


Figure 8. Seasonal variation in phytoplankton abundance in Wet season (July) and in Dry season (end of February)



Figure 9. Surface water plankton sample collection

Surface water plankton sample collection is a crucial step in studying the biological composition and ecological health of aquatic ecosystems. Before heading to the sampling site, ensure all necessary equipment is prepared and in good condition. Plankton nets,

which are typically cone-shaped nets with fine mesh designed to capture plankton. Ensure the nets are properly rinsed and free of contaminants before use. Brought sampling containers such as plastic bottles or jars with tight-fitting lids to store the collected water samples.

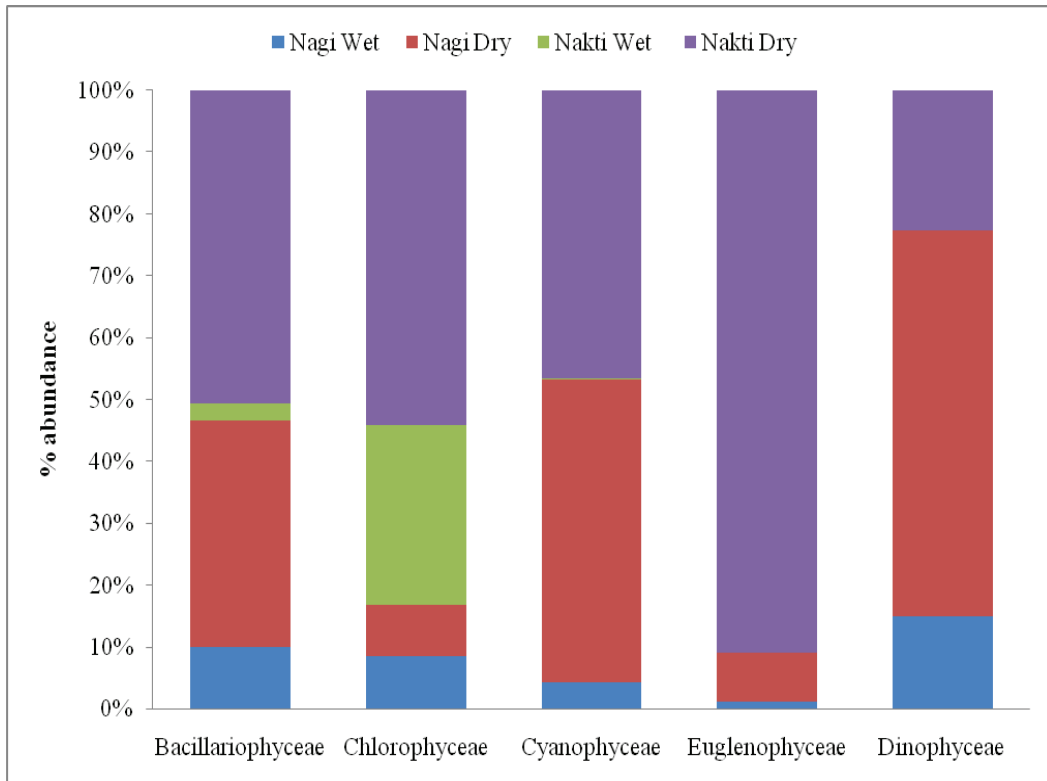
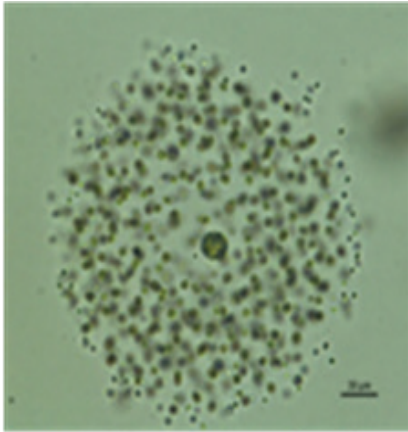
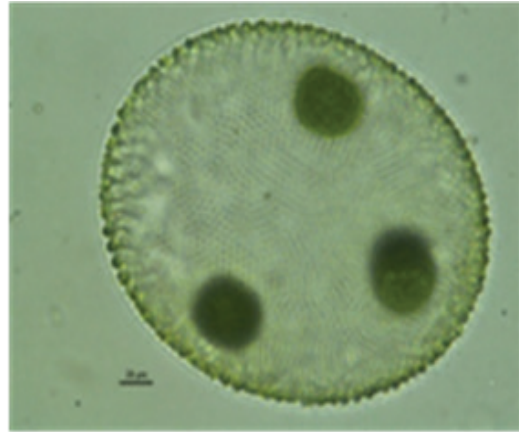


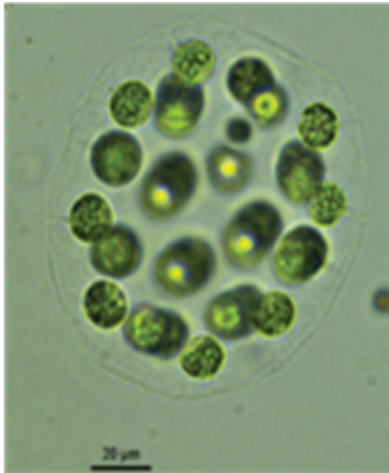
Figure 10. Group-wise phytoplankton variation in Wet season (July) and in Dry season (end of February) of both Nagi and Nakti BS



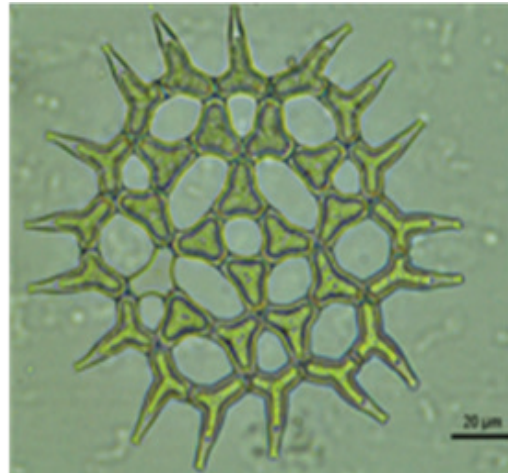
Microcystis



Volvox

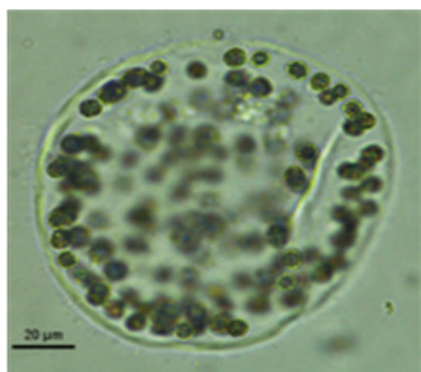


Eudorina

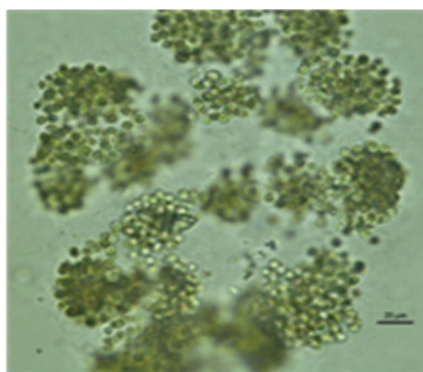


Pediatrum

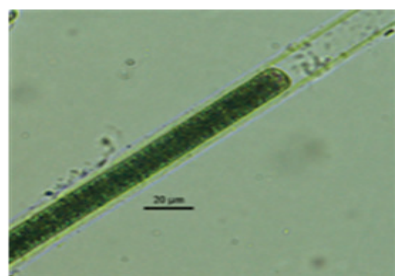
Figure 11. Some of the abundant phytoplankton in the Nagi and Nakti Bird sanctuaries. *Microcystis*: colonies of *Microcystis* sp. composed of large number of cells containing gas vesicles, *Volvox*: cells in a peripheral layer in a colony with daughter colony inside the parent colony, *Eudorina*: cells are loosely arranged in mucilage, *Pediatrum*: forms a larger coenobium with its cells arranged in circular plate



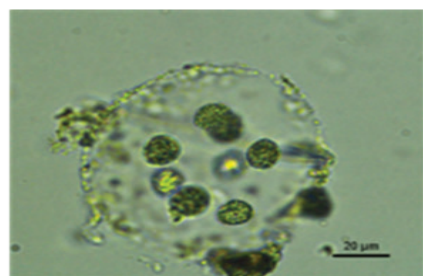
Microcystis wesenbergii



M. aeruginosa



Lyngbya sp.



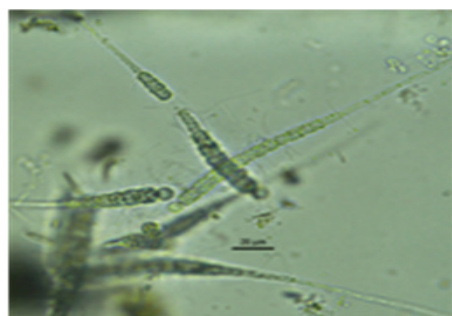
Ocystis sp.



Oedogonium sp.



Ceratium sp.



Calothrix sp.



Euglena sp.

Figure 12. Commonly found phytoplankton in the Nagi and Nakti Bird sanctuaries. *Microcystis*: colonies of *Microcystis* composed of large number of cells containing gas vesicles, *Lyngbya*: Unbranched filamentous blue green algae possess distinct sheath, *Oedogonium*: Unbranched filament with caps of cell, *Oocystis*: colonial chlorophytes with one or more chloroplast in a mother cell. *Ceratium*: contains armored plates. *Cosmarium*: two distinct symmetrical halves (semi-cells), and united together by a comparatively narrow connecting zone (isthmus), *Pinnularia*: elongated elliptical unicellular with rigid cell wall made up of silica, *Calothrix*: heterocyst at one end and tapering filaments of towards another end.

Table. 4. Phytoplankton species/taxa reported from Nagi and Nakti Bird Sanctuary

Phytoplankton	Nagi Bird sanctuary		Nakti Bird Sanctuaries	
	Wet Season	Dry Season	Wet Season	Dry Season
Bacillariophyceae				
1. <i>Cyclotella</i> sp.		+	+	
2. <i>Navicula</i> sp.	+	+	+	+
3. <i>Nitzschia</i> sp.	+	+	+	+
4. <i>Synedra</i> sp.	+	+	+	+
5. <i>Fragillaria</i> sp.	+	+	+	+
6. <i>Asterionella</i> sp.		+		
7. <i>Aulecosira</i> sp.	+	+		+
8. <i>Gomphonema</i> sp.		+		
9. <i>Cocconeis</i> sp.	+			+
10. <i>Cymbella</i> sp.	+	+		
11. <i>Achanthidium</i> sp.	+	+		
12. <i>Gyrosigma</i> sp.		+		+
13. <i>Surirellasp.</i>		+		
Chlorophyceae				
14. <i>Chlorella</i> sp.		+		+
15. <i>Pediastrum tetras</i>	+	+		+
16. <i>Pediastrum simplex</i>	+	+		+
17. <i>Pediastrum</i> sp.		+		
18. <i>Coelastrum</i> sp.	+	+	+	
19. <i>Selenastrum</i> sp.	+		+	
21. <i>Eudorina</i> sp.	+	+		+
20. <i>Pandorina</i> sp.	+	+		+
21. <i>Oocystis</i> sp.	+	+		
22. <i>Tetrastrum</i> sp.		+		
23. <i>Tetraedron</i> sp.		+		
24. <i>Scenedesmus</i>	+	+		+
25. <i>Scenedesmus quadricauda</i>	+	+		+

26.	<i>Scenedesmus bijugatus</i>		+	+	
27.	<i>Scenedesmus</i> sp.	+	+	+	+
28.	<i>Crucigenia tetrapedia</i>		+	+	
29.	<i>Crucigenia crucifera</i>	+	+		
30.	<i>Mougeotia</i> sp.	+	+		+
31.	<i>Oedogonium</i> sp.	+	+		
32.	<i>Volvox</i> sp.	+	+		+
33.	<i>Ankistrodesmus</i> sp.	+	+	+	
34.	<i>Chroococcus</i> sp.		+		
35.	<i>Staurostrum</i> sp.		+		
36.	<i>Cosmarium</i> sp.	+	+		+
37.	<i>Closterium</i> sp.		+		
Cyanophyceae					
38.	<i>Microcystis aeruginosa</i>	+	+	+	+
39.	<i>M. flosaquae</i>	+	+	+	+
40.	<i>M. wesenbergii</i>	+	+	+	+
41.	<i>Nostoc</i> sp.	+	+		+
42.	<i>Merismopedia</i> sp.		+		+
43.	<i>Pseudoanabaena</i> sp.	+	+	+	+
44.	<i>Oscillatoria</i> sp.	+	+		+
45.	<i>Anabaena</i> sp.		+		+
46.	<i>Lyngbya</i> sp.		+		
Euglenophyceae					
47.	<i>Trachelomonas</i> sp.		+		
48.	<i>Euglena</i> sp.	+	+	+	
49.	<i>Phacus</i> sp.		+		
Dinophyceae					
50.	<i>Peridinium</i> sp.		+		
51.	<i>Ceratium</i> sp.	+	+		+
Protozoa					
52.	<i>Centropyxis</i> sp.	+		+	
53.	<i>Arcellasp.</i>		+		

Note: '+' indicate presence of the species

Zooplankton

Zooplankton holds a pivotal role as a primary live food source for fish larvae, especially following the absorption of the yolk sac, within aquatic ecosystems. The survival of many small indigenous fish (SIF) in these ecosystems relies heavily on the availability of zooplankton. Scientists widely recognize that the ability of a fish population to navigate through the critical larval period with minimal mortality significantly influences the size and strength of the resulting year class. It is hypothesized that competition for food resources during this vulnerable larval stage may emerge as a significant determinant of survival and subsequent year class success.

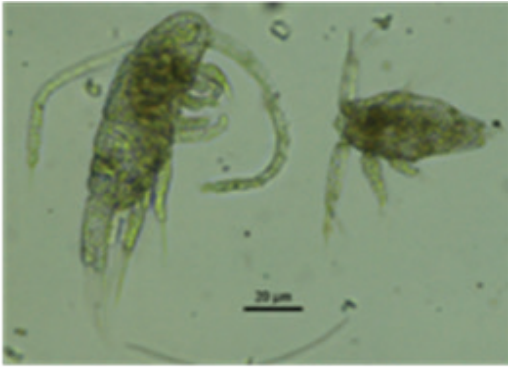
The diversity and abundance of zooplankton within the Nagi and Nakti dams were meticulously assessed using a plankton net with a mesh size of 35 μm . A comprehensive sampling approach involved filtering a total of 50 liters of water from each site along the transect to ensure maximum representation of zooplankton. The filtered zooplankton samples were carefully collected in graduated 50ml transparent bottles and promptly preserved using 5% buffered formalin to maintain their integrity for subsequent analysis.

Qualitative and quantitative assessments of zooplankton were conducted using a Sedgwick rafter cell counting chamber, complemented by reference to standard literature for species identification. The community structure of zooplankton was found to be representative of Protozoa, Rotifera, Copepoda, and Cladocera. Notably, the reproductive phase of zooplankton was observed during the month of February, likely due to favorable environmental conditions and increased food availability within the bird sanctuaries.

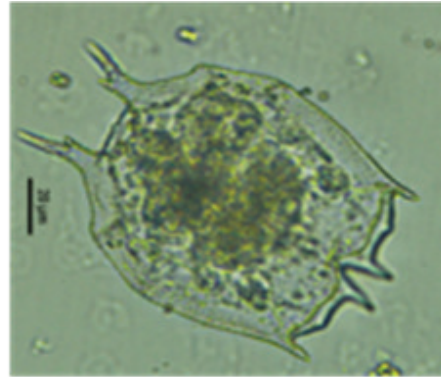
Among the 28 species and 20 genera identified as rotifers, *Brachionus*, *Lecane*, and *Keratella tropica* emerged as the most abundant genera in Nagi Bird Sanctuary. Seasonal variations in abundance were found to be significant in Nakti Bird Sanctuary but insignificant in Nagi Bird Sanctuary. In Nakti Bird Sanctuary, only 16 species of zooplankton were recorded, with dominance observed among larger-sized zooplankton such as Cladocera and Copepoda.

The mean abundance of zooplankton was recorded as 627 ± 123 individuals per liter in Nagi Bird Sanctuary and 525 ± 202 individuals per liter in Nakti Bird Sanctuary during the wet season. In contrast, during the dry season, the abundance of zooplankton increased to 876 ± 243 individuals per liter in Nagi Bird Sanctuary and 1489 ± 235 individuals per liter in Nakti Bird Sanctuary.

The observed increase in plankton abundance during winter sampling can be attributed to the input of nutrients derived from bird activity and an overall increase in primary productivity. Additionally, the relatively higher abundance of plankton in Nakti Bird Sanctuary during the dry season can be linked to its shallower depth, resulting in a wider photosynthetic zone compared to Nagi Bird Sanctuary. Overall, the abundance of zooplankton serves as an indicator of higher primary productivity in the water, reflecting the ecological health and vitality of these aquatic ecosystems.



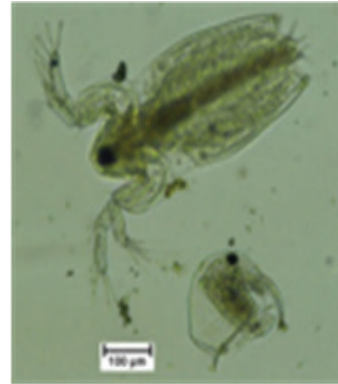
Copepod and its naupli



Brachionus



Keratella



Caldocerans

Figure 13. Some of the zooplankton which was abundant in the Nagi and Nakti Bird sanctuaries

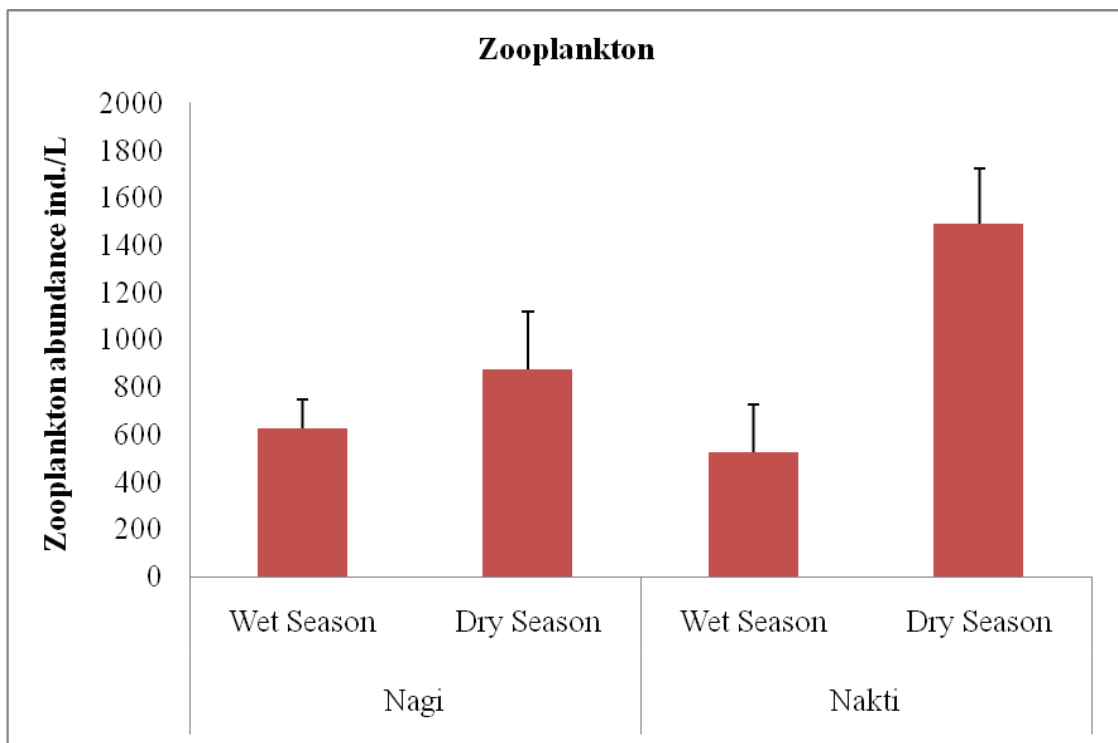
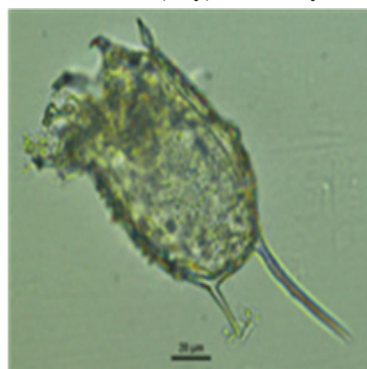


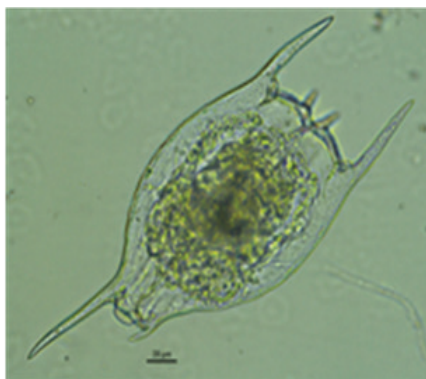
Figure 14: Seasonal variation in Zooplankton abundance in Wet season (July) and in Dry season (end of February)



Keratella cochlearis



K. tropica



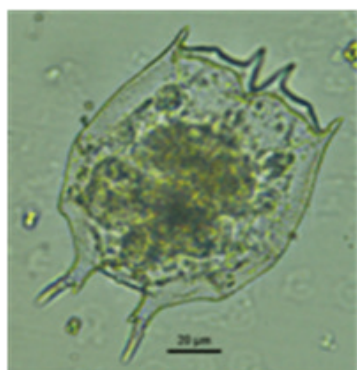
Brachionus diversicornis



B. forficula



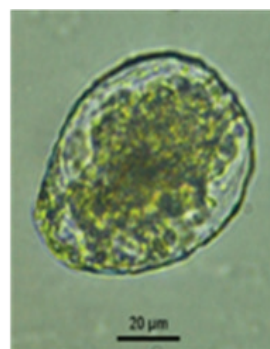
B. fulcatus



B. caudatus



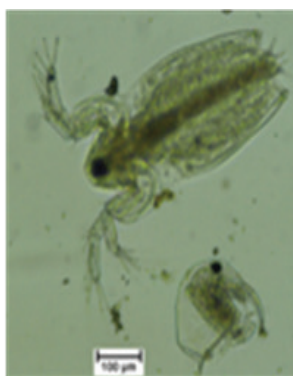
Lecane



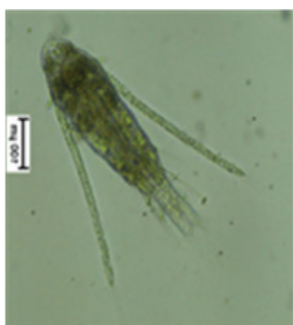
Synchaeta



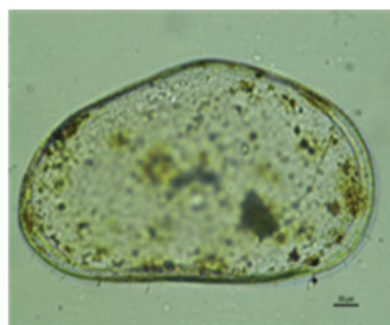
Brachionus



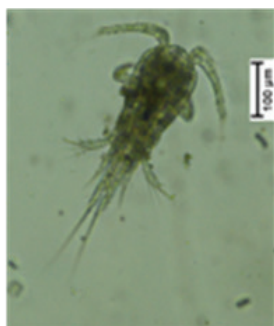
Diaphanosoma



Calanoid copepod



Ostracoda



Cyclopoid copepod



Copepod Nauplii

Figure 15. Commonly found zooplankton of Nagi and Nakti Bird sanctuaries

Table 5: Zooplankton species/taxa reported from Nagi and Nakti Bird Sanctuary

Zooplankton	Nagi BS		Nakti BS	
	Wet	Dry	Wet	Dry
<i>Keratella Cochlearis</i>	+	+		+
<i>K. tropica</i>	+	+		
<i>K. americanas</i>		+		
<i>Hexarthra</i> sp.		+	+	+
<i>Polyarthra</i> sp.		+		
<i>Brachionus caudatus</i>	+	+	+	
<i>B. calyciflorous</i>	+	+	+	
<i>B. rubens</i>	+	+	+	
<i>B. falcatus</i>	+	+	+	
<i>B. forficula</i>	+	+	+	
<i>B. diversicornis</i>	+	+	+	
<i>Synchaeta</i> sp.		+		
<i>Rotaria vulgaris</i>		+		
<i>Epiphanes clavulata</i>		+		
<i>Lacane</i> sp.		+		
<i>Cephalodella</i> sp.		+		
<i>Trichotriatetractis</i> sp.		+		
<i>Trichocerca</i> sp.		+		
<i>Horaella brehmi</i>		+		
<i>Filinia camasecta</i>		+		
<i>Bosmina</i> sp.	+			
<i>Ludbigia</i> sp.	+			+
<i>Moina</i> sp.	+			+
<i>Diaphanosoma</i> sp.	+			+
<i>Daphnia lumholtzi</i>				+
<i>Ceriodaphnia</i> sp.				+
Copepod Cyclopoid	+	+	+	+
Copepod Calanoid	+	+	+	+
nauplei	+	+	+	+

Note: ‘+’ indicate presence of the species

7. Macrophytes diversity

During the wet season, a notable increase in the proliferation of macrophytes was observed. This surge in macrophyte growth may have contributed to a decrease in plankton abundance at the onset of the wet season. These macrophytes play a crucial role as food sources for migratory birds, highlighting their ecological significance within the ecosystem.

Among the macrophytes observed, submerged species such as *Potamogeton nodosus*, *Potamogeton wrightii*, and *Potamogeton natans*, commonly known as Jheero, were found to be the most abundant, collectively constituting more than 70% of the macrophyte coverage. Other species such as *Chara*, *Najas*, and *Nymphaea* were also present, albeit to a lesser extent.

Potamogeton nodosus, characterized by its submerged, long, rooted plants with elongated leaves, exhibits a wide ecological range, from floating to submerged habitats, and from shallow to deep waters (up to 6-8 feet). It is known for its colonial nature and forms densely packed seed heads with red to reddish-brown fruit (achene), which are preferred by visiting birds according to local perceptions.

During winter sampling, a sharp decline in macrophyte coverage in the reservoirs was observed. This decline may be attributed to the congregation of migratory birds during winter, as these birds feed on the macrophytes. This observation underscores the dynamic interactions between macrophyte growth, migratory bird behavior, and ecosystem dynamics within the wetland habitat

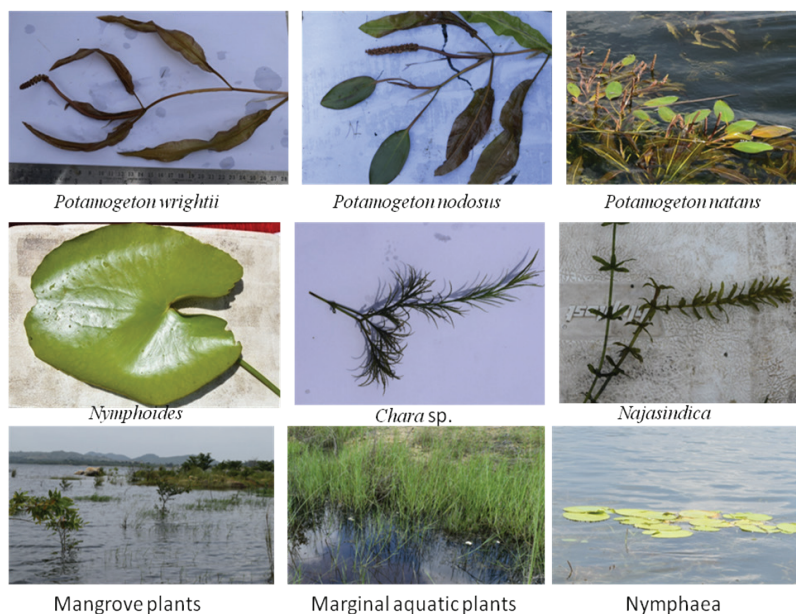


Figure 16. Commonly available macrophytes in the Nagi and Nakti Bird sanctuaries



Figure 17. Macrophyte bed: *Potamogeton wrightii* in Nagi (a) and *Potamogeton nodosus* Nakti b) Bird sanctuaries

8. Macro-invertebrate fauna

Macro-invertebrate fauna, also known as benthos, serves as an invaluable tool for bio-monitoring the health of aquatic ecosystems. Sampling techniques involved the use of a Petersen Grab to collect sediment samples from various sites within the aquatic environment. These sediment samples were then meticulously sieved through a 500 μ m sieve, and the sieved materials were carefully preserved in 4% formalin within plastic sample containers for transportation to the laboratory. In the laboratory, the organisms were sorted into groups and identified using standard literature. Additionally, molluscan samples were handpicked from the littoral zone of the bird sanctuaries.

During the winter season, only a few macro-benthos were recorded during sampling, whereas a higher concentration of benthic fauna was observed during the dry season. The study unveiled significant variations in the abundance of benthic organisms across different seasons. Eight species of macro-benthic species were identified, with the highest density recorded for *Bellamya dissimilis* and *Bellamya bengalensis* emerging as the most dominant species.

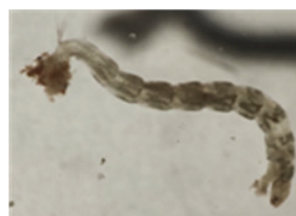
In Nagi Bird Sanctuary, the highest density of macro-benthos was recorded during the dry season (363 ± 21 ind./m²), followed by the wet season (165 ± 13 ind./m²). Conversely, in Nakti Bird Sanctuary, the abundance of macro-benthos was higher during the dry season (211 ± 7.7 ind./m²) compared to the wet season (43 ± 4.2 ind./m²). These findings underscore the dynamic nature of benthic communities and their response to seasonal variations within aquatic ecosystems.



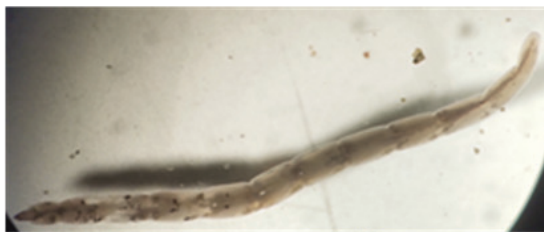
Figure 18. Collection of Benthos from littoral zone of Nagi Bird sanctuary



Thiara tuberculata



Clinotanytus sp.



Dipteran larva



Bellamya bengalensis



Indoplanorbis exustus



Lamellidens marginalis



Bellamya dissimilis



Corbicula striatella

Figure 19: Commonly available Macro-invertebrate diversity of Nagi and Nakti Bird sanctuary

9. Fish diversity

During an exploratory survey conducted in these protected habitats, a total of 29 fish and 2 prawn species were documented. Apart from the stocked species, the majority of native species were small-sized, such as *Chanda nama*, *Parambassis lala*, *Pseudambassis ranga*, *Macrognathus* spp., *Puntius* spp., *Pethia* spp., *Salmophasia* spp., *Amblypharyngodon* spp., *Rasbora* spp., and *Aplocheilichthys* spp., many of which possess ornamental value. The introduction of Tilapia fish in Nagi Bird Sanctuary through stocking has led to its proliferation and establishment of breeding populations in the reservoir.

Given the limited information available on fish diversity in these protected reservoirs, the establishment of breeding grounds for fish species signifies a significant knowledge gap among stakeholders regarding the enhancement of diversity and abundance. The relatively low recorded fish diversity may be attributed to less intensive experimental fishing, where non-destructive methods and highly selective fishing gears such as cast nets and gill nets were employed. However, the coverage of submerged macrophytes made experimental fishing challenging.

Exploratory studies on fish diversity within conserved/protected freshwater systems in India have been scarce. Previous studies in these reservoirs primarily focused on avian fauna, with only one preliminary study on ichthyofauna conducted by the University of Bhagalpur, indicating the presence of fish species in the reservoirs, primarily from the family Cyprinidae.

In the present study, total fish diversity was explored through intensive sampling during both pre-monsoon and post-monsoon periods using experimental fishing, as fishing is not permitted in the protected dams. Gillnets and cast nets were employed as fishing gears. A total of 30 fish species were recorded, with the highest taxonomic contribution from Cypriniformes (55%), followed by Anabantiformes (17%), Perciformes (14%), Synbranchiformes (7%), and Gobiiformes (3.5%).

The family-wise distribution highlights the dominance of the fish family Cyprinidae (15 species), followed by Ambassidae (4 species) and Channidae (3 species) (Figure 20). The family-wise distribution has been given in the Figure 21. It shows highest contribution of fish family Cyprinidae (15 species) followed by Ambassidae (4 species) and Channidae (3 species). The conservation status of the recorded fish species from Nagi and Nakti indicates that 3.4% of species are under the near-threatened category, 6.9% are categorized as LC-decreasing, 34.5% as LC-Stable, and 55.1% as LC-Unknown.

The conservation status of fish species recorded from Nagi and Nakti of which 3.4% species are under near threatened categories, 6.9 % species are under LC-decreasing, 34.5 % under LC-Stable and 55.1% under LC-Unknown (Figure 21).

Higher taxa diversity

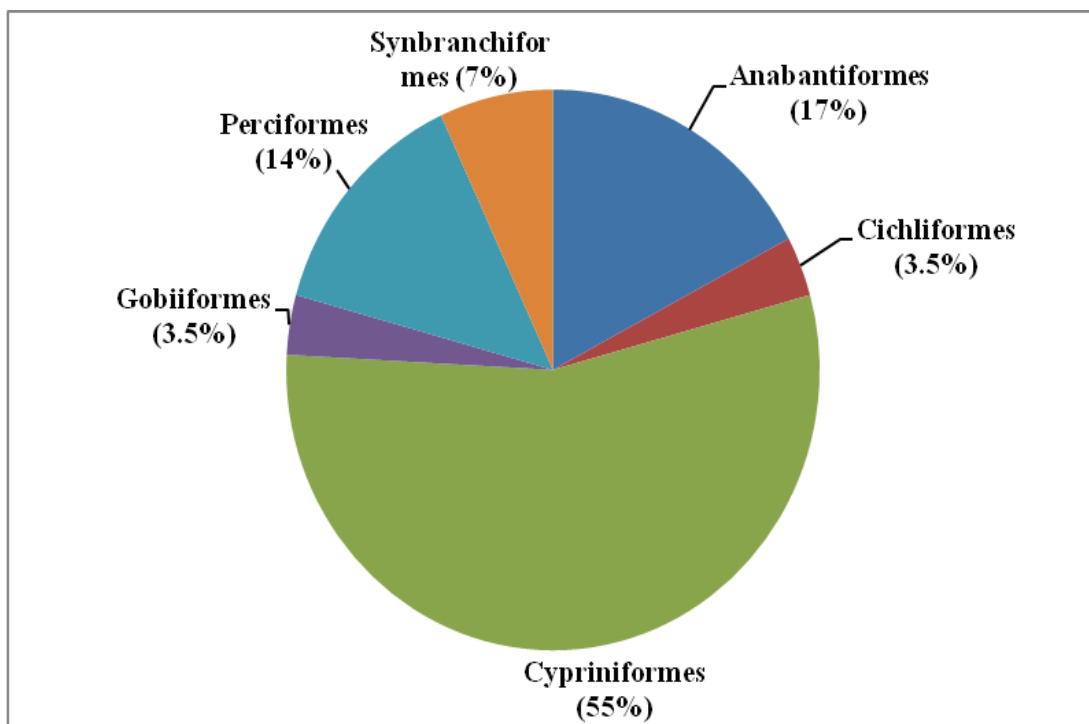


Figure 20: Higher taxonomic diversity of Nagi and Nakti Bird sanctuary

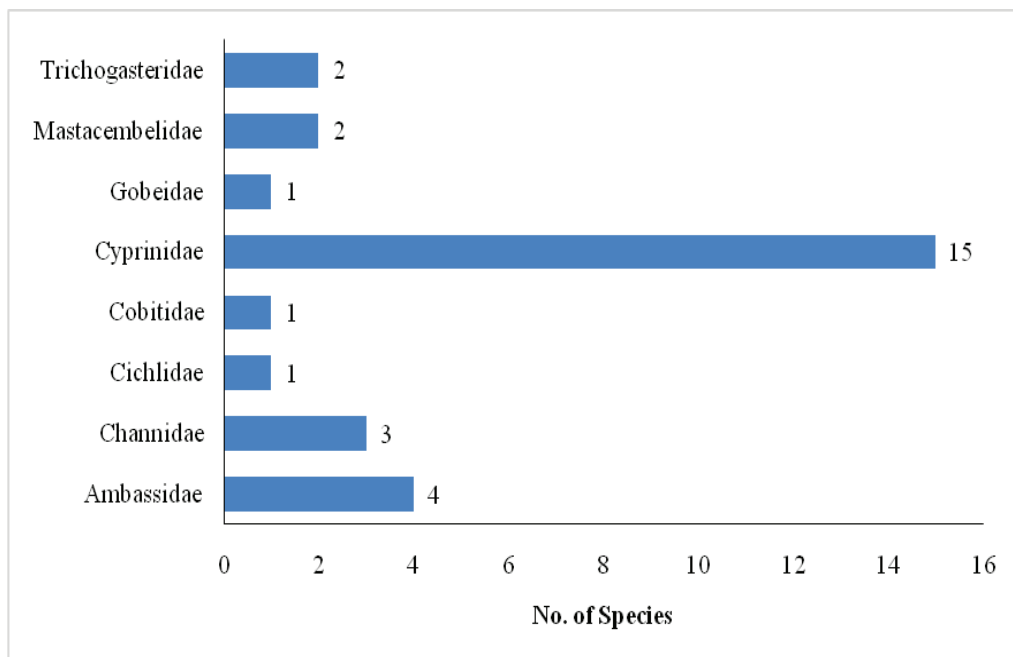


Figure 21. Family-wise distribution of fish species of Nagi and Nakti BS

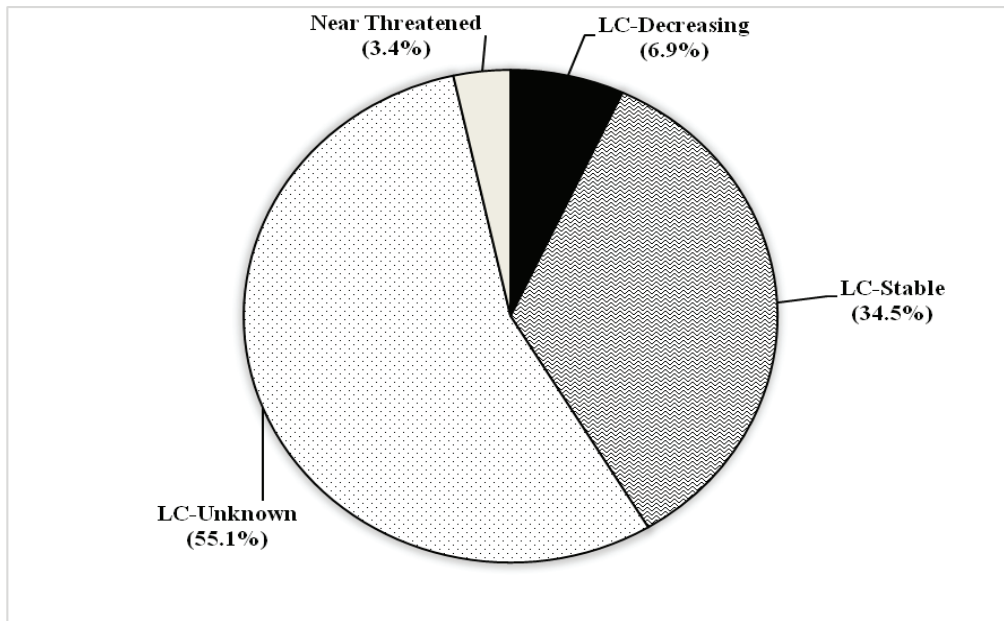


Figure 22. Percentage distribution of Conservation of status fish species of Nagi and Nakti BS

The distribution of conservation status among the recorded fish species from Nagi and Nakti Bird Sanctuaries reveals valuable insights into the overall health and vulnerability of these ecosystems. Here's an elaboration:

Near Threatened (NT) Species (3.4%):

These species are at risk of becoming threatened with extinction in the near future if the factors affecting their population decline persist. They require conservation attention to prevent further decline.

Least Concern (LC) - Decreasing (6.9%):

Species falling under this category are currently considered to be of least concern, indicating that they are not at immediate risk of extinction. However, their populations are declining, signaling potential threats to their long-term survival if not addressed.

Least Concern (LC) - Stable (34.5%):

These species are classified as least concern and exhibit stable population trends. While they are not currently facing significant threats, continued monitoring and conservation efforts are necessary to maintain their stability.

Least Concern (LC) - Unknown (55.1%):

The majority of recorded species fall under this category, indicating that their conservation status is currently unknown. More research and data collection are required to assess their population trends and conservation needs accurately.

The distribution of conservation status underscores the importance of ongoing monitoring and conservation efforts to safeguard the biodiversity of Nagi and Nakti Bird Sanctuaries. By addressing threats to vulnerable species and preserving their habitats, conservationists can work towards ensuring the long-term sustainability and resilience of these aquatic ecosystems.



Gill netting



Cast netting

Figure 23. Experimental fishing at Twin Bird sanctuary (Nagi and Nakti)





Figure 24: Collection of fish for diversity and abundance study from Experimental fishing with Gill net



Cast net



Gill net

Figure 25: Challenges in experimental fishing using different gears

Protected areas are the principal mechanism of conservation of biodiversity on Earth and serves as the most important units for in-situ biodiversity conservation. On these principle and previous report of Nagi and Nakti Bird Sanctuary reported 36 species of fish as per leaflet Protected areas play a pivotal role as the cornerstone of biodiversity conservation efforts worldwide, serving as crucial sanctuaries for preserving the planet's rich array of life forms. They represent the most significant units for in-situ biodiversity conservation, providing safe havens where flora and fauna can thrive undisturbed by human activities.

Building upon this principle, previous reports from Nagi and Nakti Bird Sanctuary, as documented by the leaflet received from the Jamui Forest Division, Jamui, reported a total of 36 fish species. With these twin bird sanctuaries being subject to limited human interventions and designated as no-fishing zones, there was an expectation of encountering even greater fish diversity within their protected habitats.

During an exploratory survey conducted within these protected areas, a total of 30 fish species and 2 prawn species were documented. Apart from the stocked species, the majority of native species observed were small-sized, including *Chanda nama*, *Parambassis lala*, *Pseudambassis ranga*, *Macrognathus* spp., *Puntius* spp., *Pethia* spp., *Salmophasia* spp., *Amblypharyngodon* spp., *Rasbora* spp., *Aplocheilus* spp., among others. Notably, many of these species hold ornamental value, contributing to their ecological significance.

Furthermore, the introduction of Tilapia fish into the Nagi reservoir through stocking has led to its proliferation and establishment of breeding populations within the sanctuary. This highlights the dynamic interactions between introduced and native species within these protected ecosystems, underscoring the need for monitoring and management to maintain ecological balance and preserve biodiversity.

Addressing the proliferation of Tilapia in Nagi Bird Sanctuary requires careful management strategies, including monitoring and control measures to mitigate their impact on native biodiversity. This may involve implementing measures to control Tilapia populations, restoring habitat for native species, and raising awareness among stakeholders about the importance of preserving biodiversity in the sanctuary.



Figure 26. Proliferation of Tilapia in Nagi Bird sanctuary

The size of Tilapia breeding populations can vary depending on various factors such as habitat conditions, availability of food resources, and reproductive behavior of the species. Typically, Tilapia reach sexual maturity at around 6 to 9 months of age, depending on the species and environmental conditions. Once mature, Tilapia can breed throughout the year under suitable conditions, with females capable of producing hundreds to thousands of eggs in a single spawning event.

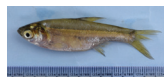
IMPORTANT CARPS & BARBS (Family :Cyprinidae)



Labeo rohita
(Rohu)



Cirrhinus mrigala
(Mrigal)



Amblypharyngodon mola
(Mola carplet)



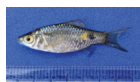
Crossoscheilus latius
(stone roller/ Gangetic latia)



Osteobrama cotio
(Cotio/ Diamond Barb)



Pethia ticto
(Two-spot barb)



Pethia conchonius
(Rosy Barb)



Puntius sophore
(Pool barb)



Salmostoma bacaila
(Large razorbelly minnow)



Salmostoma phulo
(Finescale razorbelly minnow)



Opsarius barna



Esomus danricus
(The Indian flying barb)



Rasbora rasbora
(Gangetic scissortail barb)



Rasbora daniconius
(Black-line rasbora)



Securicola gora
(Gora chela)

MURRELS (Family: Channidae)



Channa punctata- Male and female
(Spotted murrel)



Channa gachua
(The dwarf snakehead)



Channa marulius
(The Great snakehead)

SPINY EELS (Family: Mastacembelidae)



Mastacembelus armatus
(The zig-zag eel)



Macrogynathus pancalus
(Barred spiny eel/ Striped Spinyeel)

GOURAMIES (Family: Osphronemidae)



Trichogaster fasciata
(Blue striped gourami)



Trichogaster lalia
(Red striped gourami)

GLASSY PERCHLETS



Chanda nama
(Elongate glassy perchlet)



Parambassis ranga
(Indian Glassy Fish)

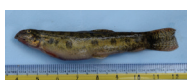


Parambassis baculis
(Himalayan Glassy Perchlet)



Parambassis lala
(Highfin Glassy Perchlet)

OTHER INDIGENOUS FISHES



Lepidocephalichthys guntea
(Guntea loach)



Glossogobius giuris
(Tank Goby)

Exotic Fishes



Oreochromis niloticus (The Nile Tilapia)- adult and juvenile fishes



The exploratory survey done in July 2021 in Nagi and Nakti reservoirs by ICAR-CIFRI recorded 29 species of fishes. The diversity list is not complete as more species are expected to be recorded in subsequent explorations.

The exotic species, *O. niloticus*, the Nile Tilapia has established in both Nagi and Nakti reservoirs and there exists a breeding population, indicated by the abundance of juveniles of this species.

Figure 27. Fish species recorded in Nagi and Nakti Bird sanctuaries

Table 6. IUCN (International Union for Conservation of Nature) conservation status and population trend of Fish species, Nagi and Nakti BS

Species	IUCN Status	Population trend
<i>Amblypharyngodon mola</i>	Least Concern (LC)	Stable
<i>Chanda nama</i>	Least Concern (LC)	Decreasing
<i>Channa gachua</i>	Least Concern (LC)	Decreasing
<i>Channa punctata</i>	Least Concern (LC)	Stable
<i>Channa striata</i>	Least Concern (LC)	Stable
<i>Cirrhinus mrigala</i>	Least Concern (LC)	Stable
<i>Esomus danricus</i>	Least Concern (LC)	Unknown
<i>Glossogobius giuris</i>	Least Concern (LC)	Unknown
<i>Lepidocephalichthys guntea</i>	Least Concern (LC)	Stable
<i>Macrognaathus pancalus</i>	Least Concern (LC)	Unknown
<i>Mastacembelus armatus</i>	Least Concern (LC)	Stable
<i>Parambassis lala</i>	Near Threatened	Decreasing
<i>Parambassis baculis</i>	Least Concern (LC)	Decreasing
<i>Parambassis ranga</i>	Least Concern (LC)	Stable
<i>Pethia conchonius</i>	Least Concern (LC)	Unknown
<i>Pethia ticto</i>	Least Concern (LC)	Unknown
<i>Puntius chola</i>	Least Concern (LC)	Unknown
<i>Puntius sophore</i>	Least Concern (LC)	Unknown
<i>Rasbora daniconius</i>	Least Concern (LC)	Unknown
<i>Salmostoma bacaila</i>	Least Concern (LC)	Stable
<i>Securicola gora</i>	Least Concern (LC)	Unknown
<i>Salmostoma phulo</i>	Least Concern (LC)	Unknown
<i>Tariqilabeo latius</i>	Least Concern (LC)	Unknown
<i>Trichogaster fasciata</i>	Least Concern (LC)	Unknown
<i>Trichogaster lalius</i>	Least Concern (LC)	Unknown
<i>Opsarius barna</i>	Least Concern (LC)	Decreasing
<i>Oreochromis niloticus</i>	Least Concern (LC)	Stable
<i>Osteobrama cotio</i>	Least Concern (LC)	Decreasing
<i>Rasbora rasbora</i>	Least Concern (LC)	Unknown

10. Ecosystem services

Designated protected area is to an effort to conserve the biodiversity, its environment and provide associated recreational, economic and social benefits to humane. Bird sanctuaries play a crucial role in providing ecosystem services that benefit both humans and the environment.

- **Provisioning Services:** These include directly usable natural products from birds, such as food, clothing, tools, and ornamentation. For instance, bird parts may be used for various purposes.
- **Regulating Services:** Birds contribute to pollination, pest control, and seed dispersal. Their activities help maintain ecological balance and enhance agricultural ecosystems.
- **Supporting Services:** Birds play a vital role in processes like pollination, seed dispersal, water purification, and nutrient cycling. These services are essential for ecological communities and agricultural systems.
- **Cultural Services:** Birds offer recreational opportunities through activities like birdwatching and hunting. They also inspire art, music, and religious customs.

Conserving bird populations not only sustains avian biodiversity but also ensures the continuity of these valuable ecosystem services, contributing to human well-being. The success of protected area is depending on the management tools and understanding the values of that they contain. The ecosystem services are provided by these twin sanctuaries for human wellbeing:

1. Irrigation and cattle farming:

Nagi Dam was constructed primarily to irrigate approximately 9,850 acres of land in the region. During the rainy season, a sufficient quantity of water accumulates in the reservoirs created by Nagi Dam. This stored water is later utilized for irrigation through a canal network that runs downstream from the dam. The land on which these waterbodies are located belongs to the Irrigation Department. However, since the sanctuaries have been notified and wildlife falls under the jurisdiction of the Forest Department, legal matters arise. The human settlements surrounding Nagi and Nakti bird sanctuaries rely on the water stored in the Nagi and Nakti reservoirs for agricultural purposes.

Local farmers divert water from the reservoirs through canal networks to their fields, ensuring the growth of crops like rice, wheat, and vegetables. Cattle farming is prevalent in the peripheral regions of the bird sanctuary. The lush grasses in the sanctuary's vicinity serve as a natural feed source for cattle. Cattle owners allow their animals to graze on these grasslands, benefiting from the nutrient-rich vegetation. The rocky terrain and open spaces around the dams provide ample grazing areas for the cattle. Local farmers often bring their cattle to the dam areas for washing and cattle drinking. The clear water surface of both Nagi and Nakti Dams makes them suitable for this purpose. The rocky hillocks surrounding the dams create a natural environment where cattle can access water without disturbing the ecosystem significantly.



Figure 28. Showing Cattle grazing, drinking and bathing at Nakti Dam

2. Diverse array of avian life thrives

The Nagi-Nakti Bird Sanctuaries, situated in Bihar, India, serve as a haven for both indigenous and migratory bird species. During the winter months, these sanctuaries witness an influx of migratory birds from various regions, including Eurasia, Central Asia, the Arctic Circle, Russia, and Northern China. Over 136 species of birds have been recorded within the sanctuary's boundaries, making it a hotspot for ornithologists and bird enthusiasts. Among the remarkable inhabitants of Nagi-Nakti, the bar-headed geese stand out. Approximately 1,600 bar-headed geese (representing about 3% of the global population of this species) choose this sanctuary as their winter refuge.

This phenomenon has garnered international attention, leading Birdlife International to recognize Nagi Dam Bird Sanctuary as an Important Bird Area for conservation efforts. The Wetlands International report highlights the sanctuary's ecological importance. Beyond its role in supporting bird populations, Nagi-Nakti contributes to ecosystem services that benefit both wildlife and local communities. These services include groundwater recharge, habitat preservation, and water availability for irrigation.

The Forest Department actively manages the sanctuary to enhance its ecological value. Afforestation, creation of islands within the wetland, and the establishment of facilities like walking trails, ecohuts, benches, and watchtowers encourage responsible tourism. By protecting Nagi-Nakti, we safeguard not only its avian residents but also the delicate balance of nature.



Figure 29. A flock of birds was observed at Nakti dam during February

3. Tourism and education

Nagi and Nakti Dam is one of the tourist destination sites for locals and kids. Nagi and Nakti Bird sanctuary is very pleasant place to have serene beauty for nature lover. The bird sanctuaries are open for visitors with certain restrictions. Bird Fest: Bihar hosted its first bird fest at Nagi-Nakti, celebrating the avian diversity in the region. There is Bird Interpretation Centre, where visitors can learn about the sanctuary's bird species, their behavior, and conservation efforts.

Environmental education among villagers and students is crucial to highlight the importance of wildlife, especially birds, in the Nagi-Nakti region. Educating local communities and students about wildlife conservation is crucial. Initiatives to raise awareness about the importance of maintaining a healthy ecosystem was taken by Nagi and Nakti Forest department. Educating villagers about sustainable practices ensures that human activities coexist harmoniously with the sanctuary's bird population.



Figure 30. Visitors watching bird at Nagi Bird sanctuary

4. Irrigation of surrounding forest plantation and agriculture crops

Jamui district, nestled in the southern expanse of Bihar, boasts a distinctive geographical and geological profile. Its landscape is defined by undulating terrain, complemented by encircling hill ranges and swathes of lush forest cover interspersed with vast alluvial plains. This diverse geological makeup profoundly shapes the district's land utilization patterns, agricultural endeavors, and the development of water resources. With a total area spanning 147.5 square kilometers, Jamui encompasses a mosaic of 9 villages.

The cropping pattern in the Ngai and Naki Bird Sanctuary is carefully curated to provide nesting sites, food sources, and shelter for the myriad bird species that inhabit the region. Cultivation practices prioritize indigenous crops known to attract and support avian populations, including varieties of grains, pulses, and fruits. Additionally, agroforestry techniques are employed to integrate tree species that offer nesting sites and serve as perches for birds, further enhancing the sanctuary's ecological resilience.



Figure 31. Irrigation forest area under the protected habitat

11. Stakeholder's meeting

Gathering with fisheries stakeholders is a crucial step in shaping sustainable aquatic resource management and ensuring the conservation of avian habitats. These collaborative meetings bring together key participants, including government agencies, local communities, scientists, fisheries experts, and representatives from forest conservation authorities. By fostering dialogue and cooperation, these engagements serve as a platform for exchanging valuable insights, discussing policies, and developing effective strategies for responsible fisheries management, ecosystem preservation, and bird conservation.

During a this stakeholder meeting, District Fisheries Officers (Jamui), Fisheries Extension Officers, scientists, fish farmers, and members of local communities came together to discuss pressing challenges and explore viable solutions. The discussions centered on responsible fish stocking practices, protecting aquatic ecosystems, and implementing measures to safeguard both indigenous and migratory birds that rely on these habitats. Such inclusive interactions enhance decision-making and pave the way for holistic conservation efforts.

The Vital Role of Bird Sanctuaries in Biodiversity Conservation

Bird sanctuaries, also known as Important Bird and Biodiversity Areas (IBAs), play a critical role in providing safe havens for avian species. These protected areas not only support diverse bird populations but also contribute significantly to broader ecosystem health and human well-being. By maintaining ecological balance, bird sanctuaries help sustain fisheries, regulate local climates, and support tourism and livelihoods.

The survival and flourishing of bird sanctuaries depend on collective stakeholder action. When government bodies, researchers, conservationists, and local communities unite, they bring together a wealth of expertise, resources, and passion. Such collaborations are essential for implementing sustainable practices, mitigating environmental threats, and ensuring long-term conservation success.

We discussed by working together, can safeguard our aquatic ecosystems, protect avian species, and preserve natural resources for future generations. These efforts reinforce the interdependence between aquatic and terrestrial ecosystems, highlighting the importance of integrated conservation approaches. Let us continue to engage, collaborate, and act responsibly to ensure that our feathered friends and the delicate environments they inhabit thrive for years to come.



Figure 32. Stakeholder's meeting before initiating sampling



Figure 33. Meeting with Forest department personnel and fisher's instruction is given before fish sample collection

12. Challenges in twin Bird sanctuaries

The Nagi Dam and Nakti Dam Bird Sanctuaries are closely located and share a common ecological habitat. These twin sanctuaries are vital conservation sites, offering a safe refuge for a diverse range of bird species. They serve as significant attractions for nature lovers, birdwatchers, and researchers. During winter, the sanctuaries witness an influx of migratory birds from regions such as Eurasia, Central Asia, the Arctic Circle, Russia, and Northern China. These migratory birds, alongside native avian species, rely on the protected waters and surrounding ecosystems for sustenance and breeding. The sanctuaries play a crucial role in maintaining avian biodiversity and ensuring the survival of endangered and vulnerable species.

Awareness and Conservation Challenges

A major hurdle in effective bird conservation is the lack of awareness among local communities and visitors regarding the importance of protective measures. Many people are unaware of the threats birds face, such as habitat disturbance, pollution, and climate change. Educating local communities, fishers, and tourists about the significance of these sanctuaries is essential for fostering a culture of conservation and responsible tourism.

Fishing Prohibition and Its Impact

To minimize human disturbance and protect the fragile avian ecosystem, all fishing activities are strictly prohibited within Nagi and Nakti Bird Sanctuaries. This regulation helps maintain the sanctuaries as undisturbed breeding and foraging grounds for birds. However, this restriction has also affected the livelihoods of local fishers who previously depended on the water bodies for sustenance. Alternative livelihood programs and compensation measures need to be explored to balance conservation efforts with socio-economic well-being.

Stakeholder Inclusiveness and Conflicts

A lack of inclusive participation among all relevant stakeholders—such as government agencies, local fishers, conservationists, and forest officials—has led to conflicts and inefficiencies in managing the sanctuaries. Effective conservation demands collaborative decision-making where all voices, including those of local communities, are heard and integrated into management policies. Promoting stakeholder dialogues and participatory governance can help in resolving conflicts and ensuring smooth operations.

Agricultural Runoff and Water Pollution

Agricultural runoff from surrounding farmlands introduces pesticides, fertilizers, and other chemicals into the sanctuary waters. This non-point source pollution leads to nutrient overloading, which can cause algal blooms, oxygen depletion, and habitat degradation. These changes negatively impact aquatic life and the overall health of the sanctuary ecosystem. Promoting eco-friendly farming practices, buffer zones, and sustainable watershed management are critical steps to mitigate this issue.

Land Dispute Between Irrigation and Forest Departments

An ongoing land dispute between the Irrigation and Forest Departments has created significant administrative roadblocks. The disagreement over jurisdiction and management responsibilities hampers the effective protection and development of the sanctuaries. Without a clear resolution, necessary conservation actions such as habitat restoration, boundary demarcation, and infrastructure development remain stalled. Legal and policy interventions are required to settle the dispute and establish a unified management framework.

Lack of Awareness About Bird Feeding Habits

A general lack of knowledge regarding the feeding preferences and dietary needs of birds poses challenges in maintaining a thriving avian population. Many visitors and local communities unknowingly disturb birds by feeding them unsuitable food items or failing to protect their natural foraging habitats. Raising awareness through educational programs, signage, and guided tours can help in preserving natural feeding behaviors and reducing human interference.

Stocking of Undesirable Fish Species

Due to limited awareness of sustainable fish stocking practices, undesirable or invasive fish species are sometimes introduced into the sanctuary waters. These species can compete with native fish, alter the food chain, and impact the ecological balance. Implementing scientific stocking guidelines, training programs, and monitoring systems will help in maintaining a healthy aquatic ecosystem that supports both fish biodiversity and avian life.

Decline in Indigenous Fish Diversity

Over the years, the diversity of indigenous fish species in Nagi and Nakti Dams has declined, as per past ecological records. Several factors contribute to this decline, including habitat degradation, pollution, climate change, and competition from introduced species. The loss of native fish species affects the sanctuary's ecological stability and food availability for birds. Restoring indigenous fish populations through conservation breeding, habitat enrichment, and water quality improvement is essential for long-term biodiversity conservation.

Reduction in Water Spread Area During Summer

During the summer months, the water spread area within the sanctuaries shrinks due to seasonal evaporation, reduced inflows, and possible water extraction for irrigation. This reduction affects both aquatic life and bird populations, as limited water availability constrains feeding and nesting opportunities. Developing water conservation strategies, such as controlled water release schedules, afforestation, and wetland restoration, can help sustain water levels throughout the year.

13. Recommendations

1. Strengthening Awareness and Conservation Efforts

Challenge: Lack of awareness regarding bird conservation and sanctuary protection.

Recommendations:

- **Community Awareness Programs:** Conduct regular workshops, nature camps, and birdwatching excursions for locals, students, and visitors to educate them about conservation.
- **Informational Signage:** Install bilingual signboards highlighting key bird species, do's and don'ts, and the importance of sanctuary preservation.
- **Eco-tourism Guidelines:** Develop and enforce responsible eco-tourism practices to minimize human disturbances.
- **School and College Engagement:** Include sanctuary visits in academic curriculums to foster environmental responsibility among students.

2. Sustainable Livelihood Alternatives for Fisher Communities

Challenge: Fishing prohibition impacts local fisher livelihoods.

Recommendations:

- **Alternative Livelihood Programs:** Introduce skill development programs for fishers in eco-tourism, handicrafts, and sustainable aquaculture outside the sanctuary.
- **Compensation and Support Schemes:** Implement government subsidies or compensation to fishers affected by the ban.
- **Sustainable Fish Farming Zones:** Identify areas outside the sanctuary for community-based fish farming, ensuring both conservation and livelihood support.

3. Enhancing Stakeholder Engagement and Conflict Resolution

Challenge: Lack of inclusiveness among all stakeholders, leading to conflicts.

Recommendations:

- **Multi-Stakeholder Committees:** Establish joint working groups involving fisheries, forest, irrigation, and local representatives to ensure inclusive decision-making.
- **Regular Consultations:** Conduct quarterly stakeholder meetings to resolve conflicts, discuss new policies, and encourage collaborative management.

- **Participatory Conservation Initiatives:** Implement community-based conservation programs where locals actively participate in bird monitoring and habitat restoration.

4. Addressing Agricultural Runoff and Water Pollution

Challenge: Chemical runoff from nearby agricultural fields pollutes sanctuary waters.

Recommendations:

- **Buffer Zone Plantations:** Establish vegetative buffer strips (grasses and trees) around the reservoirs to filter pollutants before they reach the water.
- **Organic Farming Promotion:** Encourage farmers to adopt organic or low-chemical farming practices through incentives and training.
- **Regulated Fertilizer Use:** Introduce soil testing-based fertilizer application guidelines to minimize excess chemical runoff.
- **Water Quality Monitoring:** Set up a regular water quality testing mechanism to track pollution levels and take preventive actions.

5. Resolving Land Disputes Between Irrigation and Forest Departments

Challenge: Unresolved land ownership issues hinder sanctuary management.

Recommendations:

- **Legal Mediation:** Seek state government or judicial intervention for a clear legal resolution on land ownership and management authority.
- **Unified Management Plan:** Develop an integrated sanctuary management plan with cooperation from both departments to prevent administrative conflicts.
- **Jurisdiction Clarity:** Clearly define and demarcate sanctuary boundaries to avoid future disputes.

6. Improving Knowledge on Bird Feeding Habits

Challenge: Lack of awareness regarding birds' natural diets.

Recommendations:

- **Research-Based Feeding Programs:** Conduct scientific studies to understand birds' dietary needs and avoid food shortages.
- **Public Education Campaigns:** Disseminate information through brochures, workshops, and digital platforms about what should and shouldn't be fed to birds.

- **Habitat Restoration for Natural Food Sources:** Preserve and reintroduce native plant species that provide seeds, insects, and other food sources for birds.

7. Sustainable Fish Stocking Practices

Challenge: Introduction of undesirable fish species due to a lack of awareness.

Recommendations:

- **Stocking Guidelines:** Develop and enforce scientific fish stocking policies that prioritize indigenous species over invasive ones.
- **Regular Fish Population Surveys:** Conduct annual biodiversity assessments to monitor fish diversity and take corrective actions if necessary.
- **Training for Fisheries Staff:** Provide capacity-building programs for fisheries officers and fish farmers on sustainable stocking and species selection.

8. Restoring Indigenous Fish Diversity

Challenge: Declining native fish populations.

Recommendations:

- **Native Fish Breeding Programs:** Set up hatcheries or breeding programs for important indigenous fish species.
- **Habitat Conservation Measures:** Improve water quality and aquatic vegetation to support fish reproduction and survival.
- **Catchment Area Protection:** Implement watershed conservation strategies to maintain healthy aquatic ecosystems.

9. Water Conservation Strategies to Maintain Water Spread Area in Summer

Challenge: Shrinking water spread during summer affects bird and fish populations.

Recommendations:

- **Rainwater Harvesting:** Promote check dams, percolation tanks, and wetland restoration to store and regulate water.
- **Irrigation Management:** Implement controlled water release policies to prevent excessive water withdrawals from the reservoirs.
- **Desilting and Deepening Initiatives:** Remove accumulated silt and sediments to increase water retention capacity.
- **Afforestation and Riparian Vegetation:** Plant drought-resistant trees and native vegetation along the reservoir's edge to reduce evaporation and soil erosion.

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Assessing ecosystem health and governance challenges in Nagi and Nakti Ramsar sites: developing a framework for sustainable conservation

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Abstract This study evaluates the ecological health and governance challenges of Nagi and Nakti Ramsar sites in Bihar, India, recently designated Ramsar Sites, to inform a framework for sustainable conservation. Seasonal assessments of water and soil quality revealed significant physicochemical fluctuations, particularly during the dry season, marked by reduced depth, increased mineralization, and nutrient accumulation. Two-way ANOVA indicated that water parameters such as pH, temperature, dissolved oxygen, total alkalinity, and Secchi depth varied significantly across seasons, sanctuary type, and their interaction. Soil organic carbon and phosphorus also showed seasonal shifts, influencing nutrient cycling and habitat fertility. Plankton dynamics were strongly linked to phosphorus levels, supporting the growth of Bacillariophyceae and Chlorophyceae. Zooplankton composition differed between sites, with rotifers dominant in Nagi and cladocerans in Nakti. Thirty fish species

were documented, mainly omnivores and insectivores, with Cyprinidae as the most abundant family. While the presence of diverse biota reflects ecological richness, emerging stressors such as nutrient loading and invasive species are evident. Notably, tilapia stocking poses a serious threat to native small indigenous fishes (SIFs) through competition and habitat disruption. Governance analysis revealed overlapping jurisdictional control between the Forest and Irrigation Departments, weak community involvement, and inadequate regulation of tourism activities. To address these issues, a polycentric, participatory governance model is proposed, integrating ecological monitoring, local livelihoods, and conflict resolution. The study highlights the urgency of adaptive, inclusive management to balance biodiversity conservation with socio-economic sustainability, offering a replicable model for freshwater protected areas in South Asia.

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COI Gene-Based-Molecular Identification of Invasive *Craspedacusta sowerbii* Lankester, 1880 (Hydrozoa, Limnomedusa) Freshwater Jellyfish in Arga-Parvati Wetlands, Gonda District, Uttar Pradesh

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ICHTHYOFAUNAL DIVERSITY OF RIVER KULIK AND NAGAR, TWO CONNECTED TRANSBOUNDARY RIVERS BETWEEN INDIA AND BANGLADESH

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The transboundary rivers of North Bengal, including the Kulik and Nagar rivers, play a vital role in supporting regional freshwater biodiversity and sustaining local livelihoods. However, these rivers face escalating threats from anthropogenic activities and environmental changes. This study provides a comprehensive assessment of ichthyofaunal diversity in the Kulik and Nagar rivers, both part of the Mahananda River Basin, using year-round field surveys conducted in 2022. A total of 81 fish species belonging to 32 families were documented, with 72 species common to both rivers, indicating high similarity in species composition. The Cyprinidae family dominated both rivers, followed by Danionidae and Bagridae. Three exotic species and several species of conservation concern were recorded, including one Endangered, two Vulnerable, and five Near Threatened species as per IUCN status. Diversity indices and Bray-Curtis similarity analyses revealed largely comparable alpha and beta diversity patterns between the rivers. Taxonomic distinctness indices further supported stable and balanced community structures. The presence of rare, endemic, and habitat-sensitive taxa underscores the ecological significance of these rivers. Given the increasing anthropogenic pressures and the ecological value of these systems, the study highlights the urgent need for cross-border conservation strategies and sustainable riverine biodiversity management.

Keywords Biodiversity conservation, Freshwater fish, Ichthyofaunal diversity, Kulik River, Nagar River, Transboundary rivers

Introduction

The rivers of North Bengal, including several transboundary watercourses, play a critical role in maintaining the ecological balance of the region and supporting a rich diversity of aquatic life. (Das, 2024) These rivers serve not only as key habitats for numerous freshwater species but also as vital resources for agriculture, fisheries, and livelihoods. However, increasing anthropogenic pressures such as habitat degradation, pollution, and the impacts of climate change are severely threatening biodiversity and ecological functions of rivers of

West Bengal (Chakraborty and Chakraborty, 2021).

Transboundary rivers, defined as rivers that cross at least one political boundary, are particularly significant in the context of regional water management and biodiversity conservation. India and Bangladesh share 54 rivers, along with numerous rivulets and small river networks, with India contributing the majority of rivers that flow into Bangladesh and eventually into the Bay of Bengal (Rudra *et al*, 2018). Among these, the Kulik and Nagar rivers, which form part of the larger Mahananda River Basin, represent two

Strategies for Fisheries Development of Kharagpur Lake

AM Sajina, S Kumari, Y Ali, RK Manna and BK Das



THE State of Bihar is blessed with potentially rich and varied aquatic resources. There is a vast avenue for the growth of the aquaculture sector in Bihar. Although Bihar is a landlocked and agriculturally dominated state, it has vast untapped inland water resources in the form of tanks, ponds, chauras, mauns, reservoirs and rivers, which can profitably be utilised for producing fish and congenial agro-climatic conditions for the development of aquaculture. Despite the abundance of aquatic resources of Bihar in terms of about 3,200 hectares of rivers, 5,00,000 hectares flood plain wetlands area, 9000 hectares of ox-bow lakes or mauns, 25,000 hectares of reservoirs and 80,000 hectares of ponds and tanks, fish supply is always short of demand in the state. Bihar, being an inland state, has identified inland fisheries and freshwater aquaculture as potential sectors for the state, and the government promotes the utilisation of its fishery resources.

As per the report by Ahmad in 2001 titled "Development of Freshwater Aquaculture in Bihar", the ponds and tanks in Bihar can produce 0.183 million fish per year. According to another report by the Planning Commission, a large section of the total population (53.5%) lives below the poverty line. The average size of the land holdings is very small, with marginal (<1 ha) and small (1-2 ha) farmers constituting about 84.2 and

9.2%, respectively. The state is ranked lowest in the country regarding per capita income. Out of the total 150 disadvantaged districts identified by the Planning Commission, 15 districts are in Bihar. The frequent occurrence of floods and drought is also common in the state affecting agricultural production and rural livelihood. In the final report of an NAIP-3 project focusing on livelihood improvement of disadvantaged districts of Bihar, the state is identified as a true example of a "resource-rich state" inhabited by 'poor people' and as a "high potential low productivity" state offering tremendous scope for evolving effective strategies for delivering rural services and for implementing local institutional arrangements to improve livelihoods of the rural poor through agriculture-based activities.

Agricultural advancements, including fisheries, are crucial for enhancing livelihoods in Bihar, where more than 85% of the population relies on agriculture, either directly or indirectly. The scope for fisheries development in Bihar is vast, given the state's abundant water resources and significant population dependent on agriculture. With numerous rivers, ponds, and water bodies, Bihar has the potential to enhance fish production and meet both local and regional demand. Expanding fisheries can diversify income sources for farmers, create employment opportunities, and contribute to

CURRENT STATUS OF KAWAR JHEEL AND STRATEGIES FOR REVIVING ITS CONSERVATION POTENTIAL

Suman Kumari, Sajina AM, RK Manna and BK Das

KAWAR Jheel, also known as Kabar Taal or Kawar Lake, is one of India's largest oxbow lakes, located in the Begusarai district of Bihar. Historically, a sanctuary for migratory birds and a vital fishing ground, this ancient wetland, formed by the meandering Gandak River, has been central to the region's ecology and economy. Recognised for its ecological significance, Kawar Jheel was designated a protected area under the Wildlife (Protection) Act in 1972 and later as a bird sanctuary in 1989. Despite these protections, the wetland has faced significant threats, including siltation, pollution, agricultural encroachment, and habitat degradation, causing the lake's area to shrink dramatically from 6,786 hectares in 1984 to just 2,032 hectares by 2012. This degradation has severely impacted the biodiversity of the lake, including its fish populations, which are vital for local fisheries. In 2020, the lake was designated a Ramsar site, highlighting its international significance. This study emphasises the urgent need for a comprehensive strategy to restore Kawar Jheel's ecological health.

Environmental Parameter Status

The water quality analysis conducted during the early monsoon season in June 2022 revealed several key parameters. The pH of the water was recorded at an average of 7.2, indicating a slightly alkaline nature typical of confined inland waters in India. Electrical conductivity (EC) was measured at 256 $\mu\text{S}/\text{cm}$. A low dissolved oxygen (DO) level of 5.4 ppm was observed, pointing towards the presence of organic pollution. Total hardness was found to be 148.0 mg/l, which is well within the Bureau of Indian Standards (BIS) limit of 300 mg/l for drinking water. The total alkalinity of the lake was recorded at 160.0 mg/l. A high concentration of total phosphorus (2.56 mg/l) was noted, suggesting increased nutrient levels and potential eutrophication. Silicate was present at 19.7 mg/l, higher than typical trace levels. Calcium and magnesium concentrations were 43.3 mg/l and 9.7 mg/l, respectively. Both are essential minerals, with calcium contributing to shell and bone formation, and magnesium playing a vital role in photosynthesis through its presence in chlorophyll.

Fish and Fisheries of the Lake

Kawar Jheel harbours a rich and diverse fish community, including major carp species such as Catla (*Labeo catla*), Rohu (*Labeo rohita*), and Mrigal (*Cirrhinus cirrhosus*), along with smaller indigenous species like *Puntius* spp. and *Amblypharyngodon mola*. These fish species are essential to the local fisheries, which serve as a primary source of livelihood for the communities surrounding the lake. According to a study in 2004, "A Survey of Commercially Valuable Fish Species

in Kanwar Lake, Bihar" by Anon, 41 commercially important fish species have been identified in the Jheel. Later studies by Sinha and Jamal (The Study of Indigenous Ornamental Fish Diversity from Wetland of Bihar, 2015) recorded a total of 79 fish species, reflecting the lake's biodiversity. However, a more recent study by Kumari and Kumar (2023) titled "Water Quality Index Assessment of the Groundwater of Industrial Area and Absorption by Polymer Composites" reported only 26 species, most of which are of ornamental value, indicating a possible decline in fish diversity.

Traditional fishing methods, such as cast nets, gill nets, and traps, are commonly employed by local fishers. These practices have been passed down through generations, reflecting the deep cultural connection between the community and the lake. However, the fisheries of Kawar Jheel are currently facing significant challenges. Overfishing has put pressure on fish populations, while habitat degradation — due to factors like encroachment, water diversion, and agricultural runoff has further threatened the aquatic ecosystem. Pollution from domestic and industrial sources has also contributed to the decline in water quality, affecting fish health and diversity.

Additionally, the introduction of invasive species has disrupted the ecological balance, competing with native species for resources. To address these challenges, conservation efforts are increasingly focusing on habitat restoration, community-based fisheries management, and the regulation of fishing practices. Habitat restoration aims to improve the water quality and restore the natural environment of the lake, making it more conducive for fish breeding and growth. Community-based fisheries management involves local stakeholders in decision-making processes, ensuring that conservation measures are culturally appropriate and effectively implemented. Regulation of fishing practices, including restrictions on the use of certain nets and fishing



Setting up a trap for the harvesting of small indigenous fish

REVIVING *HETEROPNEUSTES FOSSILIS*: ENSURING SUSTAINABLE FISHERIES AND LIVELIHOODS

SUMAN KUMARI¹, ANJANI KUMAR², A.M. SAJINA¹,
R.K. MANNA¹ AND B.K. DAS¹

The Asian sting catfish, Heteropneustes fossilis, is a commercially important species found across various habitats in Southeast Asian countries. Locally known as Singhi, this species is highly nutritious and rich in protein, iron, and calcium. However, its population has declined by 20% in the last two decades. While existing research has focused on aspects such as reproductive biology and population structure, little attention has been given to establishing its population naturally in its habitat. This study presents a successful case of establishing H. fossilis in the wetlands of Eastern India. A total of 312 specimens were collected through seasonal sampling from June 2021 to May 2022, with sizes ranging from 7.94 cm to 28.36 cm in total length and 1.57g to 126.7g in weight respectively. The abundance of fish, particularly in June, contributed significantly to commercial catches in the wetlands of Khagaria district of Bihar. Notably, 90% of the captured fish by weight were mature brooders, indicating the reproductive capability of the species' during this period. A systematic approach to harvesting and post-harvest management was implemented in Khagaria, with focus on identifying priority breeding habitats and implementing in-situ natural management strategies in post-breeding. The study recommends policy guidelines for the capture-based fisheries, aquaculture, conservation, and management of H. fossilis amidst changing eco-climatic conditions, emphasizing specific management measures for sustainable fisheries and livelihood generation.

Introduction

Heteropneustes fossilis, commonly known as the stinging catfish or Singhi, is a freshwater catfish species native to the Indian subcontinent. It has been an integral part of India's aquatic ecosystems and cultural heritage for centuries. *H. fossilis* is valued for its palatability, texture, and flavour, making it a popular choice in traditional cuisines across India. Its firm flesh and mild taste make it versatile for various culinary preparations, including curries, fries, and grills. Moreover, *H. fossilis* is preferred for its low bone content, which enhances its culinary appeal¹. Studies have elucidated the nutritional

composition of *H. fossilis*, emphasizing its high protein content and essential nutrients. According to Gupta et al.² *H. fossilis* is rich in proteins, containing essential amino acids crucial for human health. Additionally, it provides essential fatty acids, vitamins, and minerals, including Omega-3 fatty acids, vitamin D, calcium, and phosphorus³. *H. fossilis* is prized for its high protein content, which makes it a valuable dietary component, especially in regions where access to protein-rich foods is limited. Protein is essential for muscle growth, repair, and overall body function, making *H. fossilis* an important nutritional resource for communities relying on freshwater fisheries⁴. Omega-3 fatty acids, particularly eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are essential for cardiovascular health, brain function, and reducing inflammation⁵. The presence of Omega-3 fatty acids in *H. fossilis* enhances its nutritional value and contributes to

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Nagi and Nakti Twin Bird Sanctuaries: Conservation Challenges and the Sustainability Needs of Two Ecologically Important Ramsar Wetlands of Bihar, India

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Abstract

The Nagi and Nakti Bird Sanctuaries in Bihar, India, are Ramsar-designated wetlands of international importance. Originally built as irrigation reservoirs, these man-made ecosystems now support rich biodiversity, including over 136 bird species, 30 fish species, diverse plankton communities, and submerged macrophytes. However, these sanctuaries face critical conservation challenges such as habitat degradation, invasive species, and climate change. This article highlights the ecological significance of the sanctuaries, documents biodiversity patterns, and assesses threats. It emphasizes the urgency of integrated management strategies, habitat restoration, and community involvement to ensure long-term sustainability of these vital ecosystems and their role in avian and aquatic conservation.

Introduction

Nestled in the heart of Bihar's Jamui district, the Nagi and Nakti Bird Sanctuaries are two significant wetland ecosystems. Initially constructed for irrigation in the 1950s and 1980s, these man-made reservoirs have become vital habitats for migratory birds. Their aquatic vegetation and food abundance transformed them into essential avian sanctuaries. Recognized as sanctuaries in 1984 and 1987, they were officially notified under the Wildlife (Protection) Act, 1972, in 2009. In 2004, the sites were designated as an International Biodiversity Area and Key Biodiversity Area.

The sanctuaries span 332 ha (Nagi) and 791 ha (Nakti), surrounded by hillocks and agricultural lands. Fed by seasonal rivers and rainwater, they support over 136 bird species. Notably, the Bar-headed Goose (*Anser indicus*) is prominently found here. The Asiatic Waterbird Census 2023 recorded 7,844 birds at Nakti and 6,938 at Nagi. On June 5, 2024, they became India's 81st and 82nd Ramsar sites, emphasizing their global importance.

Despite their ecological and economic value, these sanctuaries face challenges like habitat degradation, invasive species, and water quality decline. This article explores their biodiversity, conservation challenges, and strategies for long-term sustainability.



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