

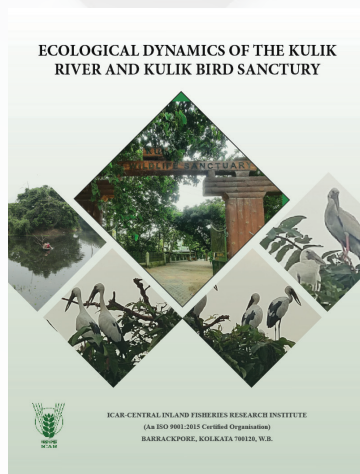
ECOLOGICAL DYNAMICS OF THE KULIK RIVER AND KULIK BIRD SANCTUARY



ICAR-CENTRAL INLAND FISHERIES RESEARCH INSTITUTE

(An ISO 9001:2015 Certified Organisation)

BARRACKPORE, KOLKATA 700120, W.B.



Ecological Dynamics of the Kulik River and Kulik Bird Sanctuary (Uttar Dinajpur, West Bengal)

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Published by: The Director, ICAR-CIFRI Barrackpore, Kolkata-700120

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Monograph 2026

ISSN: 0970-616X

Cover Design: Suman Kumari

Citation:

Suman Kumari, Sajina A. M., R. K. Manna and B. K. Das 2026 Ecological Dynamics of the Kulik river and Kulik Bird Sanctuary, ICAR-CIFRI, ISSN:, pp 50 ISSN: 0970-616X

Designed and Printed by P2C Communications

J-10, green park main New- Delhi India 110016

FOREWORD

The delicate balance of aquatic ecosystems is increasingly threatened by environmental changes and human interventions. Wetlands and river systems, such as the Kulik River and the Kulik Bird Sanctuary, serve as vital habitats for diverse flora and fauna, playing a crucial role in maintaining ecological stability. This book presents an in-depth assessment of the water quality parameters, biodiversity, and seasonal variations within these interconnected ecosystems, shedding light on the intricate relationships between environmental factors and aquatic life.

Through meticulous research, this work highlights the critical impact of seasonal shifts on key water quality indicators, including dissolved oxygen, pH, alkalinity, and transparency. The study's findings underscore the dynamic interplay between monsoon-driven nutrient influx and dry-season algal proliferation, which significantly alters habitat conditions for fish, plankton, and avian species. The documentation of phytoplankton and zooplankton composition, as well as fish diversity, provides valuable insights into the resilience and vulnerabilities of the ecosystem.

Beyond scientific analysis, this bulletin serves as a call to action for conservationists, policymakers, and researchers, emphasizing the necessity of continued monitoring and adaptive management strategies to sustain the ecological integrity of these habitats. With a growing number of migratory birds depending on the Kulik Bird Sanctuary for survival, the need for informed conservation efforts has never been more urgent.

I commend the authors for their dedication to environmental research and for contributing knowledge that will aid in the preservation of these invaluable ecosystems. This bulletin is a significant resource for those seeking to understand and protect the fragile balance of freshwater and wetland biodiversity.

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Director, ICAR-CIFRI

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Acknowledgements

We sincerely express our gratitude to Dr. B. K. Das, Director, ICAR-CIFRI, for his keen interest in the formulation of this project and his constant encouragement throughout its execution. We also extend our heartfelt thanks to Dr. U. K. Sarkar, former Head, RWF Division, for his unwavering support and guidance.

The researchers are deeply grateful to the following officials for their invaluable assistance in conducting the study in the wetlands of Kulik Bird Sanctuary (Raiganj Wildlife Sanctuary):

Principal Chief Conservator of Forests, West Bengal

District Forest Officer, Raiganj

Forest Ranger and other officials of Kulik Bird Sanctuary

We acknowledge and appreciate the cooperation extended by all officials, as well as the state fisheries departments of Darbhanga district. Our sincere thanks go to the fishing community and fish farmers, especially Sri Balram Mukhiya, for their support and collaboration in sampling and data collection.

Lastly, we gratefully acknowledge the field and secretarial assistance provided by the technical and administrative staff of ICAR-CIFRI, whose contributions were instrumental in the successful completion of this project.

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1. Executive summery

- The assessment of water quality parameters in the Kulik River and Kulik Bird Sanctuary revealed notable differences between dry and wet season. Key parameters such as dissolved oxygen (DO), pH, alkalinity, and transparency exhibited variations between the river and the sanctuary.
- One significant finding was the decrease in transparency of the Kulik River from the monsoon (wet) to the dry season, attributed to higher algal concentrations during the dry season. This seasonal fluctuation highlights the dynamic nature of aquatic ecosystems and the influence of environmental factors on water quality.
- The sanctuary attracts a growing number of migratory birds each year, indicative of its importance as a habitat for avian species. Its residential periods ranging from 6 to 7 months.
- Of particular concern was the low dissolved oxygen content observed in Kulik Bird Sanctuary, falling below the minimum requirement for fish growth and survival, which is < 5 ppm.
- A total of 42 species of phytoplankton were recorded in both seasons, including patterns observed in the Kulik River, with Cyanophyceae and Bacillariophyceae dominating, exemplified by *Microcystis* sp. within the bird sanctuary, while Bacillariophyceae prevailed in the dry season and Cyanophyceae in the wet season of the river.
- *Keratella cochlearis* and *Synchaeta stylata* identified as the most abundant genera among the 16 species and 11 genera of rotifers in Kulik Bird Sanctuary, where significant seasonal variation in abundance was noted, contrasting with Kulik River where seasonal variation was insignificant, further noting the absence of zooplankton during the wet season in Kulik Bird Sanctuary.
- The canal system exhibits a fish diversity primarily comprising Tilapias, *Amblypharyngodon mola*, *Hypophthalmichthys nobilis*, *Chanda nama*, *Labeo catla*, *Puntius sophore*, *Pethia conchoniis*, *Labeo rohita*, while exploration of connected rivers, River Kulik and River Nager, revealed 62 and 41 fish species respectively, although predominantly small-sized of Tilapia fish introduced into Kulik Bird Sanctuary supporting breeding populations and providing significant feed for avian species, alongside traditional fishing methods employed by local fishers capturing prawns, spiny eels, and other fish species.
- Overall, the assessment highlights the complex interplay between environmental factors, human activities, and management practices in shaping water quality dynamics within the Kulik Bird Sanctuary. Continued monitoring and adaptive management strategies will be crucial for maintaining the ecological integrity of this vital habitat for both resident and migratory bird populations.

2. Introduction

The global increase in the declaration of Protected Areas (PAs) stands as a testament to humanity's growing recognition of the urgent need to safeguard our natural heritage. These areas serve as bastions of biodiversity, providing crucial refuge for myriad species of flora and fauna, while also safeguarding the invaluable ecosystem services they provide. As noted by Lehtikoinen et al. (2021), the expansion of PAs between 2010 and 2019 reflects a concerted effort to address the escalating threats posed by habitat loss, overexploitation, pollution, and climate change.

s

Maxwell et al. (2020) revealed that from 2010 to 2019, the coverage of protected areas expanded from 14.1% to 15.3% of global land and freshwater environments (excluding Antarctica), and from 2.9% to 7.5% of the marine realm (UNEP-WCMC, 2019). These figures reflect a tangible commitment to conserving our planet's natural treasures. Among the myriad strategies employed for biodiversity conservation, Protected Areas emerge as a cornerstone. These designated zones utilize stringent legal frameworks to minimize human interference within defined geographical boundaries, thereby fostering the preservation and enhancement of biological diversity. With a total of 18,075 freshwater fish species worldwide, comprising 51% of all fish species and 25% of all vertebrates, their conservation is paramount (Lehtikoinen et al., 2021).

Despite their ecological significance, freshwater ecosystems face mounting pressures from human activities. The IUCN Red List of Threatened Species paints a grim picture, with 80 freshwater fish species declared extinct, 16 of them in 2020 alone. Alarming, freshwater biodiversity is declining at twice the rate of biodiversity in oceans and forests, underscoring the urgency of conservation efforts (Lehtikoinen et al., 2021).

While Protected Areas play a pivotal role in conserving biodiversity, their focus on certain taxa sometimes overlooks others. In the realm of wetland conservation, for instance, the spotlight often falls on aquatic birds, with fish diversity receiving comparatively less attention. Despite the Ramsar Convention's inclusion of fish criteria for wetland designation in 1996, many designated sites lack comprehensive assessments of their fisheries and fish diversity.

Recognizing this gap, initiatives such as the project in India aim to rectify the oversight by delving into the status and diversity of fish fauna in protected waters. By shining a light on these lesser-explored facets of biodiversity, such endeavors contribute to a more holistic understanding of ecosystem dynamics and inform targeted conservation strategies. In conclusion, the declaration and management of Protected Areas stand as crucial pillars in the global effort to safeguard biodiversity. By embracing a multifaceted approach that encompasses the diverse array of species and ecosystems, we can strive towards a more resilient and sustainable future for both nature and humanity.

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

3. Background of study site

The Kulik bird sanctuary, Raiganj (25° 37'N to 25° 62'N and 88° 07'E to 88° 12'E), West Bengal, India, is an artificial planted forest of West Bengal Forest department which had begun in 1970. The forest was declared as a wild life sanctuary in the year 1985. They constitute 60% “Jarul” trees (*Lagerstoemia speciosa*) including several other valuable trees (*Anthocephalus indicus*, *Barringtonia acutangula*, *Terminalia arjuna*, *Eucalyptus citriodora* etc.) and herbaceous species. The area of the sanctuary is around 1.30 km². The core area is about 0.14 km² and the rest is the buffer area. The broad-leaved deciduous trees provide the nesting place of many migratory and resident birds species. The river Kulik flows round a part of the sanctuary and acts as the boundary in its eastern and southern parts. The sanctuary has a network of artificial canals connected with the river Kulik (Sharma 2007). Annual rain fall varies from 1,200 mm to 1,550 mm, mean winter temperature varies from 09° C to 23° C and summer temperature from 21° C to 25° C, and humidity is 75. This sanctuary is the home of 164 species of birds (Sharma 2007). In this sanctuary Open billed stork species, *Anastomus oscitans*, breeds together with five other members of the Order: Ciconiiformes (Datta and Pal 1993). The ecology of this species in Kulik bird sanctuary, Raiganj, India has been described in few studies focusing on its population status, feeding habits as well as its conservation (Datta 1992) but relevant information is completely lacking in the flora and faunal diversity of this sanctuary. The objectives of the study were to record and assess the present situation of animals and plants species to identify (mammals, birds, reptiles, amphibian, fishes, molluscs and major plants) the constraints and content of the sanctuary. Hope, this will create a new way towards biological sciences to protect many of the flora and fauna from extinction.

The Kulik river is a trans-boundary river that flows through the Indian states of West Bengal and Bihar, and neighbouring country Bangladesh. Trans-boundary river is a river that crosses at least one political border, either a border within a nation or an international boundary. A relatively small and narrow stream, Kulik river emerges from a wetland, locally called Morar Beel, meaning ‘a water body of the dead’ in Raipur area of Baliadangi upazila in the Thakurgaon district of Bangladesh. It enters India through the southern part of Uttar Dinajpur, West Bengal. It flows southwest through Raiganj city and joins with Nagar River to its west. Both the river finally meets with the Mahananda River, south of Raiganj. Raiganj Wildlife Sanctuary, aka Kulik Bird Sanctuary is situated near Raiganj, Uttar Dinajpur of West Bengal and is the second largest bird sanctuary in Asia. The Kulik river bounds the eastern and southern parts of the sanctuary. The sanctuary also has a network of artificial canals connected with the river. The sanctuary is home to about 164 species of birds, and some 98,000 to 99,000 migratory birds visit from South Asian countries and coastal areas during 2020-2021. Thus, it clearly shows the importance of river Kulik for this area, which renders support and maintains the ecological balance of the region.

The regional topography is generally flat with a gentle southerly slope towards which the main rivers like Kulik, Nagar, Mahananda. The District forms a part of the basin lying between

Rajmahal hills on the east. Uttar Dinajpur is bestowed with a very fertile soil. The soil is very rich in nature due to the alluvial deposition which helps to grow Paddy, Jute, Mesta and Sugarcane as major crop in Raiganj on the banks of the River Kulik is the District Headquarters where the Raiganj Wildlife Sanctuary, the second largest bird sanctuary in Asia, is situated. In Uttar Dinajpur district, there are two sub-divisions, Raiganj and Islampur, 110 km (68 mi) apart from each other. There are four municipalities, nine blocks and 99 Panchayats covering 1577 villages.

The ichthyo-diversity of Uttar Dinajpur district of West Bengal, India was assessed in the current study based on structured questionnaire. The district is adorned by various rivers, feeder channels, dams, bills, ponds, reservoirs and thus contributes significantly to the aquatic productivity of the state. A field survey was conducted in randomly chosen fish markets of nine community development blocks of Uttar Dinajpur. The study found a large ichthyodiversity in the area including 76 fish species from 26 families. With 28 distinct species, the Cyprinidae family dominated (Sarkar et al., 2022). Thirteen, globally endemic, freshwater fish species were also observed during the study. *Clarias magur*, one of the endangered species, is also available in the district.

An extensive survey of the plants and animals of Kulik bird sanctuary and its adjoining area was conducted in the year 2007-2008. The sanctuary was declared as a wildlife sanctuary in 1985. There was a great diversity of plants and animals, such as major plants (34 species; 21 families), mammals (2 species; 2 families) birds (29 species; 20 families) reptiles (4 species; 4 families) amphibian (2 species; 2 families) fishes (18 species; 11 families) and molluscs (5 species; 5 families) species were observed and collected in the study period. In this sanctuary *Lagerstoemia speciosa*, *Barringtonia acutangula*, *Trewia nudiflora*, *Terminalia arjuna* and *Alstonia scholaris* are the major plant species. A large number of birds species such as Open billed stork (*Anastomus oscitans*), Little cormorant (*Phalacrocorax niger*), Night heron (*Nycticorax nycticorax*), Gray heron (*Ardea cinera*), Cattle egret (*Bulbulcus ibis*) and Little egret (*Egretta garzetta*) breeds together every year. Among the birds species maximum number of Open billed stork (*Anastomus oscitans*) was found in the breeding season (Pramanik et al., 2010).

The study also included the Nagar river and Kulik river to understand the Ichthyofaunal diversity of the adjoining rivers. Very scarce information on fish is available in public domain on fish diversity of Nagar river.

Nagar river: 25°42'29.5" N 88°02'44.8"E

Kulik River: 25°38'08.2" N 88°07'19.3"E (Kulik Bridge on NH-12, Debinagar, Subhasganj)

Study sites

Kulik Bird sanctuary: 25°38'13.3" N 88°01'06.4"E

This sanctuary is distributed in small -small pockets and a road is dividing their forest area, surrounded by Kulik river. The sanctuary's focal point is the Kulik Lake, a sprawling water body that serves as a vital lifeline for both resident and migratory birds. A dense deciduous forest with visiting and indigenous birds is pleasing atmosphere. A small semi-circular man-made lake is fed by Kulik river for Birds's well being is regularly stocked with fish. Throughout the year, the sanctuary plays host to a multitude of avian visitors, with its significance soaring during the winter months when it becomes a sanctuary of solace for migratory birds escaping the harsh conditions of their northern breeding grounds. Species such as the Northern Pintail, Common Teal, Gadwall, and Northern Shoveler flock here in impressive numbers, transforming the wetlands into a bustling avian metropolis.

The sanctuary's lush vegetation provides ample cover and nesting sites for its avian inhabitants, while also offering a sanctuary for other wildlife, including reptiles, amphibians, and small mammals. Tall grasses sway gently in the breeze, creating a serene backdrop against which the graceful flight of birds unfolds. For bird enthusiasts and nature lovers alike, the Kulik Bird Sanctuary offers a tranquil retreat where one can immerse themselves in the sights and sounds of nature. Birdwatching trails wind their way through the sanctuary, offering visitors the opportunity to observe and photograph its feathered residents in their natural habitat. In addition to its ecological significance, the sanctuary also plays a vital role in local communities, serving as a source of livelihood for fishermen and providing a space for eco-tourism.

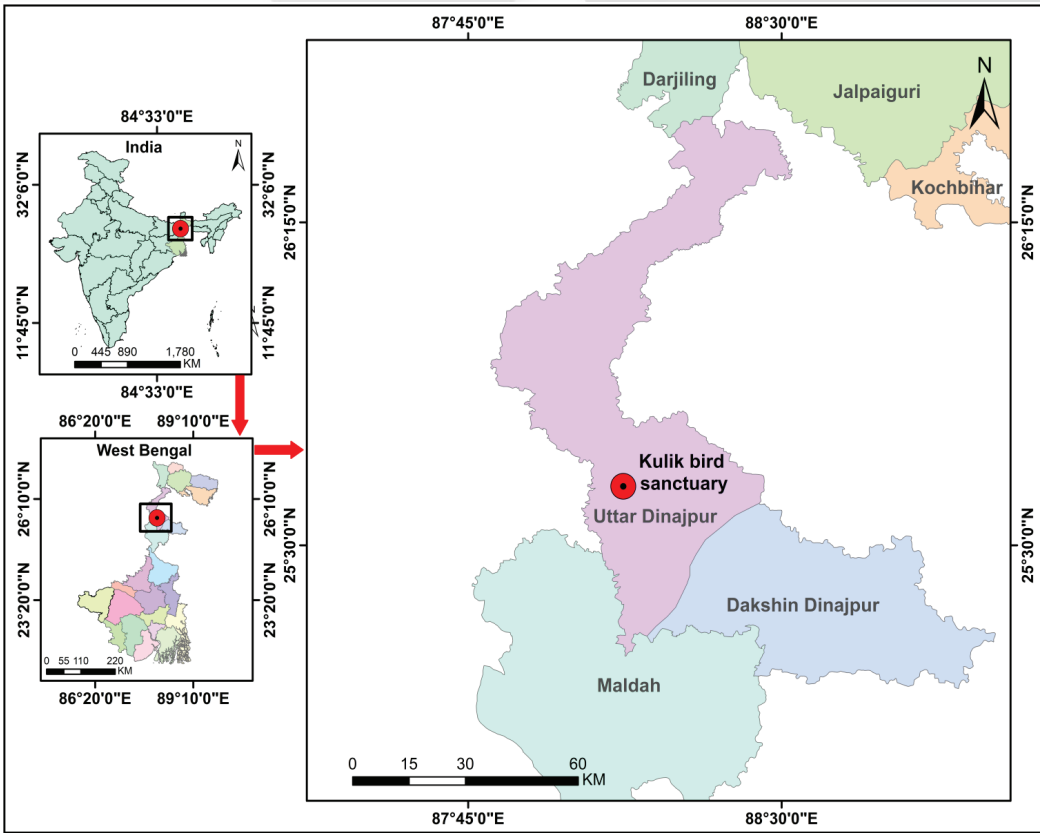


Figure 1. GIS map Kulik Bird sanctuary



Figure 2. Kulik Bird sanctuary at Raiganj

Kulik Bird sanctuary also known as Raiganj Wildlife sanctuary in Uttar Dinajpur district of West Bengal. This sanctuary is a beautiful place surrounded by nature, forest, also there are several watch towers to enjoy the beauty of forest and birds. This is very peaceful place to visit with family and friends during winter. The residential birds include flycatchers, kites, owls, woodpeckers, kingfishers, drongoes and many others birds. The main theme of this bird sanctuary is conserve birds. The ambience of the sanctuary is good for nature and bird lovers, wildlife photographers. This main entrance gate to visit sanctuary.



Figure 3. Man made wetland of Kulik Bird Sanctuary

Sampling

1. 20/06/2022-25/06/2022 (Dry season)
2. 25/08/2022- 28/08/2022 (Wet season)

The seasonal sampling was scheduled during dry season (June 2022), and wet season (August 2022) for sample collection of fish fauna, water, sediment, plankton, macrophytes, benthos, etc. from different selected sampling stations. We have selected a total of 3 sampling sites to get detailed information of habitat, ecology and fish diversity of these bird sanctuaries.

Table 1: Geographical details of sampling sites

Study sites		
Site 1	Kulik Bird sanctuary	N24°49'29.7": E086°24'06.4"
Site 2	Nagar river	N24°49'00.3": E086°24'28.8"
Site 3	Kulik River (Kulik Bridge)	N24°49'06.3": E086°24'39.3"
Site 4	Debinagar,	
Site 5	Subhasganj	



Figure 4. Map of River and Kulik Bird sanctuary (Source: Kulik Bird sanctuary office)

4. Hydrological and ecological parameters

Assessing the water quality parameters of the man-made Kulik Bird Sanctuary, which includes the Kulik River and Nagar River, is crucial for understanding and managing the health of these aquatic ecosystems. Several key water quality parameters are typically assessed to gauge the overall condition of the water bodies:

Methodology followed:

The methodology for assessing water quality parameters in the man-made Kulik Bird Sanctuary, specifically focusing on the Kulik River and Nagar River, involved a comprehensive approach utilizing various instruments and following standardized protocols. Below is a detailed description of the methodology:

Instrumentation and Equipment:

- Depth: Digital depth sounder was used to measure the depth of the water bodies.
- Transparency: Transparency was measured using a Secchi disc, with the depth at which the disc disappeared from sight recorded.
- Temperature: Temperature of the water was measured using a graduated Centigrade mercury thermometer.
- pH: pH was measured using a digital pH meter.
- Specific Conductivity and Total Dissolved Solids: These parameters were measured using a multiparameter digital probe (Eurotech).
- Dissolved Oxygen (DO): Dissolved oxygen levels were measured using a dissolved oxygen probe.
- Salinity: Salinity levels were determined using the multiparameter digital probe.
- Free Carbon Dioxide (Free CO₂), Chloride, Total Alkalinity, Total Hardness, Ca⁺⁺, Mg⁺⁺, Nitrate-N, Silicate-Si, Total Phosphorus: These parameters were assessed following the standardized methods outlined in Standard Methods (APHA, 2005; 2010) and Welch (1948).

Sampling Procedure:

- Water samples were collected from both Nagi and Nakti dams between 8 AM to 10 AM to minimize diurnal variations.
- Samples were collected using clean, sterile containers to prevent contamination.

- Care was taken to collect samples from representative locations within each water body to ensure the accuracy and reliability of the data.

On-Site Analysis:

- Upon collection, certain parameters such as temperature, pH, transparency, dissolved oxygen, specific conductivity, total dissolved solids, salinity, and free carbon dioxide were measured onsite immediately using the respective instruments.
- This immediate analysis provided real-time data and allowed for prompt adjustments or further investigation if necessary.

Laboratory Analysis:

- Water samples collected from each site were transported to the laboratory for further analysis of additional parameters.
- Standardized methods outlined in relevant literature (APHA, 2005; 2010; Welch, 1948) were followed for the laboratory analysis of parameters such as chloride, total alkalinity, total hardness, calcium, magnesium, nitrate-N, silicate-Si, and total phosphorus.
- Careful attention was paid to adhere to quality control measures and calibration procedures to ensure the accuracy and reliability of the laboratory results.

By following this systematic methodology, comprehensive data on various water quality parameters were obtained, providing valuable insights into the ecological health and integrity of the Kulik Bird Sanctuary's aquatic ecosystems. This information serves as a foundation for informed decision-making and effective management strategies aimed at preserving and protecting these invaluable natural resources.



Figure 5. Sampling site of Kulik river



Figure 6. Manmade wetland of Kulik Bird sanctuary Sampling site



Figure 7. Canal of Kulik Bird sanctuary joining to Kulik river

Water quality parameters

Water quality parameters of Kulik river and Kulik Bird Sanctuary have been assessed and given in the table 2, represented in range. Important parameter such as DO, pH, Alkalinity, Transparency has shown difference between Kulik River and Kulik BS. Transparency of Kulik river is decreased from monsoon to dry season due more algal concentration in dry season. As per the discussion with the authority of Kulik BS, the residential periods of the varies from 6-7 months. The Kulik BS receives more migratory birds every year and their trend is increasing. Dissolved oxygen content was very low in Kulik BS, whereas minimum requirement for the growth and survival of fish 5 but pH content is not significantly variable due to frequent application of lime in the bird sanctuary. This has been reflected in other water quality parameters also.



Figure 8. Sampling in dry season



Figure 9. Sampling in wet season

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

	Kuik River		Bird sanctuary	
Water quality	Wet Season	Dry Season	Wet Season	Dry Season
Depth (ft)	13.7-14.9	4.8-11.4	1.9-4.7	2.3-5.6
Transparency (cm)	47-76	41-58	52-56	61-66
Temp Air (°C)	34.8-35.6	35.2-35.9	34.4-35.1	34.2-34.4
Temp Water (°C)	29.3-31.8	31.2-31.8	31.3-30.6	31.0-30.4
pH	7.9-8.16	7.9-8.12	7.2-7.43	7.1-7.31
Specific conductivity (µS/cm)	56.1-104.4	62.3-134	132.2-146.3	134.4-156.9
Dissolved Oxygen (ppm)	7.6-7.9	8-8.2	4.5-4.6	4.2-4.5
FreeCO ₂ (ppm)	Nil	Nil	Nil	Nil
TDS (ppm)	41.5-74.2	44-95.7	96.5-110	94.6-97.4
Salinity (ppt)	0.0343-0.0553	0.0363-0.0683	0.067-0.0723	0.068-0.0787
Total Alkalinity (ppm)	20.0-27.5	16-25	36.4-37.5	39.2-40
Total hardness (ppm)	26.3-37.5	16-20	46.3-48.2	42.2-42.5
Ca ⁺⁺ (ppm)	8	6.4-9.6	11.2-11.4	14.4
Mg ⁺⁺ (ppm)	0.96-4.2	0.96-0.97	3.53	2.92
Nitrate-N (ppm)	0.07-0.16	0.04-0.17	0.21-1.12	0.23- 1.91
Silicate-Si (ppm)	23.9-27.6	3.25-3.27	12.7	4.68
Total Phosphorus (ppm)	0.111-0.018	0.063-0.086	0.96	1.01

Water depth is variable in both the bird sanctuaries. The finding was supported by the high phosphorus concentration in Kulik BS due to high input of bird's droppings. Then appearance of color of water was dark grey during dry season in bird sanctuary.

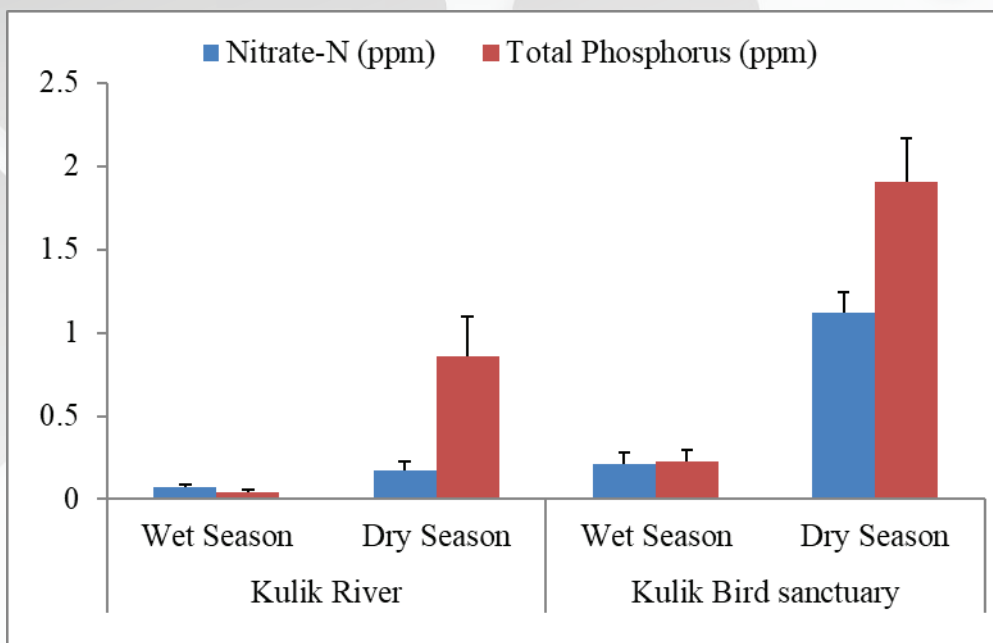


Figure 10. Seasonal variation in nitrate and total phosphorus concentration in Wet season (August) and in Dry season (June)

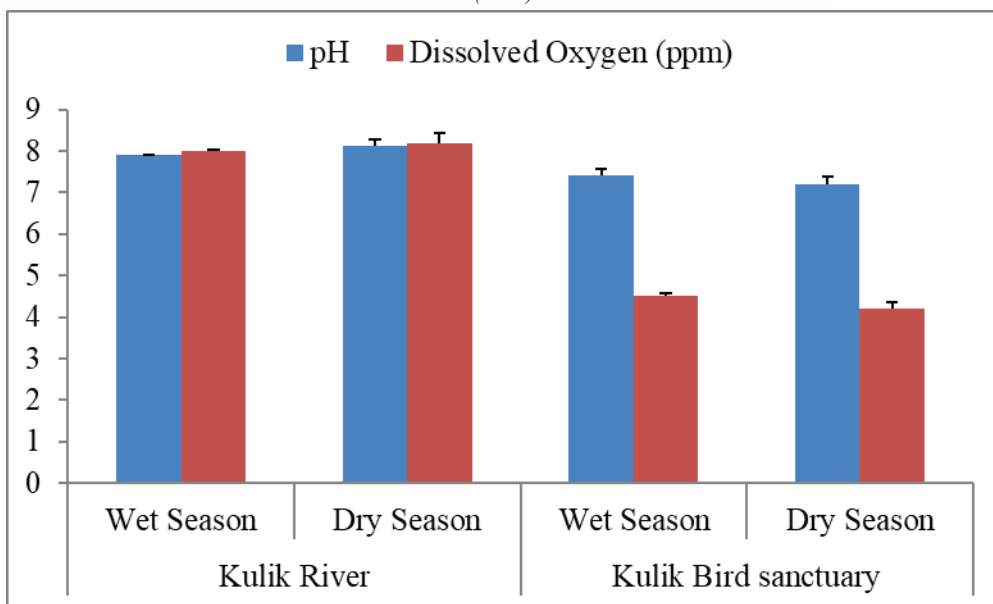


Figure 11. Seasonal variation in pH and Dissolved oxygen concentration in Wet season (August) and in Dry season (June)

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 fixing and oxygenation of aquatic ecosystem. Due to their short life cycle of plankton and thus potentially rapid response to anthropogenic disturbance and environmental changes, planktonic organisms are also regarded as ideal bioindicators for assessing the environmental status of aquatic ecosystems.

Methodology for plankton collection:

The phytoplankton sample collection protocol was followed from 4 different location taken 4 litres of subsurface water without filtration and mixed well from this mixture one litre was preserved in 4 % buffered formalin in Amber pp bottle of one litre capacity and brought to the laboratory for quantitative and qualitative analysis.

The sampling protocol for zooplankton was followed as prescribed by Sharma and Sharma (2012) respectively. Taxonomic identification to the lowest possible taxon using standard keys was carried out following standard literature Koste (1978), Battish (1992), Segers (1995) and Nogrady & Segers (2002) for rotifers Edmondson (1959), Victor and Fernando (1979), Sehgal (1983), Benzie (2005) and Dussart Defaye (2001) for cladocerans and copepods. Verification and confirmation of taxonomic nomenclature was follows for rotifers International Commission on Zoological Nomenclature (<http://iczn.org/lan/rotifer>), the Cladocerans (Kotov et al. 2013) and Copepods (Walter and Boxshall 2018). Abundance of zooplankton was expressed as ind/l. Aliquot of 5ml sample out of 50ml sample (50 ml sample concentrated from 5litres of lake water) were taken randomly after mixing, used for counting in a Sedgewick-Rafter chamber under an inverted microscope (Zeiss-Winkel). Theeach individual plankton was counted separately under the inverted microscope using Sedgwick rafter cell counting chamber.



Figure 12. Plankton sample collection

A total of 42 species of phytoplankton were recorded during both the seasons including Kulik river phytoplankton assemblage pattern. The most abundant phytoplankton is given in the figure below. In the Dry season, 21 species of phytoplankton with comparatively low abundance 4750 ± 145 cells/Litre and 10290 ± 237 cells/Litre were recorded from different sampling seasons of Kulik river. They can be classified among 4 groups. i.e Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Euglenophyceae. Among these groups most dominant group was Cyanophyceae and Bacillariophyceae most dominant species is *Microcystis* sp. inside bird sanctuary. In Kulik River most dominant one is Bacillariophyceae in dry season and Cyanophyceae in wet season.

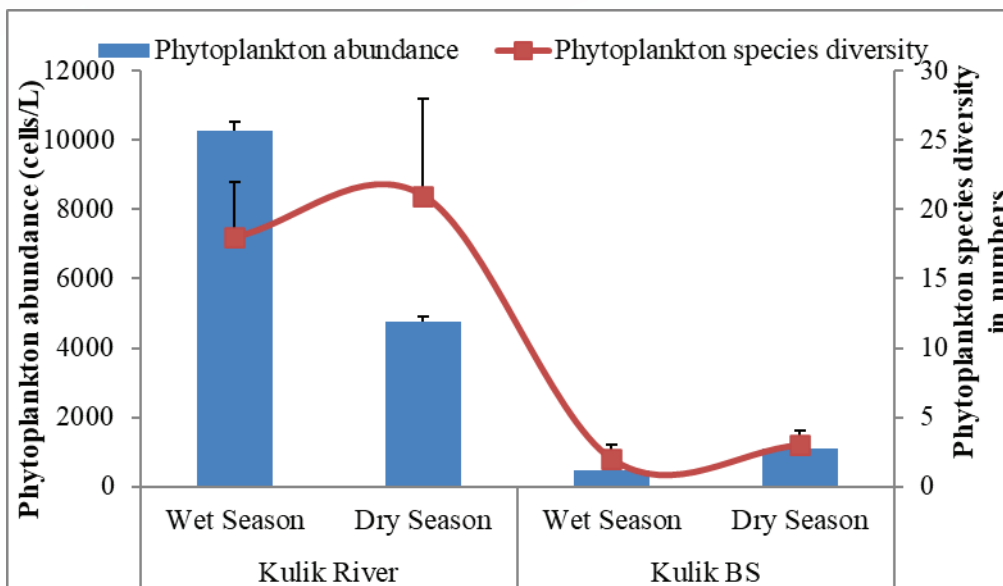


Figure 13. Seasonal variation in phytoplankton abundance in Wet season (July) and in Dry season (end of February)

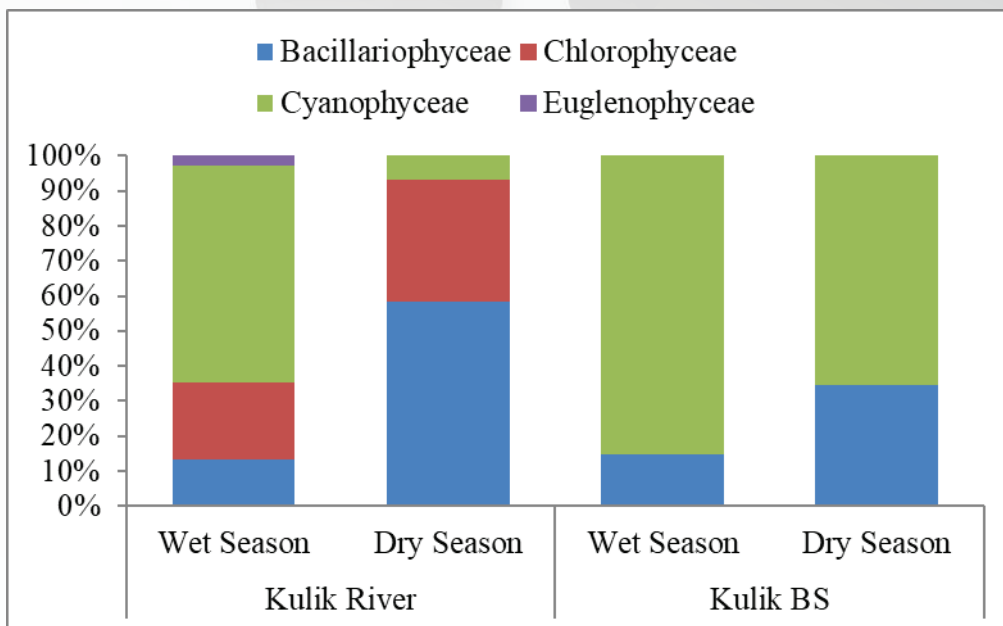


Figure 14. Group-wise phytoplankton variation in Wet season (August) and in Dry season (June) of both Kulik River and Kulik BS



Surirella



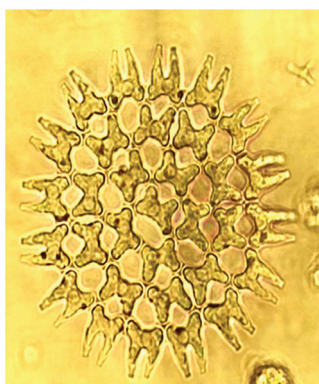
Aulecosira



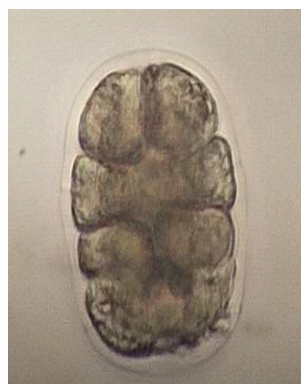
Navicula



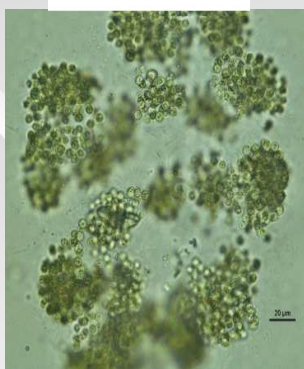
Cyclotella



Pediastrum



Pandorina



Microcystis aeruginosa



Spirogyra



Euglena

Figure 15. Commonly found phytoplankton in the Kulik river and Kulik Bird sanctuaries. *Surirella* cells slightly pointed end or heteropolar, have two large lobed plate-like chloroplast. *Aulecosira* filamentous algae composed of many monofilaments in colony, *Navicula* have two elongated olive-brown chloroplast, *Cyclotella* centric diatom valves and short and drum shaped, *Pediastrum* plat-like colony distinctly arranged peripheral and central cells, *Pandorina* Cells have flattened sides where they make contact, flagella is present but not prominent, *Microcystis*: colonies of *Microcystis* composed of large number of cells containing gas vesicles, *Spirogyra* species with multiple spiral chloroplasts and simple cross walls, the chloroplast have numerous pyrenoids, *Euglena* Single cell with discoid chloroplasts and prominent apical flagellum

Table. 3 Phytoplankton species/taxa reported from Kulik river and Kulik Bird Sanctuary

		Dry Season		Wet Season	
		Kulik BS	Kulik River	Kulik BS	Kulik River
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>Cymbella</i> sp.		+		
10	<i>Achanthidium</i> sp.		+		
11	<i>Gyrosigma</i> sp.		+		
12	<i>Surirella</i> sp.	+	+		

Chlorophyceae				
13	<i>Chlorella</i> sp.			+
14	<i>Pediastrum simplex</i>		+	+
15	<i>Pediastrum duplex</i>		+	
16	<i>Pediastrum</i> sp.		+	
17	<i>Cocinodiscus</i> sp.		+	
18	<i>Spirogyra</i> sp.		+	
19	<i>Selenastrum</i> sp.		+	
20	<i>Scenedesmus abundance</i>			+
21	<i>Scenedesmus quadricauda</i>			+
22	<i>Scenedesmus bijugatus</i>			+
23	<i>Scenedesmus</i> sp.			+
24	<i>Crucigenia crucifera</i>			+
25	<i>Chlamydomonas</i> sp.			+
26	<i>Mougeotia</i> sp.		+	
27	<i>Volvox</i> sp.		+	
28	<i>Chroococcus</i> sp.			+
29	<i>Microspora</i> sp.		+	
30	<i>Cosmarium</i> sp.		+	
31	<i>Closterium</i> sp.		+	
Cyanophyceae				
32	<i>Microcystis aeruginosa</i>	+		+
33	<i>Merismopedia</i> sp.			+
34	<i>Oscillatoria</i> sp.	+	+	+
Euglenophyceae				
35	<i>Euglena</i> sp.			+
38	<i>Phacus</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 Kulik River and Kulik 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 February month of study may be due to high food availability and conducive aquatic parameters of the bird sanctuaries. Of the 16 species and 11 genera identified as rotifers, *Keratella* and *Synchaeta* most abundant genera in Kulik BS. Season variation in the abundance was significant in Kulik bird BS but insignificant in Kulik BS. There was no zooplankton was recorded during wet season of Kulik BS. The increased plankton abundance noticed in Wet season in Kulik rives sampling can be attributed as increasing nutrients' input and also due to increase in primary productivity.

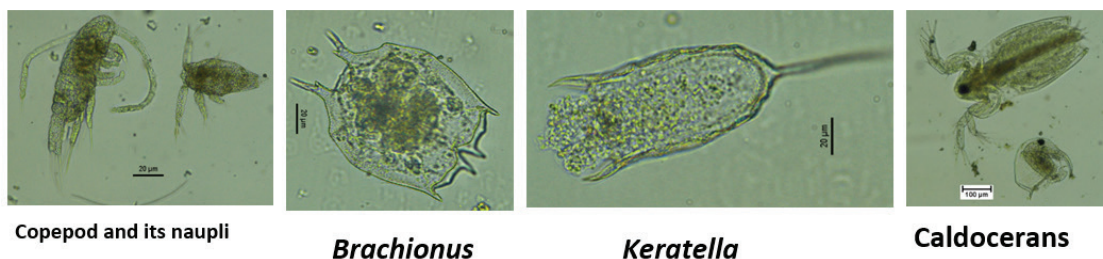


Figure 16. Some of the zooplankton which was abundant in the Kulik River

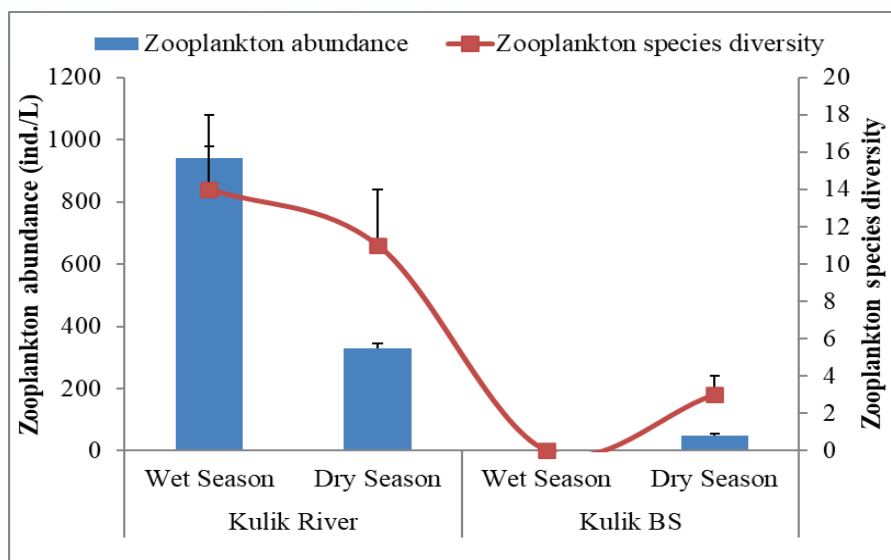


Figure 17. Seasonal variation in Zooplankton abundance in Wet season (July) and in Dry season (end of February)



Keratella cochlearis



K. tropica



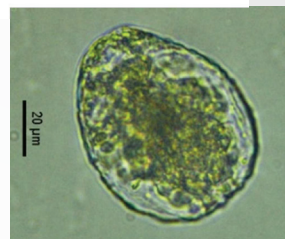
Asplanchna



B. forficula



B. fulcatus



Synchaeta



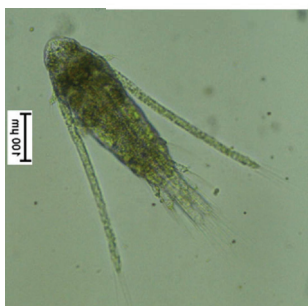
Bosmina longirostris



Diaphanosoma



Moina



Calanoid copepod



Calanoid copepod



Copepod Nauplii

Figure 18. Commonly found zooplankton of Kulik River and Kulik Bird sanctuaries

Table 4: Zooplankton species/taxa reported from Kulik River and Kulik Bird Sanctuary

		Dry Season		Wet Season	
		Kulik BS		Kulik BS	Kulik River
Rotifer					
	<i>Keratella Cochlearis</i>	+	+		+
	<i>Keratella tropica</i>		+		+
	<i>Brachionus caudatus</i>				+
	<i>B. Calycifluous</i>				+
	<i>B. rubens</i>		+		+
	<i>B. fulcatus</i>				+
	<i>B. forficula</i>				+
	<i>Asplanchna</i>				+
	<i>Synchaeta</i>	+	+		
Cladocera	<i>Bosmina</i>		+		
	<i>Moina</i>		+		+
	<i>Diaphanosoma</i>				+
Copepoda	Copepod Cyclopoid		+		+
	Copepod Calanoid		+		+
	nauplei				+
Protozoa	<i>Arcella</i>		+		
	<i>Centropyxis</i>		+		+
	<i>Diffugia</i>		+		

Note: ‘+’ indicate presence of the species

6. Macrophyte diversity

Aquatic plants are plants that have adapted to living in aquatic environments. They are also referred to as hydrophytes or macrophytes to distinguish them from algae and other microphytes. A macrophyte is a plant that grows in or near water and is emergent, submerge, or floating. Emergent vegetation such as *Typha*, *Phragmites*, and *Cyperus* creates dense cover, offering secure nesting and roosting areas for species like herons, egrets, moorhens, and bitterns, while floating plants like *Nymphaea* and *Eichhornia* serve as nesting platforms for jacanas and grebes. Additionally, macrophytes act as a primary food source, supporting herbivorous birds that feed on submerged vegetation such as *Potamogeton*. They also sustain a diverse invertebrate community, including insects, snails, and crustaceans, which form the diet of wading birds like storks, spoonbills, and kingfishers. Floating macrophytes *Nymphea*, *Pistia* and *Lemna* of Kulik Bird sanctuary recorded during study. These macrophyte are found on patches as shown in the figure.



Figure 19. Floating Macrophyte bed: *Nymphaea* in open area in Kulik BS (a) and *Pistia* and *Lemna* in shade region of man-made lake

7. Macro-invertebrate fauna

Macro-invertebrate fauna (benthos) is an excellent bio-monitoring tools to assess the health of an aquatic ecosystem. Sampling was done using Petersen Grab to collect sediment sample. The collected sediment sample from each site was sieved through 500µm sieve and sieved materials were preserved with 4% formalin in a plastic sample container and brought to the laboratory for further analysis. Subsequently group –wise sorting of organism was done in laboratory. The sorted specimen was identified using standard literature. The molluscan sample was also collected from littoral zone of the bid sanctuaries by hand picking. The Macro-invertebrate fauna recorded in Kulik river during study period have been given below. In the Kulik Bird sanctuaries in manmade like no mollusc have been recorded but they culture some of the invertebrate species for bird feeding.



Thiara tuberculata



Bellamya bengalensis



Corbicula striatella



Lamellidens marginalis



Bellamya dissimilis

Figure 20. Commonly available Macro-invertebrate diversity of River Kulik

8. Bird diversity of the Sanctuary

Raiganj Wildlife Sanctuary, aka Kulik Bird Sanctuary is situated near Raiganj, Uttar Dinajpur of West Bengal and is the second largest bird sanctuary in Asia. The Kulik river bounds the eastern and southern parts of the sanctuary. The sanctuary also has network of artificial canals connected with the river. The sanctuary is home to about 164 species of birds, and some 80,000 to 98,000 migratory birds visit every year from South Asian countries and coastal areas. Thus, it clearly shows the importance of river Kulik for this area, which renders support and maintains the ecological balance of the region. Most dominant migratory birds have been observed different species of Open Bill Stock. The information on year-wise abundance other dominant bird species have been provided from forest department species of Uttar Dinajpur, West Bengal. Year wise statistics of four important species such as Open Bill Stock, Night Heron, Egret and Cormorant have been given below

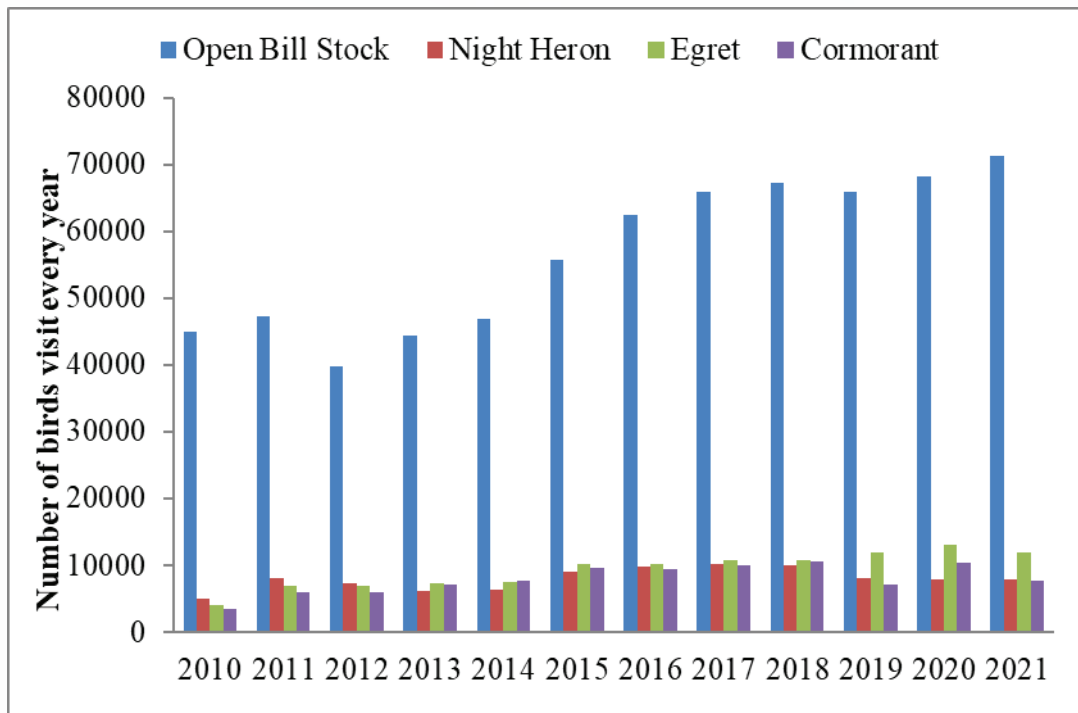


Figure 21. The annual visit of four most dominant migratory bird stocks to the Kulik Bird Sanctuary



Figure 22. Open Bill Stock bird nesting



Figure 23. Pairing formation of Open Bill Stock bird for breeding



Figure 24. Most preferred place for roosting of Great white egret Bamboo plan

9. Fish diversity

The exploratory survey and sampling work was carried out in Kulik Bird Sanctuary, located in Raigunj, Uttar Dinajpur district of West Bengal. The 1.3 km² completely protected bird sanctuary support roosting and nesting of around 1 lakh birds, the major 4 migratory species being Open bill storks, great white egrets, little cormorants, and night herons. There is a network of man-made canals within the Sanctuary, which is connected to River Kulik through sluice gates and these canals support the feeding of birds while they roost and nest on the tree tops in the Sanctuary. The canals are being stocked with fishes and apple snails to support the increased feed requirement of birds. The canals are being stocked with fishes and apple snails to support the increased feed requirement of birds. The fish diversity (8 fish species) within the canal system consists mainly Tilapias (*O. niloticus* and *O. mossambicus*), *Amblypharyngodon mola*, *Hypophthalmichthys nobilis*, *Chanda nama*, *Labeo catla*, *Puntius sophore*, *Pethia conchonius*, *Labeo rohita*, *Chanda* spp, *Mystus* spp, etc. The fish diversity of connected rivers River Kulik and River Nager were explored and 62 and 41 fish species were recorded respectively, though most of the fishes were small-sized and the fish catch from the river is meagre and do not form a commercially viable fishery. As per report Tilapia fish was introduced in Kulik BS through stocking is proliferating and has establishes breeding populations in the wetland so get good amount of feed for birds. The fish diversity of River Kulik was explored and 62 fish species were recorded, though most of the fishes were small-sized and the fish catch from the river is meagre and do not form a commercially viable fishery. The local fishers employ traditional fishing gears like traps ('Dhol') which catch mostly prawns, spiny eels and other fishes. The diversity of connected river, River Nagar was also explored by fish market surveys.



Figure 25. Collection of fish for diversity and abundance study from Experimental fishing with Cast net



Figure 26. Catch of Indigenous fish including stocked fish Tilapia in experimental fishing using cast net



Figure 27. Fishing at Kulik River using 1) gill net 2) Trap



Figure 28. Fish diversity of Kulik and Nagar river collected from Subhasganj and Devinagar market

This fish shown above photographs are catch of Kulik river. This is fish landing centre and fish market of River Kulik at Subhashgunj. The fish diversity of this site is consists of mainly *Amblypharyngodon mola*, *Ompok bimaculatur*, *Macrognathus ara*, *Mastacembelus armatus*, *Labeo bata*, *Puntius* spp, *Pethia* spp, *Catla catla*, *Labeo rohita*, freshwater parwn , *crab* etc. This fish has been caught from Kulik river using varius nets and traps most efficient gear used in Kuilk river is tarp ('*Dhol*') which catch mostly prawns, spiny eels and other fishes. The diversity of connected river, River Nagar was also explored by fish market surveys. They are catching fish daily for sustaining their livelihood.



Figure 29. Dhol trap used in River Kulik

Traps are impounding devices into which an organism is lured either for food or shelter and are unable to escape. There are a wide variety of fish trapping devices and methods operated in the rivers and wetlands. ‘Dhol’ is an indigenous fish trap, popularly used by fishers in River Kulik, flowing through the Uttar Dinajpur district of West Bengal. It is a cylindrical shaped fishing gear, made of metallic and bamboo frames and nylon netting. In the currently prevalent version of Dhol, circular iron frames are used in the both ends of the trap and these frames are horizontally connected by around 10 numbers of bamboo splitters. The metal frames and bamboo splitters form the main skeleton of the trap that prevent losing their shape during fishing. The outer covering of the trap is the fine mesh netting made of nylon. Dhol is a single funnel trap where there is an inside funnel or entrance leading to catch collecting area, which is made of circular iron frame and fine mesh netting. There is a long wall of netting with a length of 3.5- 4 m, tied perpendicular to the open side of trap that helps in driving the fishes towards the trap and improves the catch. The length of Dhol varies slightly around 90 cm to 1m and the outer diameter is around 65 cm whereas the inner funnel diameter is around 12 cm. Like any other trap design, Dhols are also passive fishing gears and are designed in such a way that the fish can enter voluntarily into the passage but the same passage becomes a non- return device and the fish get trapped. Dhols are operated both with and without baits and wheat doughs are commonly used as the baits. The local fishers employ this traditional fishing gear to catch mostly prawns, spiny eels and other native fishes. Fishers use small canoes to deploy the Dhols in suitable fishing areas, typically in proximity to banks and river stretches rich in vegetations, in the evening hours and are collected back in morning hours. These traps are selective fishing gears which can be used for sustainable fishing in the region, which are economical and have energy related advantages over active fishing methods.



Figure 30. On field fish identification, biology study and preservation of sample for laboratory study

10. Systematic Account of fish species recorded and species description

Phylum CHORDATA

Class OSTEICHTHYES-bony fishes

Subclass ACTINOPTERYGII – ray-finned fishes

Superorder OSTEOGLOSSOMORPHA

Order OSTEOGLOSSIFORMES

Superorder OSTARIOPHYSI

Order CYPRINIFORMES

Family CYPRINIDAE

31. *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 hyline.
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

32. *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.
W	
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

Subseries OVALENTARIA

Family AMBASSIDAE

33. *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

34. *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

35. *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.



36. *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.



37. *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.



38. *Oreochromis mossambicus* (Peters 1852)

Family Cichlidae

Common name:	Mozambique tilapia
Habitat:	Freshwater; brackish; benthopelagic; potamodromous. Occurs in a wide variety of freshwater habitats like rivers, lakes, sewage canals and irrigation channels
Distribution:	Africa: naturally occurring in coastal rivers of Israel, Nile basin. Widely introduced for aquaculture, with many existing strains.
Food Habit:	Feeds mainly on phytoplankton or benthic algae. Additionally, insect larvae are of some importance, as are aufwuchs and detritus; juveniles tend to be more omnivorous than adults
Reproductive Traits	Oviparous. Ovophilic, males dig simple pits in shallow water. A maternal mouthbrooder.
Taxonomic description:	Dorsal spines: 15 - 18; Dorsal soft rays: 11-13; Anal spines: 3; Anal soft rays: 9 - 11; Vertebrae: 30 - 32. A large deep-bodied tilapia, with a relatively small head. Jaws of mature male not greatly enlarged, length of lower jaw 29-37% of head length. Most distinguishing characteristic is the presence of black bars that extend from the blotches to dorsal fins, at all life stages, of regular vertical stripes throughout depth of caudal fin
Species Prospects	Several countries report adverse ecological impact after introduction.



Different size of Oreochromis mossambicus

11. Ecosysytem services

1. Bird roosting

The Asian open bill stork is the one of the largest wading bird of family Ciconiidae. This stork are mainly found in South East Asia. This fish migrate to Raiganj Bird sanctuary in fovourable weather in search of food and habitat for breeding. As per the information given by the officials of Rainganj Bird sanctuary, Asian open bill stork feed mailly on snails.



Figure 39. Birding of migratory birds: Asian open bill stork

2. Tourism and education

The sanctuary has been carefully designed to create and protect natural habitats that support a diverse range of bird species, including both resident and migratory birds. The concept behind the establishment of this sanctuary is not only to conserve bird populations but also to restore and maintain their natural habitats, ensuring a sustainable environment for their survival. Visitors, including wildlife enthusiasts, bird watchers, and conservationists, are drawn to the sanctuary to witness the rich avian biodiversity and experience the beauty of a well-preserved wetland ecosystem. School and college students frequently visit as part of educational tours and nature study programs, where they gain valuable insights into wildlife conservation, wetland ecology,

and the importance of preserving biodiversity. Additionally, researchers, academicians, and environmentalists utilize the sanctuary for scientific studies on bird behavior, migration patterns, habitat ecology, and the interaction between flora and fauna. The presence of diverse species of birds, fish, macrophytes, and plankton makes Kulik Bird Sanctuary an ideal location for ecological research. Environmentalists and conservationists visit the sanctuary to assess the impact of human activities, climate change, and habitat alterations on bird populations and wetland health. The sanctuary also serves as a living laboratory for studying biodiversity conservation strategies and sustainable wetland management.



Figure 40. Natural habitat for Bird resting, feeding and breeding

3. Forest plantation

Forest plantation in Kulik Bird Sanctuary plays a vital role in maintaining ecological balance, providing shelter, nesting sites, and food sources for various bird species, particularly the thousands of migratory birds that visit the sanctuary each year. The plantation efforts focus on increasing the green cover with native tree species such as Kadamba (*Neolamarckia cadamba*), Arjun (*Terminalia arjuna*), and Acacia (*Acacia auriculiformis*), which enhance biodiversity and improve habitat quality. These trees not only support avian life but also contribute to soil stabilization, carbon sequestration, and climate regulation within the sanctuary. Additionally, plantations of bamboo and fruit-bearing trees provide food for frugivorous birds and mammals,

further enriching the ecosystem. The forested areas act as buffer zones, protecting the wetland from external disturbances, including agricultural runoff, pollution, and habitat encroachment.



Figure 41. Forestation is continuous process for keeping natural habitat maintained for birding

12. Stakeholder's meeting

The project work was initiated by visiting Directorate of forests office of the Divisional Forest Officer, Raiganj Division, Uttar and Dakshin Dinajpur, District of West Bengal. We have interacted with the District fisheries Officer and range officer about our project work and requested for their cooperation during project work. We have also discussed regarding the establishment and availability of the birds' species and their number, their residential periods and also regarding fisheries activities.



Figure 42. Meeting with District Forest offices and range offices

13. Challenges in the protected habitat of Kulik Bird sanctuaries

Approximately one lakh birds visit every year in this sanctuary and stay for 7-8 months. Feeding of birds is major challenge is notices. To overcome these challenges the forest department has been stocking mozambic tilapia with other species such as big head carp and other carps. *Pethia*, *Puntius* and *Amblypharyngodon* are self-recruiting but insufficient to feed the fishes. The manmade wetland channeled from the Kulik river has been challenging to keep water level maintained due to less rainfall in year 2022.



Figure 43. Challenges of Protected habitat of Kulik bird sanctuary

14. Recommendations

1. Maintain Water Levels by Removing Silt and Excess Deposition

The accumulation of silt and excess sediment deposition in the water channels of the wetland can lead to reduced water depth, poor water circulation, and habitat degradation. Periodic desilting and dredging should be carried out to maintain an optimal water level, ensuring sufficient aquatic habitat for fish, amphibians, and invertebrates that serve as food for birds. Proper sediment management will also help prevent water stagnation, which can lead to low oxygen levels and reduced biodiversity.

2. Removal of Debris from Leaf Litter in Water

Large amounts of leaf litter from trees surrounding the wetland can accumulate in the water body, leading to organic matter decomposition that reduces oxygen levels and increases nutrient loading. This can contribute to excessive algal growth, poor water quality, and unfavorable conditions for aquatic organisms. Regular manual or mechanical removal of debris should be undertaken to prevent clogging of channels, maintain water flow, and sustain a healthy aquatic environment.

3. Maintain Minimum Dissolved Oxygen Concentration (>5 ppm) in the Man-Made Wetland

Dissolved oxygen (DO) is a critical factor for the survival of aquatic life, including fish and invertebrates that serve as food for birds. Oxygen levels below 5 ppm can lead to fish kills and habitat degradation. To maintain adequate DO levels, aeration methods such as water circulation pumps, fountains, or introducing aquatic macrophytes like submerged plants should be considered. Reducing organic pollution, controlling excessive algal growth, and maintaining adequate water depth will also help sustain oxygen levels.

4. Application of Lime to Stabilize Water pH

The water pH significantly affects aquatic biodiversity, influencing the survival of fish, invertebrates, and aquatic plants. Lime should be applied based on pH levels:

- If pH is between 6.0 and 6.5, apply lime at 200–250 kg/ha to maintain water quality.
- If pH drops below 6.0, increase the lime application to 500 kg/ha to neutralize acidity and create a stable environment for aquatic organisms.
- Regular pH monitoring should be conducted to determine the appropriate lime dosage and avoid overuse, which can negatively impact water chemistry.

5. Develop a Species-Specific Action Plan for Migratory Bird Conservation

Migratory birds require specific habitat conditions, food availability, and nesting sites for successful seasonal visits. A species-specific conservation plan should be developed, focusing on habitat protection, food supply, and disturbance reduction. This may include planting preferred vegetation, maintaining water depth, controlling human interference, and reducing noise pollution to ensure migratory birds find a suitable environment in the sanctuary.

6. Prioritize the Protection of Natural Habitat

The natural ecosystem of Kulik Bird Sanctuary should be preserved and protected from urbanization, agricultural expansion, pollution, and deforestation. Special attention should be given to safeguarding wetland vegetation, maintaining natural water sources, and preventing encroachment. Strengthening buffer zones around the wetland and controlling pollution, and tree-cutting activities are essential for long-term ecological stability.

7. Stocking Indigenous Fish Species for Bird Consumption

Birds depend on native fish species as a primary food source. Stocking indigenous fish such as *Amblypharyngodon mola*, *Puntius sophore*, *Labeo bata*, and *Cirrhinus reba* will support the diet of wetland birds. Exotic species such as Tilapia (*Oreochromis niloticus*) and Bighead Carp (*Hypophthalmichthys nobilis*) should be strictly avoided, as they can compete with native species, disrupt ecological balance, and degrade wetland habitats. Regular fish population assessments should be conducted to ensure sustainable stocking levels.

8. Ensure Sufficient Production of Snails to Meet Bird Dietary Needs

Snails form an important component of the diet for certain bird species, such as waders, ibises, and storks. To maintain an adequate food supply, snail populations should be monitored and managed effectively. Measures should be taken to encourage their natural growth and prevent overharvesting by humans or excessive predation by fish.

9. Create a Suitable Environment for Snail Abundance and Production

The growth and survival of snails depend on various environmental factors, including temperature, substrate composition, aquatic macrophytes, and water quality. Ensuring an adequate supply of soft aquatic plants (such as *Hydrilla* and *Vallisneria*), maintaining stable water levels, and protecting wetland sediments can significantly improve snail populations. Additionally, snails thrive in areas with muddy or organic-rich sediments, so minimizing habitat disturbances and ensuring the availability of calcium-rich substrates will further enhance their reproduction and sustainability.



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