Evaluation of Fish Biodiversity and Conservation Strategies in Kaptai Lake: The Preeminent Manmade Lake of Bangladesh

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Abstract: Kaptai Lake, recognized as Bangladesh's largest human-created reservoir, is a key freshwater fishery sustaining numerous aquatic species and resources. This study, conducted from March 2021 to February 2022, aimed to evaluate fish biodiversity and conservation status in the lake through field surveys, interviews, and secondary data. A total of 74 finfish species, 13 exotic species, and 9 shellfish (including 7 prawns, 1 crab, and 1 tortoise) were identified. The predominant species were *Gudusia chapra*, *Corica soborna*, and *Mystus aor*. The most abundant crustaceans were *Macrobrachium rosenbergii*. Out of 54 nationally threatened fish species in Bangladesh, 20 were identified in the lake: 7 classified as vulnerable, 10 as endangered, and 3 as critically endangered. Biodiversity indices indicated moderate diversity (Shannon-Weiner index H = 1.145; Margalef's richness d = 1.77). Species dominance by *Chapila* and *Kachki* reflects ecological imbalance, while carp and commercial fish production are declining. Major threats include habitat degradation, illegal fishing, invasive species, and pollution. To sustain fish diversity, the study recommends enhanced conservation, strict regulation, habitat restoration, and sustainable fishing practices. These findings offer crucial insights for sustainable fisheries management in Kaptai Lake and similar ecosystems.

Keywords: Kaptai Lake, Fish Biodiversity, Diversity indices, Threats, Sustainable Fisheries Conservation

INTRODUCTION

Bangladesh is a biological hotspot that contains over 265 fish species (Hussain et al. 2010), representing it one of the richest countries in terms of aquatic biodiversity. This vast diversity plays a crucial role in sustaining the livelihoods of millions of people, depending on fishing and aquaculture for income generation and nutrition source. Freshwater fisheries play an important role in the nation's food supply, providing a cheap source protein for the consumers. The sector has become a crucial and growing component of nation's economy, having the potential to evolve into a sustainable and thriving economic division. The sector has had significant expansion, accounting for 2.81% of the total GDP and ranking second in inland capture fisheries (DoF, 2025).

Kaptai Lake is the largest manmade freshwater reservoir in Southeast Asia, situated in the Rangamati district of Bangladesh. It was established in 1961 by damming the Karnaphuli River, principally for hydroelectric power generation (Bashar et al., 2015). It covers an area of about 58,300 hectares (or 68,800 hectares when considering the entire supply), making it the largest inland water body in the region, accounting for more than 19% of the total inland water bodies (Shalehin et al., 2020). Kaptai Lake is very crucial for its main role in hydroelectric power production. Beyond its main role, also contributes to flood control, navigation, and irrigation for agricultural lands, along with additional advantages like supporting fisheries production (Hanif et al., 2020). In the period spanning 2022 to

2023, Kaptai Lake reached a fish production total of 17,937 MT (Lima et al., 2023). This reservoir is acknowledged as one of the most diverse in Bangladesh and is receiving recognition for its carp reproductive areas (Hussain et al., 2010). Additionally, it serves as an essential habitat for small indigenous species (SIS), with approximately 143 species of fish identified as SIS in Bangladesh. Nonetheless, in spite of the extensive variety of fish species, a significant number of them have yet to be evaluated (Hanif et al., 2020).

Kaptai Lake harbors 66 native fish species over 17 distinct groups, in addition to two exotic species and two prawn species (Suman et al. 2021). Among them, 36 species of fish are exploited for commercial purposes. Some species include the chapila (*Gudusia chapra*), the kechki (*Corica soborna*), the ayre (*Mystus aor*), the kuncho chingri (*Macrobrachium lamarrei*), the kajoli (*Ailia coila*), the mola (*Amblypharyngodon mola*), the tilapia (*Oreochromis mossambicus*), the nailotica (*Oreochromis niloticus*), and the bata (*Labeo bata*) (Shalehin et al., 2020). Although carp species were historically the principal contributors to fish output, two clupeid species, chapila (*Gudusia chapra*) and kechki (*Corica saborna*), have recently gained prominence, now representing over 30% of the entire fish production in Kaptai Lake. Nonetheless, the output of primary carp species and high-value fish has been declining over time (Shalehin et al., 2022).

Kaptai Lake is an essential freshwater resource in Southeast Asia, providing water provision to riparian villages, navigation to remote areas, freshwater fisheries, and flow regulation for the Chattogram city and seaport, in addition to hydropower generation (Haque et al., 2018).Small-scale fisheries are supported by the lake, which is home to a wide variety of fish species.

Nevertheless, Kaptai Lake has been considerably influenced by several of human activities, including land-use changes, habitation, inland navigation, tourism, and construction activities such as road and bridge construction in recent years (Karmakar et al., 2019). The Bangladesh Fisheries Development Corporation (BFDC) has no control over the water level, although fisheries are the second-largest sector in Kaptai Lake (Ahmed et al., 2005b). Despite the fact that it offers a plethora of ecological advantages to society and is home to a diverse aquatic ecosystem, the sustainability of its wetland ecosystems is at risk due to the numerous challenges that the lake's biodiversity is currently facing from both natural and anthropogenic stressors (Suman et al., 2021; Rayhan et al., 2021) have primarily concentrated on primary productivity, lake management, and population biology for a limited number of species in previous research on the Kaptai Lake. The primary focus of current research on this lake is the determination of primary productivity, lake management, and population dynamics of a few species, such as *Labeo rohita* and *Amblypharyngodon mola* (Ahmed et al., 2005a). Nevertheless, no research has been conducted to determine the current state of the fish diversity in the lake. Finding out more about the fish species and problems they may be facing was the main goal of the research. This study highlighted various aspects of fish production, potential hazards, conservation status, and associated management issues relevant to sustainable of the lake. These insights can be employed to develop effective management strategies that are designed to sustainably preserve the lake's resources and may have a more widespread impact on the management of freshwater fisheries in other regions.

Materials and Methods

Study area

The present investigation was conducted at three distinct locations within the Kaptai Lake in the Rangamati area, which are selected for its abundant, diverse fish species and high productivity. It is geographical positioned at Latitude 22°09'N and Longitude 92°17'E, has submerged nearly the entirety of the central Karnafuli valley along with the lower sections of the Chengi, Kasalong, and Rinkhyong Rivers. (Fig. 1).

Study period

The data were collected concerning fisheries, especially fisheries biodiversity and its production of the Kaptai Reservoir for one year from March 2021 to February 2022.

Data collection

Primary data were collected in accordance with standardized field protocols using a structured interview design. Three purpose-built questionnaires were administered to retailers, aratdars (commission agent who owns a warehouse and acts as a middleman for the stocking and selling of fish), and beparis (trader or merchant, especially one who buys and sells fish for profit) . To complement these data, pertinent records from non-governmental organizations, independent agencies, and government bodies were reviewed. Information was obtained from fishers, Bangladesh Fisheries Development Corporation (BFDC) fish marketing officer, and the BFDC logbook.

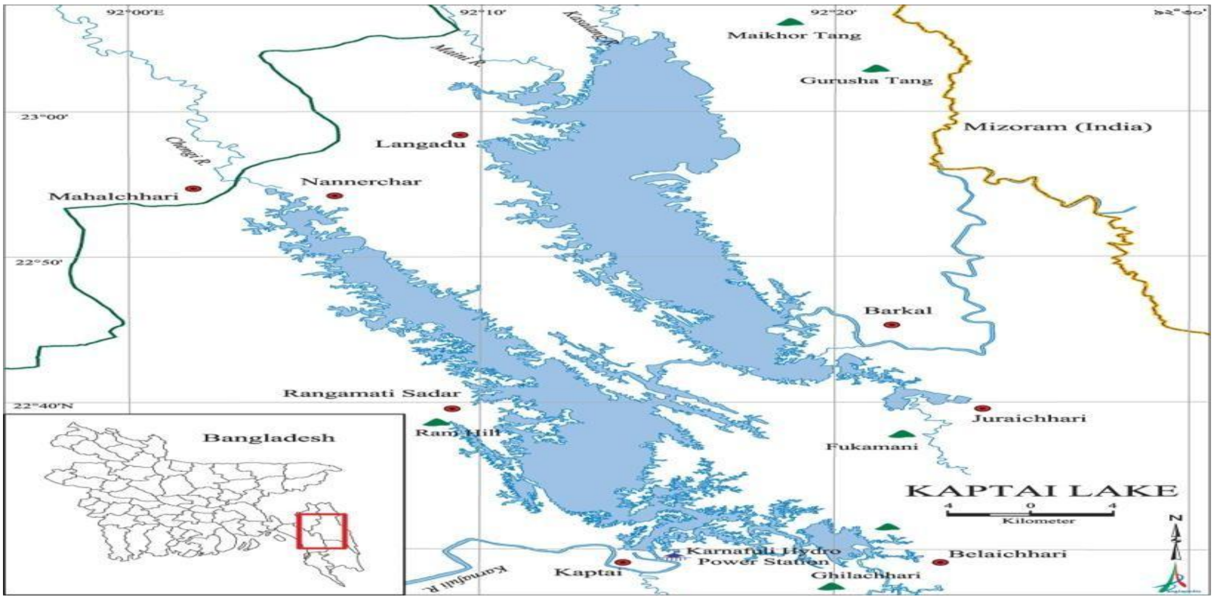


Fig. 1. Spatial position of the study area in Kaptai Lake, Rangamati District, Bangladesh.

Data on lake management and problems

Ten focus group discussions (FGDs) with professional anglers and interviews with BFDC personnel were conducted to identify possible factors for the reduction of fish diversity and its management aspects. In addition, direct visits to different parts of the lake were also conducted to observe anthropogenic pressure.

Data analysis

After completing the field survey, the raw data were carefully checked for possible errors and inconsistencies. Monthly reviews were carried out to maintain uniformity, during which the information was edited and processed. Following verification, all data were merged into a unified sheet to facilitate systematic tabulation and analysis. Tables were then generated to align with the study's objectives, as this format is widely accepted for clarity and ease of interpretation (Creswell et al., 2018). The survey responses were organized, categorized, and analyzed according to the selected parameters, with numerical records treated separately. The finalized dataset was further summarized, and graphical illustrations were produced using MS Excel and MS Word to support the analysis.

Fish abundance and biodiversity status analysis

To evaluate the diversity and distribution of fish species, the analysis incorporated a range of ecological indices such as Shannon–Wiener (H), Simpson's dominance (D), Simpson's diversity (1–D), Margalef's richness (d), and evenness (E) following by:

Shannon-Weiner diversity index: $H' = -\sum[(pi)\times\log(pi)]$.

Define Pi as n/N, where n represents the number of individuals in each species and N represents the total number of individuals in all species.

Simpson's dominance index: D = Σni(ni-1) / N(N-1).

The sample is composed of N individuals for all species and ni individuals for each species.

Simpson's diversity indicator: 1-D = 1 - ni(ni-1) / N(N-1)

Evenness index: E= H/lnS, where H depicts the diversity index and S symbolizes the total species count.

Margalef's richness index: d = (S-1)/ln. N

S represents the total count of species, while N denotes the total count of individuals.

Results and Discussion

Fish biodiversity assessment

Table 1 represents the catch abundance of Kaptai Lake in terms of annual production. Among the recored fish species, the most abundant species were Chapila (*Gudusia chapra*) and Kachki (*Corica soborna*) whose annual production were 116.398 MT & 975.38 MT, respectively, contributing 47% and 39% of the total fish production (Fig. 2). Conversely, the lowest productions were found for silver carp, mrigal, and chital, with annual productions of 1.589 MT, 2.390 MT, 2.392 MT & 2.392 MT, respectively.

A total of 74 finfish species were documented, of which 30 were predominantly available in winter (WN), 19 in summer (SM), and the remaining 26 occurred year-round (TY). All exotic species recorded were freshwater in origin and remained present throughout the year, largely due to continuous culture practices by local fish farmers. A total of nine shellfish species were recorded, many of which were commonly observed in local markets and at landing sites. Detailed lists of freshwater, marine, crustacean, and exotic species including their scientific, family, common, and local names were presented in Tables 2, 3, and 4.

The analysis further indicated that species richness and abundance were highest within the order Cypriniformes (Table 4). Earlier worked by Mohammad et al. (2024) identified 80 fish species representing the 11 orders and 28 families where Cypriniformes had the highest percentage (38.75%), and ranged from 1.25% to 22.50% for the other orders in Kaptai Lake that showing species diversity either matching or surpassing that of this study.

A diverse assemblage of freshwater finfish and crustaceans was documented in Rangamati town and its surrounding areas during the study period. These species were primarily sourced from rivers, creeks, and Kaptai Lake within the greater Rangamati district. Dominant taxa included *Gudusia chapra* (Chapila), *Labeo bata* (Bata), *Gonialosa manmina* (Chapila), *Corica soborna* (Kachki), *Mystus aor* (Air), *Macrobrachium lamarrei* (Kuncho chingri), *Ailia coila* (Kajoli), *Amblypharyngodon mola* (Mola), and *Oreochromis mossambicus* (Tilapia) (Fig. 2).

In the present study, 20 threatened fish species were documented out of 54 taxa recognized as threatened by IUCN Bangladesh (2015), comprising seven vulnerable, ten endangered, and three critically endangered species in Kaptai Lake. Earlier research by (Alam et al., 2004; Basak et al. 2016) reported 73 fish species belonging to 47 genera and 25 families, along with two prawn species and one dolphin. Both historical and current surveys highlighted *Corica soborna* (Kachki), *Gudusia chapra* (Chapila), *Mystus aor* (Air), *Notopterus notopterus* (Foli), *Oreochromis niloticus* (Nilotica), *Macrobrachium lamarrrei* (Kuncho chingri), and *Labeo gonius* (Ghoria) as dominant taxa. Of the 20 threatened species recorded in this study, 16 (29.6%) were relatively abundant, suggesting that certain taxa categorized as threatened at the national level may still sustain viable populations within the lake. For example, *N. notopterus* (Foli), *Sperata aor* (Air), *Ailia coila* (Kajoli), and *Puntius ticto* (Punti) were commonly observed, whereas critically endangered or regionally extinct species such as *Silonia silondia*, *Bagarius bagarius*, *Tor tor*, *Otolithoides pama*, and *Clupisoma goura* were absent. In addition, some species, including *Setipinna phasa*, *Ompok bimaculatus*, *Puntius sophore*, *P. sarana*, *Chanda nama*, and *Cirrhinus reba* were recorded only in low numbers, indicating possible localized declines.

In addition to finfish, nine shellfish species were recorded at the Rangamati landing centers during the study, whereas (Basak et al., 2016) documented 11 species from the same sites. The study further revealed that 13 exotic freshwater fish species were actively cultivated by commercial farmers, ensuring their availability throughout the year.

Table 1. Diversity and harvest amounts of fish species documented in Kaptai Lake

Local Name	Common Name	Scientific Name	Total amount of catch (MT)	% of the total catch
Chapila	Indian River shad	*Gudusia chapra*	1,177.40	46.89%
Kachki	Ganga river	*Corica saborna*	975.376	38.84%
Mola	Mola carplet	*Amblypharyngodon mola*	61.585	2.45%
Kuchu chingri	Yellow shrimp	*Metapenaeus brevicornis*	42.254	1.68%
Kata Moilla	Indian carplet	*Amblypharyngodon microlepis*	38.456	1.53%
Kazuli	Gangeticalilia	*Ailia colia*	28.061	1.38%
Ayre	Long-whiskered catfish	*Sperata aor*	34.716	1.12%
Bailya	Scribbled goby	*Awaous guamensis*	16.587	0.66%
Foli	Bronze featherback	*Notopterus notopterus*	16.25	0.65%
Shol	Striped snakehead	*Channa striatus*	14.63	0.58%
Kalo tengra	Tengra catfish	*Batasio tengara*	14.552	0.58%
Tilapia	Mozambique tilapia	*Oreochromis mossambicus*	11.976	0.48%
Boal	Freshwater shark	*Wallaga attu*	11.892	0.47%
Kalibaus	Orange-fin labeo	*Labeo calbasu*	11.058	0.44%
Gozar	Giant snakehead	*Channa marulius*	8.478	0.34%
Baim	Zig-zag eel	*Mastacembellus armatus*	7.739	0.31%
Bata	Bata	*Labeo bata*	6.727	0.27%
Tengra	Assamese batasio	*Batasio tengana*	5.483	0.22%
Pabda	Pabo catfish	*Ompak pabo*	5.145	0.20%
Shing	Stinging catfish	*Heteropneustes fossilis*	4.912	0.20%
Catla	Catla	*Catla catla*	4.666	0.19%
Grass Carp	Grass Carp	*Ctenopharyngodon idella*	4.009	0.16%
Rui	Rohu	*Labeo rohita*	2.715	0.11%
Chital	Humped featherback	*Notopterus chital*	2.392	0.10%
Mrigal	Mrigal	*Cirrhinus cirrhosus*	2.39	0.10%
Silver Carp	Silver Carp	*Hypophthalmichthys molitrix*	1.589	0.06%

Table 2. Checklist of crustacean species documented in the Kaptai Lake

Local Name	English Name	Scientific Name	Taxonomic family	Seasonal availability
Golda chingri	Freshwater Prawn	*Macrobrachium rosenbergii*	Palaemonidae	TY
Chatka chingri	Monsoon river prawn	*Macrobrachium malcolmsonii*	Palaemonidae	TY
Gura chingri	Spider Prawn	*Nematopalaernon tenuipes*	Palaemonidae	TY
Bagda chingri	Giant tiger Shrimp	*Penaeus monodon*	Penaeidae	TY
Chaka chingri	Indian white Shrimp	*Penaeus indicus*	Penaeidae	TY
Horina chingri	Brown Shrimp	*Metapenaeus monoceros*	Penaeidae	TY
Shela kakra	Mud crab	*Scylla serrata*	Portunidae	TY
Pond tortoise	Kasim	*Melanochelys trijuga*	Bataguridae	TY

WN (winter), SM (summer), TY (Throughout the Year)

Table 3. Native fish species recorded in Kaptai Lake and their national conservation status

Native fish species				
Order	**Family**	**Species**	**Conservation**	**Availability**
Beloniformes	Belonidae	*Xenentodon cancila* (Hamilton, 1822)	Least Concern	Common
Clupeiformes	Clupeidae	*Gudusia chapra* (Hamilton, 1822)	Vulnerable	Very Common
		Gonialosa manmina (Hamilton, 1822)	Least Concern	Common
		Corica soborna Hamilton, 1822	Least Concern	Very Common
Cypriniformes	Cyprinidae	*Labeo gonius* (Hamilton, 1822)	Near Threatened	Rare
		Labeo calbasu (Hamilton, 1822)	Least Concern	Very Common
		Labeo bata (Hamilton, 1822)	Least Concern	Common
		Gibelion catla (Hamilton, 1822)	Least Concern	Very Common
		Cirrhinus cirrhosus (Hamilton, 1822)	Near Threatened	Common
		Pethia ticto (Hamilton, 1822)	Vulnerable	Rare
		Labeo rohita (Hamilton, 1822)	Least Concern	Very Common
		Puntius chola (Hamilton, 1822)	Least Concern	Common
		Puntius sophore (Hamilton, 1822) LC C	Least Concern	Common
		Amblypharyngodon mola (Hamilton, 1822)	Least Concern	Common

	Nemacheilidae	*Paracanthocobitis zonalternans (Blyth, 1860)*	Least Concern	Rare
	Cobitidae	*Lepidocephalichthys guntea (Hamilton, 1822)*	Least Concern	Common
	Botiidae	*Botia dario (Hamilton, 1822)*	Endangered	Rare
Osteoglossiformes	Notopteridae	*Notopterus notopterus (Pallas, 1769)*	Vulnerable	Common
	Anabantidae	*Anabas testudineus (Bloch, 1792)*	Least Concern	Low Availability
	Ambassidae	*Chanda nama Hamilton, 1822*	Least Concern	Low Availability
	Channidae	*Channa striata (Bloch, 1793)*	Least Concern	Common
Perciformes				
		Channa marulius (Hamilton, 1822)	Endangered	Very Common
	Osphronemidae	*Trichogaster lalius (Hamilton, 1822)*	Least Concern	Low Availability
	Gobiidae	*Glossogobius giuris (Hamilton, 1822)*	Least Concern	Common
	Ailiidae	*Ailia coila (Hamilton, 1822)*	Least Concern	Common
	Clariidae	*Clarias magur (Hamilton, 1822)*	Least Concern	Very Common
	Heteropneustidae	*Heteropneustes fossilis (Bloch, 1794)*	Least Concern	Very Common
	Bagridae	*Mystus cavasius (Hamilton, 1822)*	Near Threatened	Common
Siluriformes		*Mystus vittatus (Bloch, 1794)*	Least Concern	Common
	Pangasiidae	*Pangasius pangasius (Hamilton, 1822)*	Endangered	Rare
	Schilbeidae	*Eutropiichthys vacha (Hamilton, 1822)*	Least Concern	Common
	Siluridae	*Wallago attu (Bloch & Schneider, 1801)*	Vulnerable	Common
		Ompok pabda (Hamilton, 1822)	Endangered	Common
Synbranchiformes	Mastacembelidae	*Macrognathus aculeatus (Bloch, 1786)*	Near Threatened	Common
	Synbranchidae	*Monopterus cuchia (Hamilton, 1822)*	Vulnerable	Low Availability

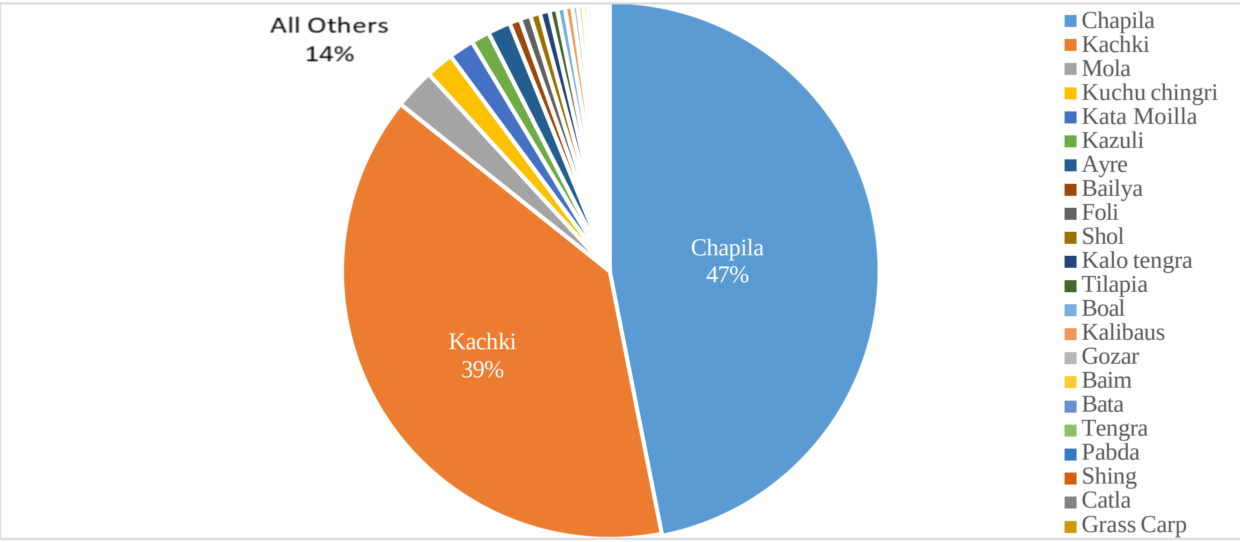


Fig.2. Proportional catch composition of different fish species in Kaptai Lake

Seasonal variation of fish species

An analysis of the total production in different months shows that the highest amount of catch was found after the ban period in September (650.731 MT) and October 2021 (478.190 MT) and the lowest in May before the ban period. Fig. 3. Illustrates the seasonal dynamics of fish abundance in Kaptai Lake. Water levels were lowest in January, coinciding with the minimum fish availability. Abundance peaked in September, followed by a steady decline through December and January, before gradually increasing again from March onward. Overall, catches were comparatively reduced during the winter months (December–January).

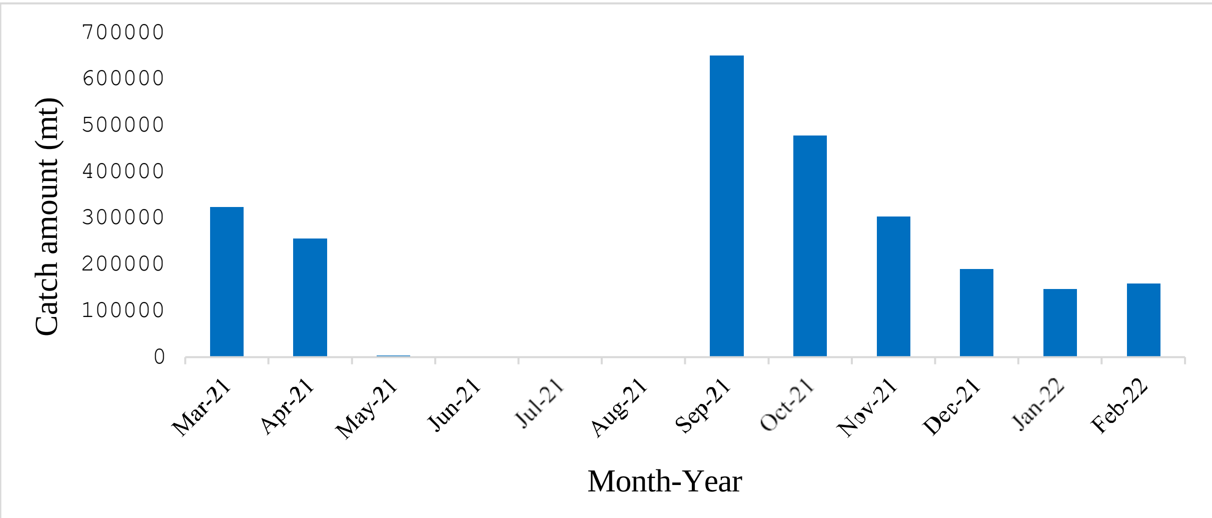


Fig.3. Temporal variation in monthly fish catch composition from Kaptai Lake

Present trends of fish production

Kaptai Lake has remained one of the most productive inland fisheries in Bangladesh, generating substantial yields annually. Data from the Bangladesh Fisheries Development Corporation (BFDC) indicated that over the last 14 years, the highest production was recorded in 2021–2022 (12,696 MT), whereas the lowest occurred in 2008–2009 (5,578 MT). Overall, the catch trend has shown a steady increase, with small indigenous fishes and catfishes representing the dominant groups. Historical assessments by the Bangladesh Fisheries Research Institute (BFRI) suggested that major carps (*Labeo rohita*, *Catla catla*, *Cirrhinus cirrhosus*, etc.) accounted for nearly 81% of the total harvest in 1965–1966 (Ahmed et al., 2002). However, this proportion has drastically declined to approximately 5% over the past four decades, despite continuous annual stocking of carp fingerlings. In contrast, the contribution of small clupeids, particularly *Gudusia chapra* (Chapila) and *Corica soborna* (Kachki), has risen sharply and now constitutes about 90% of the total catch. The reduced production of carps and other commercially important species can largely be attributed to the overwhelming dominance of these two clupeid species. Apart from Chapila and Kachki, 24 additional fish species collectively contribute about 14% of the lake's total output. Notably, the present study revealed that *Amblypharyngodon mola* alone accounted for 61,585 MT, highlighting its growing significance in the fishery.

Table 4. Trends of total fish production in Kaptai Lake from 1965–1966 to 2021–2022.

Production capacity (kg.ha⁻¹)	Contribution of major species to total yield (%)	Total production (MT)	Year	References
221.58	Ganges river gizzard shad, Indian River shad, and Ganges river sprat: 69.76 % Carpet: 2.01 % Carp: 1.06 %	12,696	2021-2022	In this study
181.42 [1] Ganges River gizzard shad, [2]Indian river shad and [3]Ganges river sprat: 115.68 [4]Carplet: 5.46 [5]Carp: 2.83	Ganges river gizzard shad, Indian river shad and Ganges river sprat: 63.76 % Carplet: 3.01 % Carp: 1.56 %	10,577	2018–2019	(Suman et al., 2021)
141.28	Carp: 4 % Ganges river sprat, Ganges river gizzard shad, Indian river shad, Pabdah catfish and Butter catfish: 92 %	8,248	2007–2008	(Bashar et al., 2014)
81.5 Ganges river gizzard shad, Indian River shad, and Ganges river sprat: 32	Ganges river gizzard shad, Indian River shad, and Ganges river sprat: 63.4 %; Carp: 5.1 %	4,751	2000–2001	(Ahmed et al., 2006)
-	Ganges river gizzard shad, Indian river shad and Ganges river sprat: 65.0 % Carp: 6.42 %	-	1998–1999	(Ahmed et al., 2003)
20.58	Carp: 81 %; Ganges river gizzard shad, Indian river shad, Ganges river sprat, [6]Pabda catfish and [7]Butter catfish: 3 %	1200	1965–1966	(Ahmed et al., 2002)

[1]Ganges river gizzard shad *(Gonialosa manmina*), [2] Indian river shad (*Gudusia chapra*), [3]Ganges river sprat *(Corica soborna*), [4]carplet (*Amblypharyngodon microlepis*, *Amblypharyngodon mola*), [5]Carp (*Labeo calbasu*, *Gibelion catla*, *Labeo rohita*, *Cirrhinus cirrhosis*, *Labeo gonius*, *Labeo bata*), [6]Pabdah catfish *(Ompok pabda*), [7]Butter catfish (*Ompok bimaculatus*).

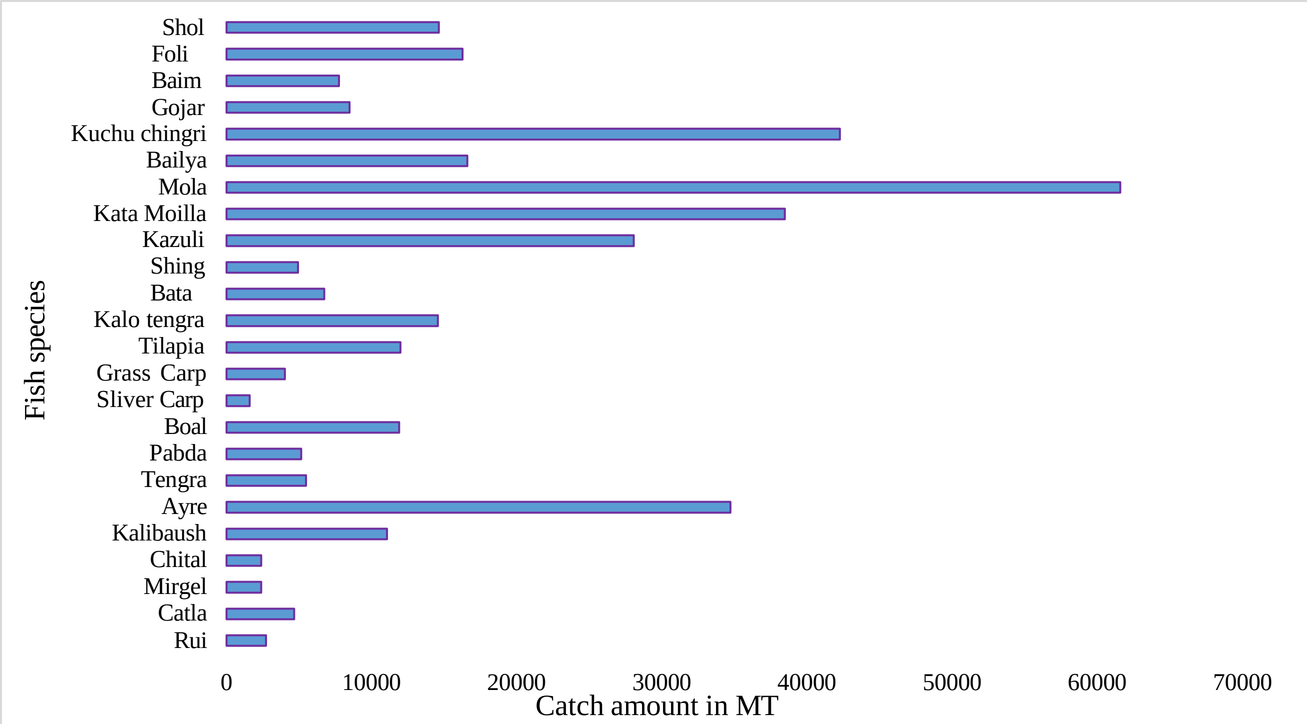


Fig.4. Abundance of other fish in Kaptai Lake

Abundance of catfishes and carnivorous species

In the present study, the catch amount of catfish species in Kaptai Lake was highest in April (17.452 MT) and after the ban period in September (11.825 MT). The annual total production of catfish species in Kaptai Lake was 62.148 MT, among these *Sperata aor* (34.716 MT), *Wallaga attu* (11.892 MT), *Ompak pabo* (5.145 MT), *Heteropneustes fossilis* (4.912 MT) and *Batasio tengana* (5.483 MT) were the most common (Fig. 5A).

Different carnivorous fish species were found in Kaptai Lake, viz., *Channa striatus*, *Channa marulius*, *Notopterus chital* and *Notopterus notopterus*. The abundance of carnivorous species in Kaptai Lake was highest before the ban period in March (8.897 MT) and April (13.253 MT). The annual total production of carnivorous species in Kaptai Lake was 41.750 MT, which was *Channa striatus* (14.630 MT), *Channa marulius* (8.478 MT), *Notopterus chital* (2.392 MT), and *Notopterus notopterus* (16.250 MT), respectively (Fig. 5B).

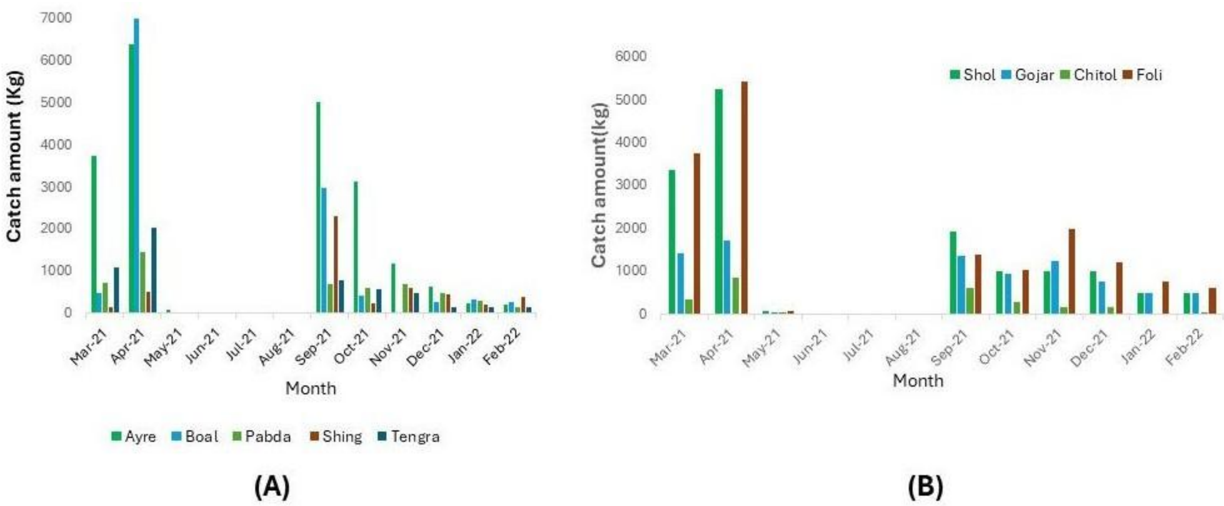


Fig. 5. (A) Abundance of catfish species in Kaptai Lake (B) Abundance of carnivorous fish species in Kaptai Lake

Comparison of the most dominant species Chapila (*Gudusia chapra*) **and Kachki** (*Corica soborna*) **with all other species**

Over time, the production of carps and other commercially valuable species has declined markedly, largely as a consequence of the rapid expansion of two clupeid species, *Gudusia chapra* (Chapila) and *Corica soborna* (Kachki). This shift represents a considerable setback for both the biodiversity and the overall fishery output of Kaptai Lake. Findings from the present study indicated that Chapila and Kachki contributed 47% (Fig. 6A) and 39% (Fig. 6B), respectively, of the total catch, amounting to 2,510.14 MT (Fig. 6C).

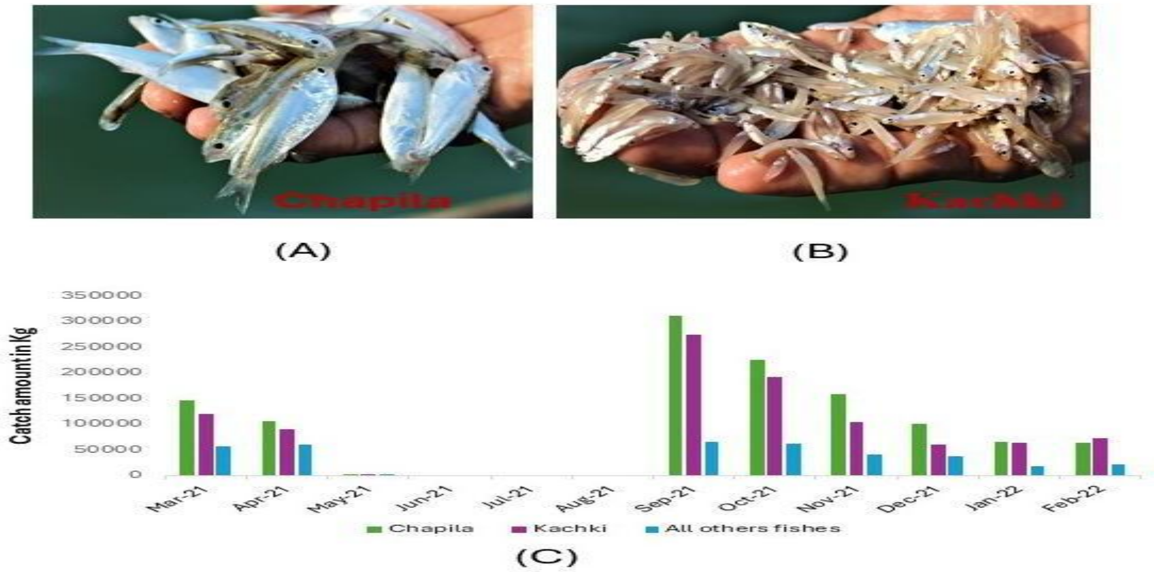


Fig. 6. (A) Chapila fish (B) Kachki fish (C) Showing comparison of the most dominant species chapila and kachki with all other species.

Comparison among Indian major Carp species and exotic species

Several species of Indian major carps, including Rui (*Labeo rohita*), Catla (*Gibelion catla*), Mrigal (*Cirrhinus cirrhosus*), Kalibaus (*Labeo calbasu*), etc. were observed during data collection. The annual total production of Indian major carps was 20.829 MT, of which Kalibaus (*Labeo calbasu*) was 11.058 MT, Mrigal (*Cirrhinus cirrhosus*) 2,390 MT, Catla (*Gibelion catla*) 4.666 MT, and Rui (*Labeo rohita*) 2.715 MT, respectively. The maximum abundance was seen in September 2021, with a total production of 5.355 MT, including Kalibaus (*Labeo calbasu*) 3.025 MT, Mrigal (*Cirrhinus cirrhosus*) 420 kg, Catla (*Gibelion catla*) 1.360 MT, and Rui (*Labeo rohita*) 550 kg, respectively. The lowest abundance was seen in February 2022, when total production was only 223 kg, in which Kalibaus (*Labeo calbasu*) accounted for 166 kg, Rui (*Labeo rohita*) 27 kg, and Catla (*Gibelion catla*) 30 kg. Surprisingly, the Mrigal species was not observed during this period. The result indicated that fish production in recent years have shown a decline status (Fig. 7A).

During the field survey, several exotic species were found, including Silver Carp (*Hypophthalmichthys molitrix*), Grass Carp (*Ctenopharyngodon Idella*) and Tilapia (*Oreochromis mossambicus*). The annual total production of Indian major carp was 17.574 MT, with Tilapia (*Oreochromis mossambicus*) 11.976 MT, Grass Carp (*Ctenopharyngodon Idella*) at 4.009 MT, and Silver Carp (*Hypophthalmichthys molitrix*) 1.589 MT. The maximum abundance was seen in September 2021, when total production was 3.370 MT, in which Tilapia(*Oreochromis mossambicus*) 2.040 MT, Grass Carp (*Ctenopharyngodon Idella*) 1.330 MT while Silver Carp (*Hypophthalmichthys molitrix*) was not found. The lowest abundance was seen in May 2021, when total production was only 85 kg, with 75 kg in Tilapia (*Oreochromis mossambicus*) and 10 kg in Grass Carp. However, recent observations indicated a decline in this production (Fig. 7

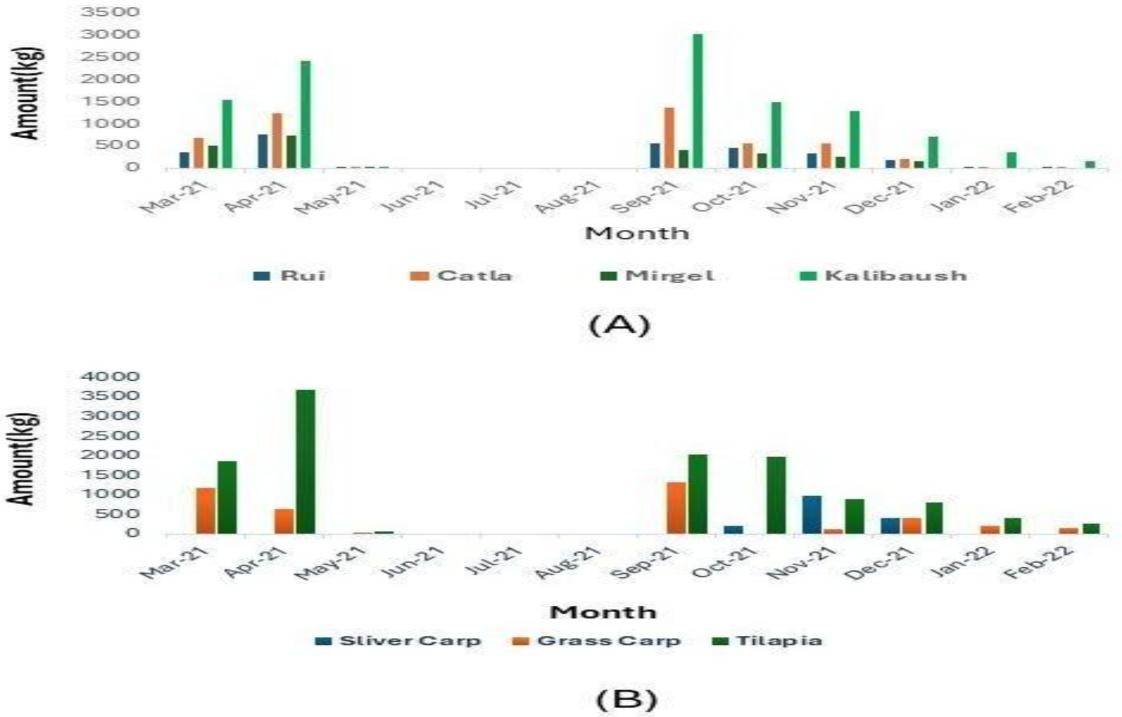


Fig. 7. (A) Comparison among Indian major carp species. (B) Comparison among exotic species

Monthly top 10 abundant fish species in Kaptai Lake (highest to lowest):

Chapila (*Gudusia chapra*)
The annual total production of Chapila (*Gudusia chapra*) species was 1177.396 MT. The abundance of Chapila fish species was found to increase during September, with a total amount of 311.094 MT and it was found to decrease during May, with a total amount of only 1.751 MT. Then, from October to February, there is a gradual decline in trends (Fig. 8A).

Kachki (*Corica saborna*)
The annual total production of Kachki (*Corica saborna*) species was 975.376 MT. Abundance, or catch amount, per month increases after the ban period during September, with the total amount being 273.951 MT and the lowest in May, which is only 1.565 MT. Then it is decreasing onwards from October (Fig. 8 B).

Mola (*Amblypharyngodon mola*)
The annual total production of Mola (*Amblypharyngodon mola*) species was 61.585 MT. The abundance of these species was highest in March, with a total amount of 12.267 MT and the lowest amount was found in December, which is only 4.0 MT. Then it slightly decreases onwards from April to after the ban period (Fig. 8C).

Kuchu Chingri (*Metapenaeus brevicornis*)
The annual total production of the Kuchu chingri (*Metapenaeus brevicornis*) species was 42.254 MT. The abundance of these species was highest after the ban period in November, with a total amount of 14.926 MT and the lowest amount was found in December, which was only 2.254 MT (Fig. 8D).

Kata Moilla (*Amblypharyngodon microlepis*)
The annual total production of Kata Moilla (*Amblypharyngodon microlepis*) species was 38.456 MT. Here, the highest abundance was in October and December, with a total of 20.169 and 16 MT, respectively. And another month saw that the amount of catch was decreasing slightly and the least available one was November, which was only 244 kg respectively. (Fig. 8E).

Kazuli (*Ailia colia*)
The annual total production of Kazuli (*Ailia colia*) species was 28.061 MT. Here, the abundance of Kazuli species before the ban period was higher in September, with a total amount of 8,500 MT and the lowest amount was found in May, which was only 100 kg. We observed a slight decrease in these species' abundance in January and February of this year. (Fig. 8F).

Ayre (*Sperata aor*)
The annual total production of Ayre (*Sperata aor*) species was 34.716 MT. The abundance of these species is highest in September, with a total amount of 8.500 MT, but lowest in May, which is only 110 kg. After the ban period, although the abundance or catch amount increased in September, it then once again exhibited a gradual decrease slightly (Fig. 8G).

Baila (*Awaous guamensis*)
The annual total production of Baila (*Awaous guamensis*) species was 16.587 MT. The abundance of these species is different from other species. From Fig. 20, we can see that before the ban period, the abundance of the Baila species is not available, but after the ban period, the catch amount is increased in September, which amounts to about 8.787 MT although later the abundance is decreased slightly (Fig. 8H).

Foli (*Notopterus notopterus*)
The annual total production of Foli (*Notopterus notopterus*) species was 16.250 MT. The highest abundance was in April, with a total amount of 5.438 MT, and the lowest amount was found in May, which is only 80 kg. After the ban period, the abundance remains upstage (Fig. 8I).

Shol (*Channa striatus*)
The annual total production of Shol (*Channa striatus*) species was 14.630 MT. The highest abundance was found in April, with the total amount being 5.253 MT and the lowest abundance was found in May, which is only 70 kg. After the ban period, the abundance decreases slightly (Fig. 8J).

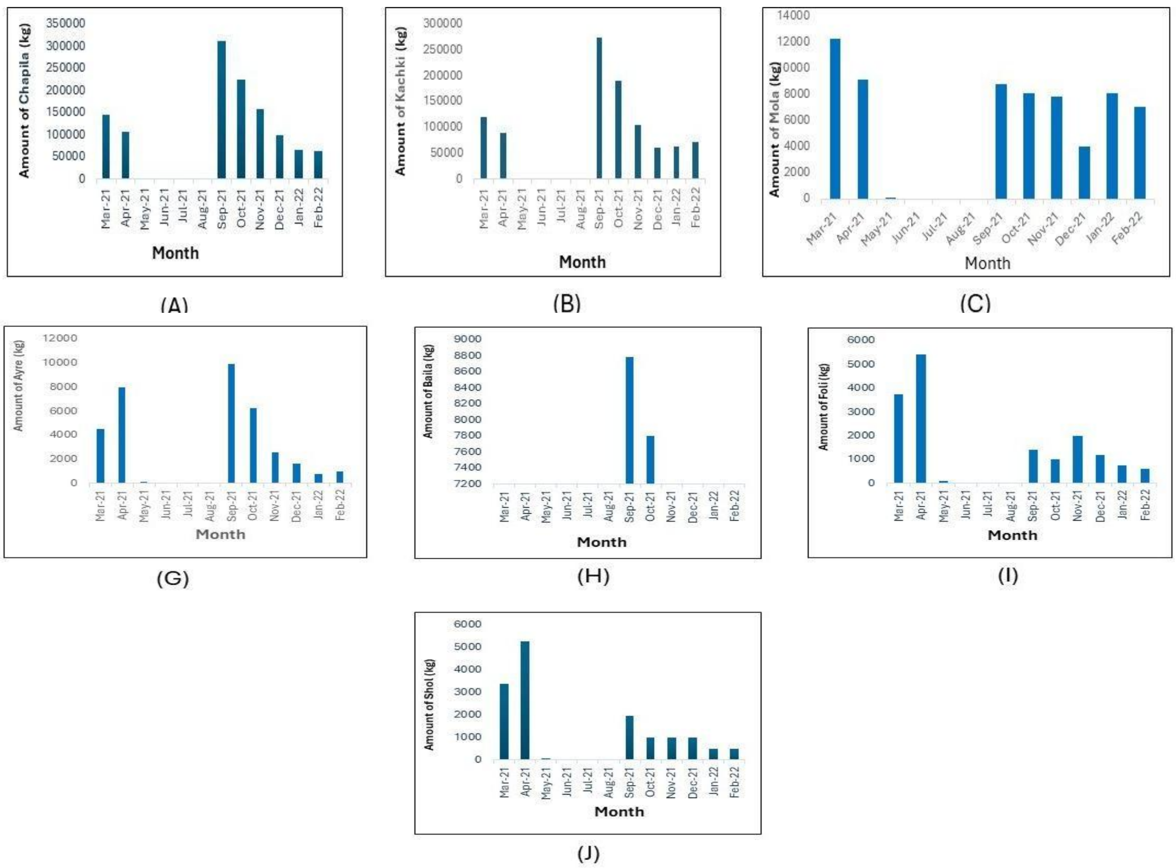


Fig. 8. Monthly abundance of (A) Chapila, (B) Kachki, (C) Mola, (D) Kuchu chingri, (E) Kata Moilla, (F) Kazuli, (G) Ayre, (H) Baila, (I) Foli, and (J) Shol species.

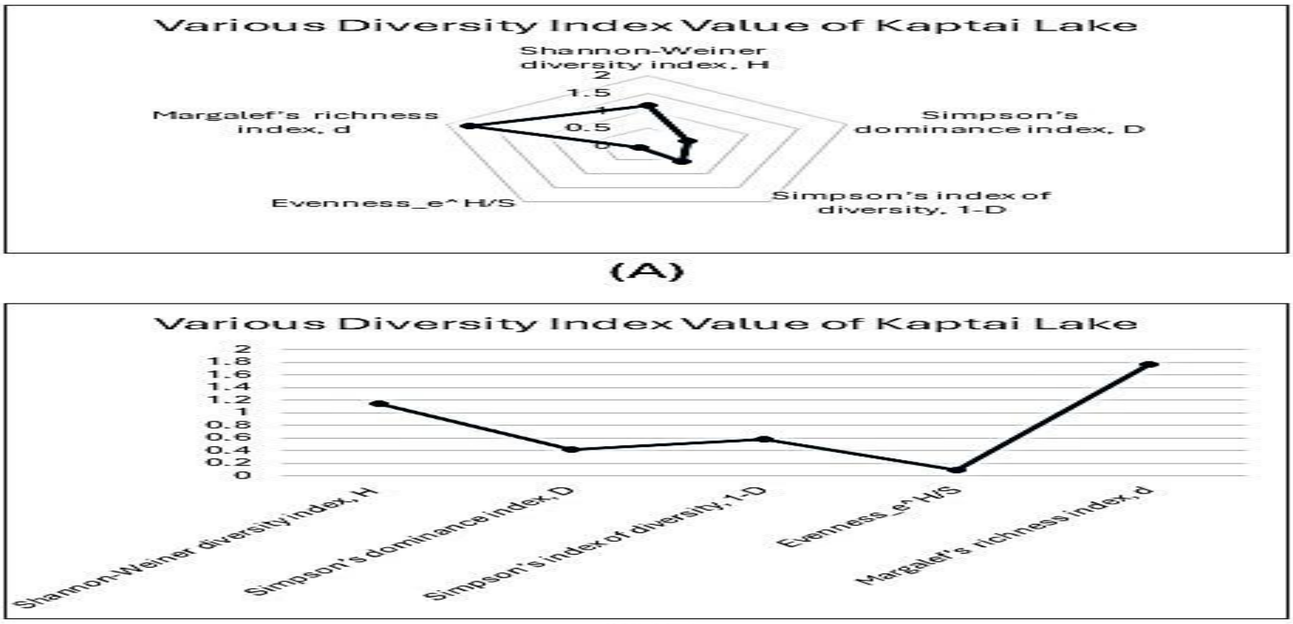
Ecological Diversity Indicators Analysis

The calculated value for the Shannon-Weiner index (H) was 1.145, Gibson's evenness (E) 0.0924, Simpson's dominance index (D) 0.4138, Simpson's index of diversity (1-D) 0.5862, and Margalef's richness index (d) 1.77 (Table 5).

Table 5. Various biodiversity parameters in Kaptai Lake.

Biodiversity Parameters	Kaptai Lake
Shannon-Weiner diversity index, H	1.145
Simpson's dominance index, D	0.4138
Simpson's index of diversity, 1-D	0.5862
Evenness_e^H/S	0.0924
Margalef's richness index, d	1.77

These diversity indices indicated less species diversity with some level of uneven distribution, which was dominated by a few species and moderate species richness (Simpson et al., 1949; Krebs et al., 1999; Pielou et al., 1966; Rahata et al., 2022; Rahman et al., 2014).



(A)

(B)

Fig. 9. (A) and (B) Graphical representation of various diversity index values of Kaptai Lake.

Threats to Kaptai Lake and biodiversity

Kaptai Lake is facing increasing pressure from both human activities and natural processes (Table 6). Illegal fishing during the fishing ban period is one of the most persistent problems, severely limiting the ability of fish populations to recover. The use of harmful fishing gear, particularly during the dry season, has compounded this issue by indiscriminately removing juveniles and degrading habitats. Reproductive success of major carps has also declined markedly, as siltation and fluctuating water levels have damaged or eliminated many of the lake's historically favorable spawning grounds. Reduced water flow further aggravates this situation by accelerating habitat degradation, diminishing natural seed production, and shrinking spawning sites for key carp species (Rahman et al., 2014).

Beyond these ecological challenges, poor enforcement of fishing regulations has intensified the decline. Seasonal bans are often introduced too late or lifted prematurely, undermining their intended purpose and leading to the depletion of broodstock. The combined effect of these factors poses a serious threat to both fish biodiversity and fishery productivity in Kaptai Lake. Unless stricter regulatory frameworks are implemented and coupled with ecological restoration strategies, the long-term sustainability of the lake's fisheries will remain in jeopardy.

Table 6. Problems of fisheries in Kaptai Lake.

Types	Problems
Man-made	Illegal fishing during the ban period.
	Use of harmful fishing gear (e.g., Jak net and Gara net).
	Introduction of non-native species threatening native biodiversity
	Indiscriminate exploitation of fish during the dry season
	Disposal of non-biodegradable waste (e.g., plastics, polythene) from tourism activities
	Siltation problem, primarily due to 'jhum' cultivation of crops (or burn agriculture) in hilly surrounding areas which involves clearing the trees and other vegetation resulting in increased silt deposition into the lake
Natural	Reduced water level in breeding grounds during summer (e.g., Maini channel breeding ground)
	Natural siltation through rivers feeds the lake.
	Climate change impacts, particularly rising temperatures and reduced rainfall

Pollution indicators

Shannon–Wiener diversity index (H′) value of 1.145 indicated a moderately polluted environment, consistent with the interpretation thresholds proposed by (Staub et al., 1970) and further supported by (Bora et al., 2024).

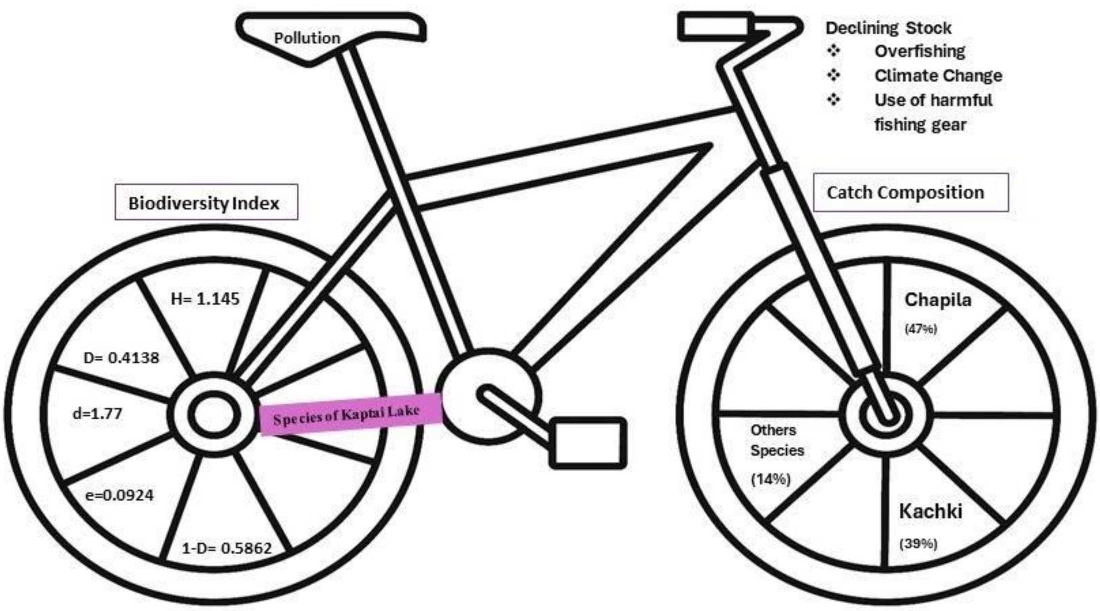


Fig.10. Driving forces of biodiversity distribution at Kaptai Lake

Management Overview and Recommendations

Kaptai Lake faces a variety of management challenges linked to both human and environmental pressures. Major concerns include untreated wastewater, watershed pollution, unregulated land use, and persistent illegal fishing. To promote natural recruitment, a 90-day annual fishing ban is enforced during the peak breeding season, and six breeding and nursery grounds have been declared sanctuaries where fishing is prohibited (Ahmed et al., 2002; Basak et al., 2017). Despite these measures, unauthorized harvests remain common, especially in remote areas. Conservation regulations, such as minimum mesh size limits for gill nets (7.62 cm), bans on monofilament nets (current jal), and prohibitions on brush fisheries, were established to protect brood fish and sustain stocks (Ahmed et al., 2006). However, weak enforcement and limited surveillance capacity reduce their effectiveness, highlighting the need for stronger legal frameworks and stricter compliance (Cooke et al., 2007; Bhuyan et al., 2017).

Carp stocking has been practiced since 1964 to enhance fish production, food security, and local livelihoods. In 2018–2019, 28 MT of hatchery-reared fingerlings were released, usually during the closed season between April and June. To improve outcomes, management strategies should focus on stricter regulation, expansion of no-take breeding sanctuaries, and restoration of degraded habitats. Promoting community-based aquaculture, including creek, cage, and pen culture, could also enhance resource use, as carp polyculture in such systems has shown promising results (Basak et al., 2017).

Further priorities include mapping natural carp breeding sites, expanding protected areas, and improving stocking practices with healthier and larger fingerlings (DoF, 2021). Dredging should remain a last-resort intervention, applied only under careful planning to prevent ecological damage. Given the lake’s role in domestic water supply, fisheries, and biodiversity, management must integrate conservation and community needs to prevent habitat loss and disease outbreaks while safeguarding the long-term sustainability of Kaptai Lake (Suman et al., 2021).

Conclusion

This study provides updated insights into the ichthyofaunal diversity and management challenges of Kaptai Lake, Bangladesh. The results underscore a critical shift in the fish community, marked by the increasing prevalence of threatened taxa, the decline of several commercially valuable species, and the disproportionate dominance of a few clupeid stocks. Such patterns reflect ecological imbalance and highlight the vulnerability of the lake’s fishery resources to anthropogenic and environmental stressors.

Addressing these issues requires an ecosystem-based management framework that integrates conservation biology with adaptive fisheries governance. Strengthened regulatory enforcement, the promotion of sustainable harvesting regimes, the reduction of pollutant inputs, and the rehabilitation of degraded spawning and nursery habitats are essential to restore ecological resilience. Moreover, continued ecological monitoring and advanced research on trophic interactions, recruitment dynamics, and habitat productivity will provide the scientific basis for adaptive management. Through participatory co-management, involving government institutions, non-governmental organizations, local fishing communities, and policy stakeholders, the long-term productivity and biodiversity of Kaptai Lake can be safe guarded.

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Authorship contribution statement:

Abdullah-Al-Hasan: Writing- reviewing & editing, Conceptualization, Validation, Data curation, Funding acquisition, Project administration, Supervision.

Aongnuching Marma: Methodology, Writing- original draft, Data analysis, Data curation, Table & graph preparation.
Al Azim: Methodology, Formal analysis, Data curation, Graph preparation.
Razon Sarkar: Methodology, Data curation, formal analysis, Table & graph preparation.
Arif Uddin Ahmad: Methodology, Data curation, formal analysis, Graph preparation.
Tanjila Akter: Writing- reviewing & editing, Data curation, Table & graph preparation, Resources.

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