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Fish Biodiversity at Nikli Haor of Northeastern Bangladesh: Fish abundance, Composition and Conservation Status

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ABSTRACT

The objectives of the current study are to categorizing existing fish species diversity, abundance and conservation status with specific biodiversity losses of Nikli Haor located in Kishorgonj district in Northeastern part of Bangladesh. This haor is recognized for its fish resources and revenue for many fishermen. This study was conducted from June 2022 to July 2023. Data were collected monthly by field survey, focus group discussions (FGD), questionnaire interviews (QI) of fishermen, and secondary data collection from the Nikli Haor. A comprehensive inventory has shown the presence of 53 distinct fish species, which can be classified into 20 families and 8 orders. The Cypriniformes has been documented as the most predominant group in terms of both species richness and population abundance. In this study, a notable proportion of fish species, specifically 35.84%, are facing various levels of vulnerability. This includes 11.32% classified as vulnerable, 18.87% as endangered, and 5.66% as critically endangered. The study resulted diversity, evenness, and richness indices with values of 3.62, 0.79, and 7.27, respectively. Nonetheless, the abundance and diversity of fish species in the Nikli Haor are declining. As a result, the findings could be utilized to develop and implement action plans that will help in the long-term management of Haors.

Keywords: Diversity, Nikli Haor, Fish composition, Threats, Management approaches

1 | Introduction

Bangladesh has an abundance of various fisheries resources, which make it one of the most productive and dynamic industries with significant potential for future economic growth. (Shamsuzzaman et al., 2020). Bangladesh is a wetland region with a variety of inland and marine fisheries resources (Pandit et al., 2021), Rivers, beels, flood plains, estuaries, and haor basins support about 4.24 million hectares of inland water (DoF, 2022).

The haor is a marshy wetland ecosystem, located in northeastern Bangladesh that takes the form of a bowl or sauer-shaped depression with some different deeper areas (locally called beels) that resemble an inland sea during the monsoon (BHWDB, 2012; Pandit et al., 2015 and 2021). Haors are incredibly valuable as a habitat because of the diverse and dynamic ecosystems. There are 373 Haor/wetlands in the regions of Sunamgonj, Sylhet, Habigonj, Maulavibazar, Netrokona, Kishoregonj, and Brahmanbaria. It was estimated that these 373 Haors account for around 43% of

the total area of the Haor districts. Various types of freshwater prawns and fish are found in the Haor ecosystem (Alam et al.,2010).

The status of fish diversity in the haor regions of Bangladesh has been assessed through multiple studies, revealing variations in species composition over time. Research conducted in 2012 reported 155 fish species, including 143 native and 12 alien species (BHWDB, 2012). In comparison, previous research in 2008 recorded 108 fish species in the haor ecosystem. (Islam et al., 2008). Furthermore, a 2015 assessment based on accounts from local fisherman found that over 84 distinct fish species were commonly caught in the Haor region (Pandit et al., 2015). These data point to variations in fish diversity, which may be driven by environmental changes, fishing pressure, and habitat deterioration. Haor exhibits a diverse array of plant and animal life, including reptiles, birds, fish species, amphibians, etc., all of which contribute to the health of the haor ecosystem (Chowdhury, 2016). Consequently, the haor region is vital to the maintenance of biodiversity, providing local and regional needs, and the production of fish (Salauddin and Islam, 2011). Although the Kishoreganj haor area is particularly well- known for its abundance of SIS (Small Indigenous Fish Species), with 30 species spread over 7 orders and 15 families (Rownok et al., 2014).

However, haor ecosystems face numerous threats due to a combination of human- induced and natural factors (Pandit et al., 2015 and 2021). Fish and other aquatic resources are in decline for many reasons, including overfishing, dewatering of key areas, the use of illegal and harmful gears, and climate change (CEGIS, 2012; Alam et al, 2015; Aziz et al, 2021). Additional factors contributing to the occurrence include road infrastructure, embankments, drainage systems, flood management strategies, pollution levels, aquaculture practices, and the accumulation of sediment. Many fish species are decreasing as a result of these actions, which can cause genetic erosion and endanger native fish species (Alam et al., 2015).

Nevertheless, it is worth noting that the majority of wild populations in rivers and streams of Bangladesh have experienced significant declines mostly as a result of excessive exploitation. The decline has been exacerbated by several ecological modifications and the degradation of natural habitats (Hossain et al., 2012). A total of 54 fish species in Bangladesh that are designated as endangered by the IUCN are in immediate risk owing to human activities. The significance of undertaking comprehensive biodiversity assessments of water bodies is further demonstrated by these findings, as they provide insights into their present condition and facilitate the implementation of sustainable management practices (Imteazzaman and Galib, 2013).

Though several studies on the biodiversity of fishes have been conducted in Bangladesh (Galib et al., 2009; Hossain et al., 2009; Mohsin et al., 2009; Zafar et al., 2007; Rahman et al., 2012).

Nikli Haor is an ecologically significant wetland that supports a variety of fish species, which are important to local communities. While prior research has recorded fish diversity in many haor ecosystems, information unique to Nikli Haor is limited or outdated. This study aims to bridge this gap by providing an updated account of fish abundance, species composition, and conservation status in this Haor. The findings will enhance understanding of the current state of fish biodiversity in Nikli Haor, contribute to conservation planning, and serve as a baseline for future ecological studies and management strategies in the region.

2 | Materials and Methods

Location and study period

The present investigation was carried out in the Nikli haors, located in the Kishoreganj region of Bangladesh. The study involved the selection of three sampling sites, as depicted in Fig. 1. Sampling sites and geographical coordinates of

the locations are presented in Table 1. Fish specimens were collected on a monthly basis from the designated locations between July 2022 and June 2023.

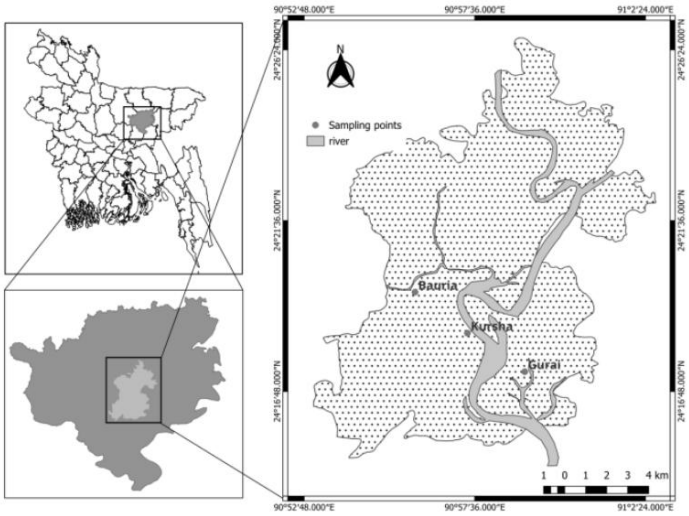

Fig. 1. Location of the study sites.

Table 1. Geographic location of the sampling sites.

Study location	Sampling site	Coordinates
Nikli Haor	Bauria	24°32′66″ N, 90°96′21″ E
	Kursha	24°30′73″ N, 90°95′44″ E
	Gurai	24°28′92″ N, 90°95′30″ E

Sampling methods

Fish samples were collected from the specified sampling site with the assistance of experienced fishermen on each sampling date. A seine net with a length, width and mesh size of 100 m, 5 m and 1-2 mm, respectively, was used for sampling of fishes. The fishes that were obtained were treated with a 10% formalin solution in order to preserve them. They were subsequently taken to the laboratory at the Freshwater Station of the Bangladesh Fisheries Research Institute in Mymensingh for subsequent study. The morphometric and meristic features of fishes were assessed in the laboratory. The identification and systematic categorization of species were conducted following the methodologies outlined by (Bhuiyan, 1964; Rahman, 2005; Talwar and Jhingran, 1991). The fishes that were identified were systematically classified in accordance with the taxonomy outlined by (Nelson, 2006).

Methods for collecting data

In order to collect primary data, conducting face-to-face interviews with individuals engaged in fishing, fish traders, and members of the local community were carried out.

A combination of a semi-structured and a structured questionnaire was used in certain focus group discussions. The process of cross checking was conducted by means of an interview with the Fisheries Officer responsible for the Nikli upazila. Species of fish that have been identified were classified into one of four categories taking into consideration public perception (including their opinions, knowledge, and beliefs about different species, conservation, and ecosystem health) and the frequency of their occurrence (the percentage of investigations in which the researcher documented the definite species).

The various groups include Species that are regularly observed throughout the year (frequency > 75%); Species that are consistently observed, although in low numbers, all year round (frequency ranging from 51% to 75%) are considered "commonly available" (CA). Species with a frequency between 26% and 50% are considered "Moderately Available" (MA), whereas those with a frequency below 25% are considered "Rarely Available" (RA), (Pandit et al., 2020 and 2021).

Fish diversity analysis

The analysis of fish diversity was conducted using the Shannon-Wiener diversity index, Margalef's richness index, and Pielou's evenness index.

Shannon-Wiener diversity index: $H' = -\Sigma (ni/N) \ln(ni/N)$, where ni denotes the number of individuals of the i-th species and N denotes the total number of individuals.

Pielou's evenness index: $e = H'/\ln S$, where H' is the Shannon-Wiener diversity index and S is the total number of species observed in the sample.

Margalef's richness index: $D = (S - 1)/\ln N$, where S is the number of species and N is the total number of individuals in the sample.

Statistical analysis

Errors and discrepancies were reduced to a minimum by summarizing, processing, and verifying the data. The information was examined using Microsoft Excel 2010. All investigations regarding the diversity indices were conducted using Version 4.0 of the software PAST (Paleontological Statistics).

3 | Results

Comprehensive compilation of data related to fish orders, families, species, English names, local names, and their corresponding status in Bangladesh, along with the percentage representation of each species in the overall capture is shown in Table 2.

Fifty-three fish species representing 20 families and eight orders have been documented at the studied Haor

Table 2: Fish diversity status of Nikli Haor and percentage in total catch

Fish Order	Family	Local Name	English Name	Scientific Name	Current availability status	Conservation Status	
						BD	World
Beloniformes	Belonidae	Kakila	Freshwater Garfish	*Xenentodon cancila* (Hamilton, 1822)	CA	LC	LC
		Ek Thuita	Congaturi Halfbeak	*Hyporhamphus limbatus* (Valenciennes, 1846)	RA	CR	EN
Channiformes	Channidae	Taki	Spotted Snakehead	*Channa punctatus* (Bloch, 1793)	CA	LC	LC
		Shol	Stripped Snakehead	*Channa striatus* (Bloch, 1793)	MA	LC	LC
		Cheng	Walking Snakehead	*Channa orientalis* (Bloch & Schneider, 1801)	MA	LC	VU
		Gajar	Giant Snakehead	*Channa marulius* (Hamilton, 1822)	RA	EN	LC
Clupeiformes	Clupeidae	Kachki	Ganges River-Sprat	*Corica soborna* (Hamilton, 1822)	AA	LC	LC
		Chapila	Indian River Shad	*Gudusia chapra* (Hamilton, 1822)	AA	LC	LC
Cypriniformes	Cyprinidae	Catla	Catla	*Gibelion catla* (Hamilton, 1822)	MA	LC	LC
		Rui	Rahu	*Labeo rohita* (Hamilton, 1822)	MA	LC	LC
		Bata	Bata Labeo	*Labeo bata* (Hamilton, 1822)	CA	LC	LC
		Kalibau	Orangefin	*Labeo calbasu*	CA	LC	LC

Fish Order	Family	Local Name	English Name	Scientific Name	Current availability status	Conservation Status	
						BD	World
		Laacho	Reba	*Cirrhinus reba* (Hamilton, 1822)	MA	NT	LC
		Dhela	Cotio	*Osteobrama cotio* (Hamilton, 1822)	MA	NT	LC
		Sar Punti	Olive Barb	*Systomus sarana* (Hamilton, 1822)	AA	LC	LC
		Jat Punti	Pool Barb	*Puntius sophore* (Hamilton, 1822)	AA	LC	LC
		Darkina	Flying Barb	*Esomus danricus* (Hamilton, 1822)	AA	LC	LC
	Cobitidae	Rani	Queen Loach	*Botia dario* (Hamilton, 1822)	MA	EN	LC
		Gutum	Guntea Loach	*Lepidocephalichthys guntea* (Hamilton, 1822)	MA	EN	LC
Osteoglossiformes	Notopteridae	Chital	Humped Featherback	*Notopterus chitala* (Hamilton, 1822)	RA	EN	NT
		Foli	Gray Featherback	*Notopterus notopterus* (Pallas, 1769)	MA	VU	LC
	Anabantidae	Koi	Climbing Perch	*Anabas testudineus* (Bloch, 1775)	CA	LC	LC
	Ambassidae	Nama Chanda	Glass-Perchlet	*Chanda nama* (Hamilton, 1822)	AA	LC	LC
		Ranga Chanda	Indian Glassy Fish	*Pseudambassis ranga* (Hamilton, 1822)	AA	LC	LC
	Gobiidae	Bailla	Tank Goby	*Glossogobius giuris* (Hamilton, 1822)	CA	LC	NT
Perciformes		Chuno	Glass Goby	*Gobiopterus chuno*	CA	LC	DD

Fish Order	Family	Local Name	English Name	Scientific Name	Current availability status	Conservation Status	
						BD	World
	Nandidae	Bheda, Meni	Mud Perch	*Nandus nandus* (Hamilton, 1822)	MA	EN	LC
	Osphronemidae	Khalisha	Giant Gourami	*Colisa fasciata* (Bloch, 1801)	MA	VU	NE
Siluriformes	Bagridae	Air	Long Whiskered Catfish	*Mystus aor* (Hamilton, 1822)	RA	VU	LC
		Tengra	Gangetic Mystus	*Mystus cavassius* (Hamilton, 1822)	CA	LC	DD
		Gulsha Tengra	Stripped Dwarf Catfish	*Mystus vittatus* (Bloch, 1797)	MA	NT	LC
		Rita	Rita	*Rita rita* (Hamilton, 1822)	RA	EN	VU
	Siluridae	Kani Pabda	Butter Catfish	*Ompok bimaculatus* (Bloch, 1797)	MA	EN	NT
		Pabda	Pabda Catfish	*Ompok pabda* (Hamilton, 1822)	RA	CR	NT
		Boal	Boal	*Wallago attu* (Schneider, 1801)	MA	VU	VU
		Kajuli	Gangetic Ailia	*Ailia coila* (Hamilton, 1822)	MA	LC	NT
		Ghaura	Garua Bacha	*Clupisoma garua* (Hamilton, 1822)	RA	EN	LC
		Batashi	Potasi	*Neotropius atherinoides* (Bloch, 1794)	MA	LC	LC
		Bacha	Indus Garua	*Eutropiichthys vacha* (Hamilton, 1822)	MA	LC	LC

Fish Order	Family	Local Name	English Name	Scientific Name	Current availability status	Conservation Status		
						BD	World	
	Chacidae	Chaka	Squarehead Catfish	*Chaca chaca* (Hamilton, 1822)	RA	EN	DD	C
Tetrodontiformes	Tetradontidae	Potka	Common Pufferfish	*Tetraodon cutcutia* (Hamilton,1822)	RA	LC	LC	C

Note. Based on IUCN (2015) and IUCN Bangladesh (2000). Conservation status: AA = Abundantly available; CA = Commonly available; MA = Moderately available; RA = Rarely available; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LC = Least Concern; NT = Near Threatened; NE = Not Evaluated; DD = Data Deficient.

Cypriniformes was the most common group, accounting for 41.76 percent of all species. Other dominating orders outside Cypriniformes were Clupeiformes (15.81%), Perciformes (10.16%), and Siluriformes (10.16%) (Fig. 2). Cyprinidae was the most common family, accounting for 39.97% of all species captured. Clupeidae (26.48%), Siluridae (4.67%), Bagridae (4.49%), and Mastacembelidae (4.35%) were also highly diverse families (Fig. 3).

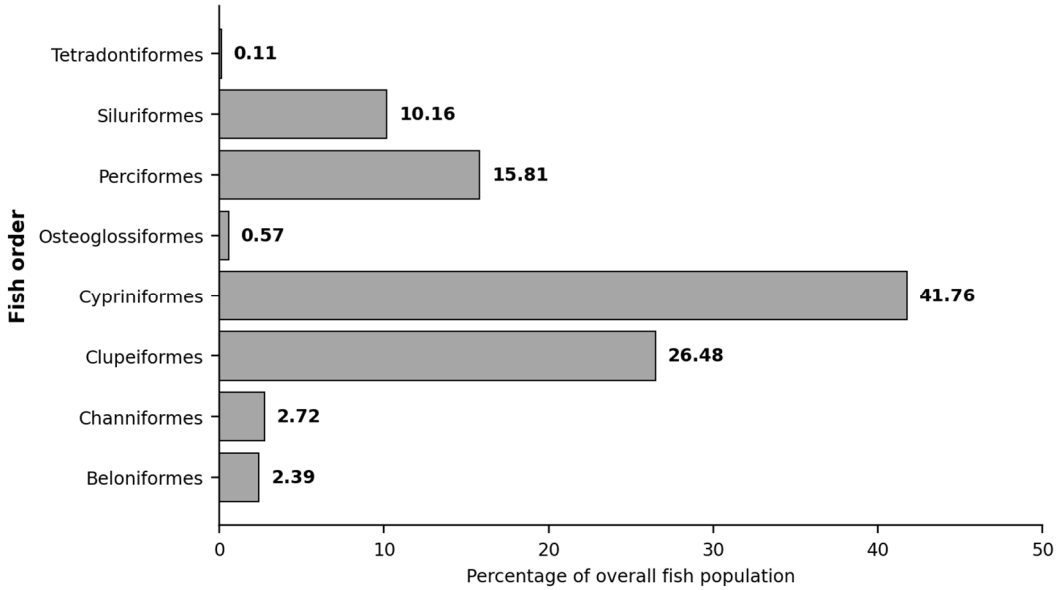

Fig. 2. Composition of fish species available in Nikli Haor under different orders.

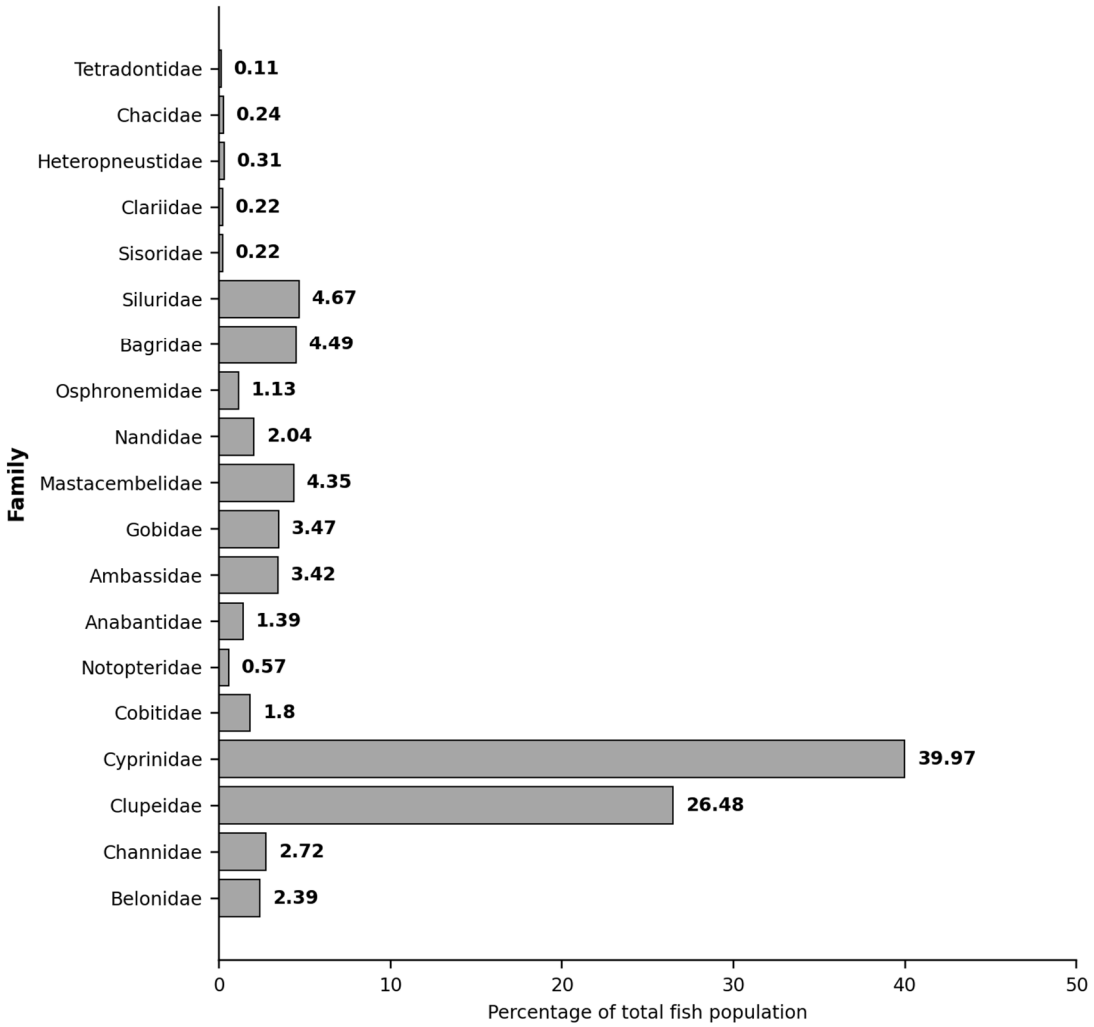

Fig. 3. Contribution of families to the fish population in the Nikli Haor.

According to the IUCN Bangladesh (2000) report, it was observed that 35.84% of the identified fish species were categorized as threatened (IUCN Bangladesh, 2000). This percentage accounted for 48.19% of the overall number of fish species that were classified as threatened in the country. These include 11.32% vulnerable, 18.87% endangered, and 5.66% highly endangered species. 50% Osteoglossiformes species, 50% Beloniformes, 40% Cypriniformes, 20% Perciformes, and 32% Siluriformes were threatened (Fig. 4). In this study Threatened fish species comprised 35.84% of the total species (Fig. 4). In this study, a higher number of 51 different species was observed in December and January and a lower number of 33 species was observed in June (Table 3). Gudusia chapra accounted for 13.37% of the entire capture, followed by Corica soborna (13.10%), Systomus sarana (11.9%), and Amblypharyngodon mola (9.81%) in order of abundance (Table 1).

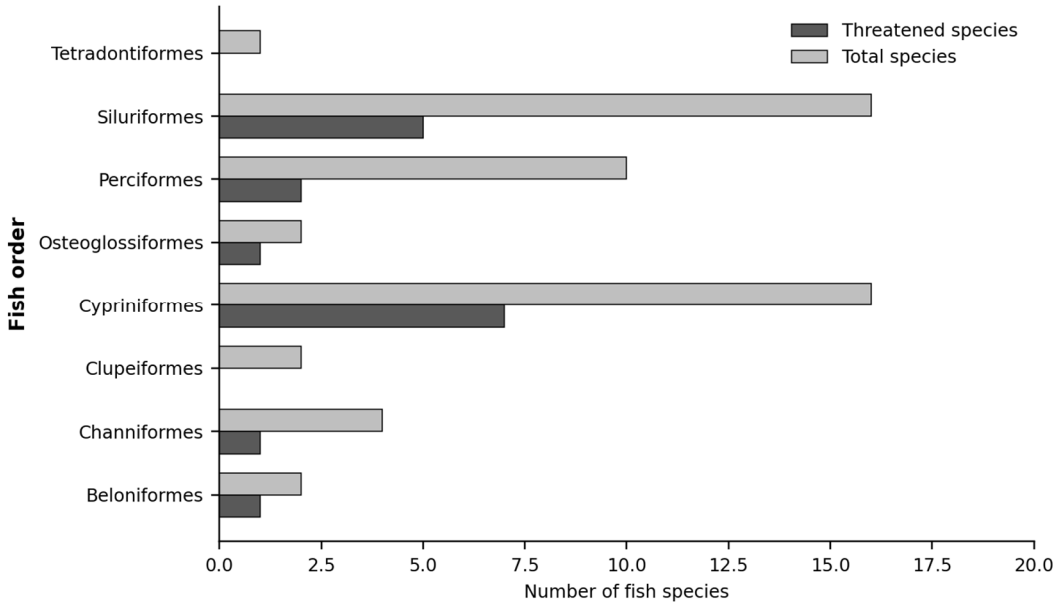

Fig. 4. Fish species diversity including the threatened species in Nikli Haor.

Current Fish Diversity Status

There were 15.09% abundantly available fish, 20.75% commonly available fish, 39.62% moderately available fish, and 24.53% rarely available fish identified throughout the research period in the study sites (Fig. 5).

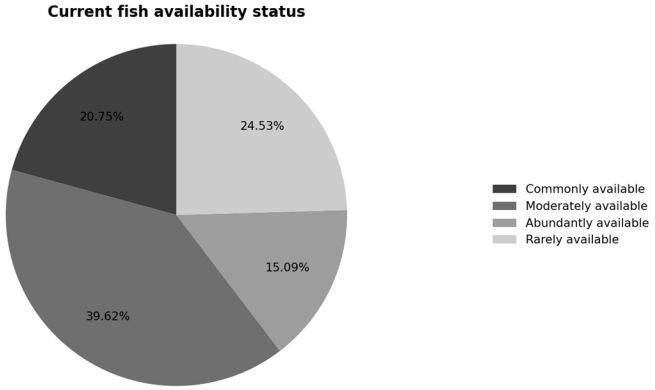

Fig. 5. Current status of fish availability in the Nikli Haor.

Conservation Status

The majority of fish species (66.04%) are classified as having a low risk of extinction (least concerned category) by the International Union for the Conservation of Nature (IUCN, 2021). This is followed by vulnerable species, which account for 13.21%, near threatened species make up 9.43%, while those classified as data deficient represent 5.66%. A smaller proportion of fish species, specifically 3.77%, have not been evaluated for their conservation status. Lastly, the endangered category comprises just 1.89% of the fish species (Fig. 6A).

In terms of national conservation status, least concern was at the top (50.94%), followed by endangered (20.75%), near threatened (13.21%), vulnerable (9.43%), and critically endangered (5.66%) (Fig. 6B).

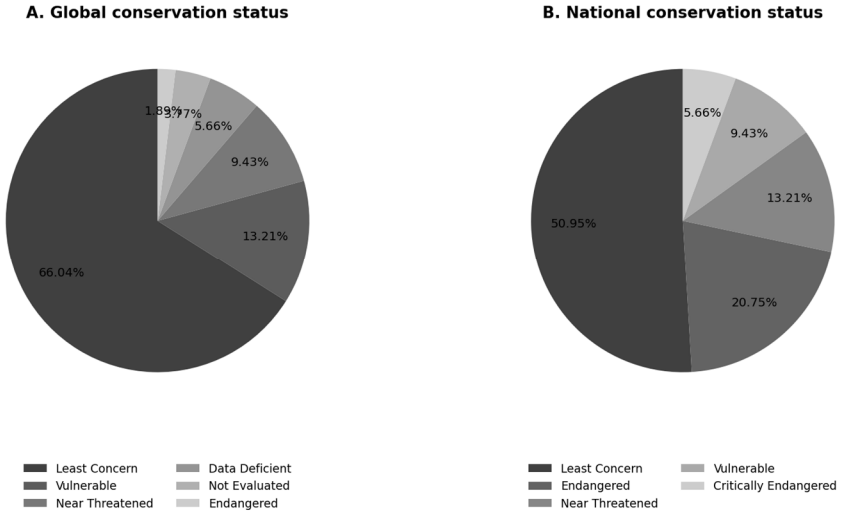

Fig. 6. Conservation statuses of fish species in the Nikli Haor.

Diversity, evenness and richness indices

Monthly values for Shannon-Weaver (H), Pielou (e), and Margalef (D) diversity, evenness, and richness indices are displayed in Table 3. However, when taking into account all of the specimens examined throughout the study period, H, e, and D were determined to have values of 3.62, 0.79, and 7.27, respectively. The values of the diversity index, evenness index, and richness index varied from 2.89 in June to 4.68 in December, and from 0.55 in June to 0.94 in January, respectively Fig. 7.

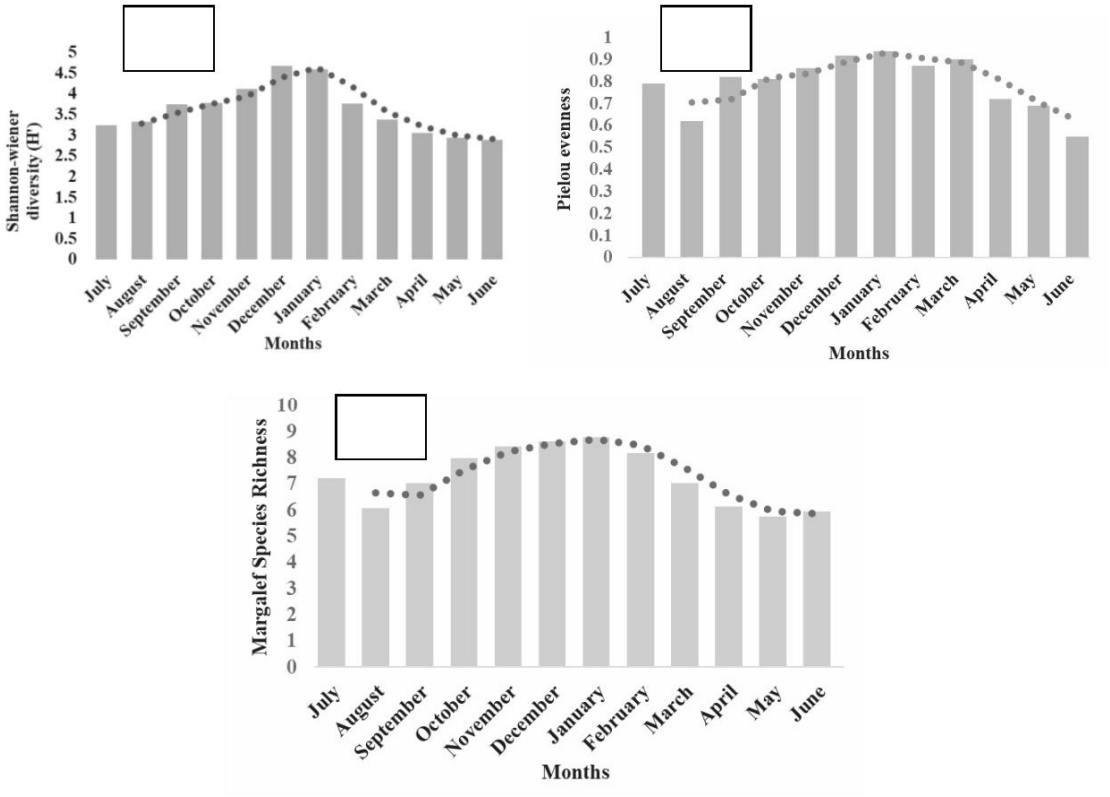

Fig. 7. Monthly variation of species diversity indices. (A) Shannon-Wiener, (B) Pielou evenness, (C) Margalef richness.

4 | Discussion

A comprehensive investigation was conducted on the fish species inhabiting Nikli Haor in Kishoreganj, Bangladesh. The study revealed the presence of a total of 53 distinct species, belonging to 20 families and 8 orders. Several studies have been conducted to investigate the fish diversity in the Kishoreganj Haor area. However, no prior research has been conducted on fish biodiversity in the Nikli Haor. According to a study, there are 57 different species of fish in Hakaluki Haor (Islam et al., 2021). A total of 65 species from 23 families were identified in the Dekar Haor of Sunamganj District (Pandit et al., 2015). In the Borulia Haor of Nikli, Kishoreganj, 47 fish species were discovered (Nath et al., 2010). Reasons for the availability of fish species in the Nikli Haor may include geographic location of the haor and connectivity as a tributary of the biologically diverse Dhanu and Gorautra Rivers. Cypriniformes was the most dominant (41.76%) group followed by clupeiformes (26.48%), perciformes (15.81) and siluriformes (10.16). The most prevalent family was listed as Cyprinidae (39.97%), followed by Clupeidae (26.48%), Siluridae (4.67), Bagridae (4.49%), and others. A study undertaken documented the presence of 17 families inhabiting in Kishorgonj haor (Hasan et al., 2017), a region in Bangladesh. Somewhat a greater number of families in their study conducted in Dekhar Haor, Bangladesh (Islam et al., 2021; Pandit et al., 2015). The dominant fish species in freshwater bodies of Bangladesh have been documented by earlier studies conducted (Akhi et al., 2020; Sunny et al., 2020; Chowdhury et al., 2019).

The Cypriniformes order was the most abundant in the studied area, which may be attributable to the favorable habitat and vegetation type of haor. A report results that are comparable to these (sultana et al., 2019). One third of all catches were made up of the species Gudusia chapra, followed by Corica soborna (13.10%), Systomus sarana (11.99%), and Amblypharyngodon mola (9.81%). The predominant fish species found in the Chalan beel of Bangladesh are jat punti (Puntius sophore) and tit punti (Pethia ticto), followed by chanda (Chanda nama and Parambasis ranga), chapila (Gudusia chapra), and tengra (Mystus vittatus) (Hossain et al., 2009). According to the study conducted in the Halti beel of Bangladesh revealed that the species Puntius sophore, commonly known as jat punti, exhibited the highest level of dominance (Galib et al., 2013).

Variations in survey duration, fishing methods, fishing gear availability, etc., could all account for the study's observed results.

In a study, it was observed that the fish species consisted of 18% AA, 20% CA, 42% MA, and 20% RA (Kamal et al., 2022). The fish species composition in the Dhanu River and nearby Haor ecosystems was found to comprise 17.4% AA, 27.5% CA, 31.9% MA, and 23.1% RA (Pandit et al., 2021). These findings have resemblance to the findings that are currently available. In this study, nearly a quarter (24.53%) of fish species were classified as rarely available, meaning their appearances was irregular. Local fishermen have expressed concern that these species might soon disappear. The majority of fish species (66.04%) belongs to the least concerned group when considering their global conservation status (IUCN, 2021). This is followed by the vulnerable (13.21%), near threatened (9.43%), data deficient (5.66%), not evaluated (3.7 %), and endangered (1.8 %) categories. This result is consistent with those of a previous study (Kamal et al., 2022). The category that exhibited the least level of concern attained the highest rank in relation to the national conservation status, accounting for 50.94% of the total. The endangered category followed with a proportion of 20.75%, while the near threatened category constituted 13.21%. The vulnerable category accounted for 9.43% of the total, and the critically endangered category represented the smallest proportion at 5.66%. A significant proportion, particularly 53.8%, of the species inhabiting the Dhanu River and its surrounding vicinity were categorized as least concerned (Pandit et al., 2021). This was followed

by 17.6% of species categorized as near threatened, 12.1% as endangered, 11.0% as vulnerable, 3.3% as critically endangered, and 2.2% as data deficient. These findings closely align with the present study's results.

During the winter months (November–February), the greatest diversity of fish was observed. It's because the absence of rain has made the water shallow, letting fishermen use their equipment more efficiently. A similar abundance of fish species was recorded during the winter months. June and July have the fewest species because rising water level make fishing difficult due to rainfall (Iqbal et al., 2015; Nath and Deca, 2012). A study found that H = 3.690, d = 9.497, and e = 0.971 in the Ratargul freshwater marsh forest of Bangladesh (Das et al., 2017). The values for H in Konoskhai Haor, Northeastern Bangladesh, ranged from 3.12 to 2.9, d from 3.0 to 2.70, and J from 0.82 to 0.88 (Iqbal et al., 2015).The Shannon-Wiener diversity index (H') varied between 3.72 and 3.74, with the highest value found in Tanguar haor (0.95), and the lowest value found in Dekhar haor (0.9). While Tanguar haor (4.6) has the highest Margalef richness score, Dekhar haor (4.3) had the lowest (Sunny et al., 2020). This study found a little higher value of the diversity and richness index compared to the prior findings, suggesting relatively richer biodiversity in the study area.

Variables that affect fish populations and conservation efforts

Currently, the loss of biodiversity poses a significant and concerning hazard. However, it is imperative to use timely and efficient management strategies in order to address this issue effectively. Fish conservation is crucial for upholding ecological, nutritional, and socio-economic balance, as argued (Lakra, 2010). Bangladesh is inhabited to many endangered fish species, accounting for 35.84% of those documented in the Nikli Haor.

Dewatering beels (89.06%), overexploitation (87.24%), use of harmful fishing gear (85.03%), the degradation of natural habitats (65.54%), the construction of roads and embankment (78.21%), the use of pesticides (81.39%), siltation (56.07%), indiscriminate fishing during peak breeding season (72.64%), a lack of effective monitoring (30.75%), and drought (26.49%) are among the utmost manmade factors leading to the decline of species (Table 4). Kishoreganj, Bangladesh, is home to the Dhanu River and the Haors, and faces a comparable management challenge (Pandit et al., 2021). The fish fauna in the Hakaluki Haor, located in northeast Bangladesh, is at risk because to many human activities. These activities include beel drying, excessive rainfall, overfishing, siltation, and the utilization of destructive gear, fluctuations in temperature, and the application of urea fertilizer for fishing purposes (Aziz et al.,2021)

Table 4. Causes of decreasing fish species abundance.

Sl. No.	Variables that influence fish diversity	Total number of respondents (%) N = 382
1	Dewatering beels	89.06
2	Over exploitation	87.24
3	Use of harmful fishing gear	85.03
4	Degradation of natural habitats	65.54
5	Infrastructures (road and embankment) in the Haor	78.21
6	Pesticides used in fishing and	81.39

	agriculture land	
7	Silt deposited by nearby rivers	56.07
8	Indiscriminate fishing during peak breeding season	72.64
9	Lack of effective monitoring by Govt./NGO	30.75
10	Drought	26.49

This updated information is critical for choosing effective conservation management techniques. The development of protected areas is also important for mitigating habitat loss and degradation. Saunders et al., 2002 advocated for the establishment of freshwater protected zones as a means of directly conserving freshwater species and habitats. Fish sanctuaries always increase fish production, biodiversity, and fishers' economic and social well-being (Azher et al., 2006; Hossain et al., 2017; DoF, 2026; Hasan et al., 2012). It is also highly recommended that ecosystem-based management measures that involve the local population be put into place in the Haor region to protect fish biodiversity and guarantee sustainable fisheries output.

5 | Conclusion

The Haor basin of Bangladesh holds significant importance in terms of food security, protecting biodiversity and meeting equally local and regional demands. Twenty families and eight orders were represented among the 53 freshwater fish species recorded at Nikli Haor during the study periods. The study results revealed that a significant proportion of fish species, specifically 35.84%, were identified as being at risk within the designated research area. Approximately 50% of the fish population exhibited vulnerability or were classified as nearly threatened, underscoring the urgent necessity for conservation efforts. The findings of the study indicated that fish diversity and abundance in the study area were adversely affected by both natural and anthropogenic factors. In context of these outcomes, the study suggests using a variety of mitigation strategies to address these problems. In order to properly manage and conserve these aquatic resources in the Haor ecosystem, cooperation between governments and NGOs is essential.

Author Contributions

Md. Nahiduzzaman: Conceptualization, data collection, data analysis, interpretation, manuscript writing, and editing. Ehsanul Karim: Conceptualization, data collection, data analysis, manuscript writing, and editing. Nazia Naheen Nisheeth: data collection and data analysis. Md. Shahin Alam: data collection and data analysis. Al-Amin: data collection and data analysis. Md. Harunor Rashid: supervision, manuscript writing, and editing; and Anuradha Bhadra: fund acquisition supervision, manuscript writing, and editing. All authors have read and approved the final published article.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

All data generated and analyzed during this study are included within the manuscript. No additional datasets are available.

Ethics Statement

Not applicable.

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