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Assessing Freshwater Fish Biodiversity in Amuladah Beel: Unveiling Status, Threats, and Conservation Imperatives

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ABSTRACT

This study aimed to assess fish biodiversity and conservation challenges in Amuladah Beel, located in Bhuapur Upazila, Tangail. The research documented 43 fish species across 9 taxonomic orders, 19 families, and 27 genera. Among these, the silver carp (*Hypophthalmichthys molitrix*), the bighead carp (*Aristichthys nobilis*), and tilapia (*Oreochromis mossambicus*) were identified as exotic species, while the others were native to Bangladesh. Cypriniformes and Cyprinidae were the most predominant, comprising 37% and 35% of the fish population in their respective orders and families. Carp species represented the largest group, accounting for 37% of the six most commonly recorded groups. Notably, 19 species were classified as threatened, with 9 (47%) vulnerable, 6 (32%) endangered, and 4 (21%) critically endangered. The study also highlighted the degradation of water quality due to domestic and industrial effluents, jute rotting, excessive agrochemical use, and agricultural runoff. Environmental pollution and indiscriminate fishing appear to be major contributors to the decline in fish diversity in Amuladah Beel. The findings revealed that the number of species is lower than expected based on Bangladesh's overall fish biodiversity. To address these challenges, it is recommended to mitigate water pollution, ensure the natural flow of water, and raise public awareness. Immediate implementation of comprehensive management and conservation programs is crucial to prevent species extinction and to improve fish diversity in Amuladah Beel.

INTRODUCTION

Amuladah Beel, located in Tangail district of Bangladesh, represents a significant freshwater ecosystem renowned for its rich biodiversity of fish species. Beels, which are oxbow lakes or floodplain wetlands, play a crucial role in supporting aquatic life and maintaining ecological balance in Bangladesh's landscape **(Byomkesh *et al.*, 2008)**. Amuladah Beel, covering approximately 200 acres, serves as a habitat for diverse fish communities that contribute both economically and ecologically to the region.

Biodiversity refers to the wide array of life forms found on earth, encompassing diverse species of plants, animals, and microorganisms **(Yadav *et al.*, 2023)**. It includes the composition, number, and richness of species, as well as genetic diversity within species, between species, and at the ecosystem level. Assessments of biodiversity aim to understand ecosystem structure and evolution, preserve genetic resources, manage environmental risks, and identify suitable areas for biological diversity conservation **(Ring *et al.*, 2010)**. The fish

biodiversity of Amuladah Beel encompasses a variety of indigenous and exotic species, each adapted to its unique aquatic environment characterized by seasonal variations in water level, temperature, and nutrient availability. These variations influence the distribution, abundance, and reproductive patterns of fish species throughout the year, shaping the overall ecosystem dynamics of the Beel.

The study area is a significant fisheries site in Bangladesh, renowned for its rich aquatic resources. Located in the Bhuapur area, Amuladah Beel stands out among other rivers and floodplains in the region. It spans across Akalu, Bilchapra, and Olua under Bajpur upazila, with the main portion of the Beel situated in Akalu under Bhuapur upazila. Amuladah Beel is entirely rain-fed, filling with water during the monsoon months (March-December) and partially drying up during winter and summer (January-March). The Beel's high fertility is attributed to its extensive sediment layers, rich in organic matter, which results in dark-colored soil that supports abundant natural food production for fish and other aquatic organisms. This fertile soil creates attractive habitats for diverse fauna, contributing to the overall productivity of the Amuladah Beel ecosystem.

Despite its ecological significance, Amuladah Beel faces numerous conservation challenges, including habitat degradation, water pollution, overfishing, and invasive species. These factors threaten the sustainability of fish populations and the overall health of the aquatic ecosystem **(Lisbeth, 2023)**. Conservation efforts are crucial to address these challenges and to preserve the diverse fish fauna of Amuladah Beel for future generations.

This introduction highlights the importance of Amuladah Beel's fish biodiversity, emphasizing its ecological roles, conservation needs, and the significance of research and management initiatives aimed at safeguarding this vital freshwater resource. Nearly every Beel in Bangladesh faces threats from population pressures, climate change, and developmental activities. The significant loss of freshwater aquatic biodiversity underscores the urgent need for a comprehensive, systematic study to evaluate the current state of biodiversity in Amuladah Beel. Such an assessment is essential for formulating effective strategies to conserve and manage the aquatic fauna effectively.

MATERIALS AND METHODS

Sampling area

Water samples were collected from three random spots of the Beel during pre-monsoon (April-June), full-monsoon (July-September), and post-monsoon (October-December). The sampling area encompasses the major sections of Amuladah Beel, including its various fishing spots. The main portion of Beel is situated at Alua union which is about 25km away from Bhuapur upazilla in Tangail district. The Beel is situated at 24°27´ North latitude and 89°52´East longitude and covers an area of about 200 acres of land (Fig. 1).

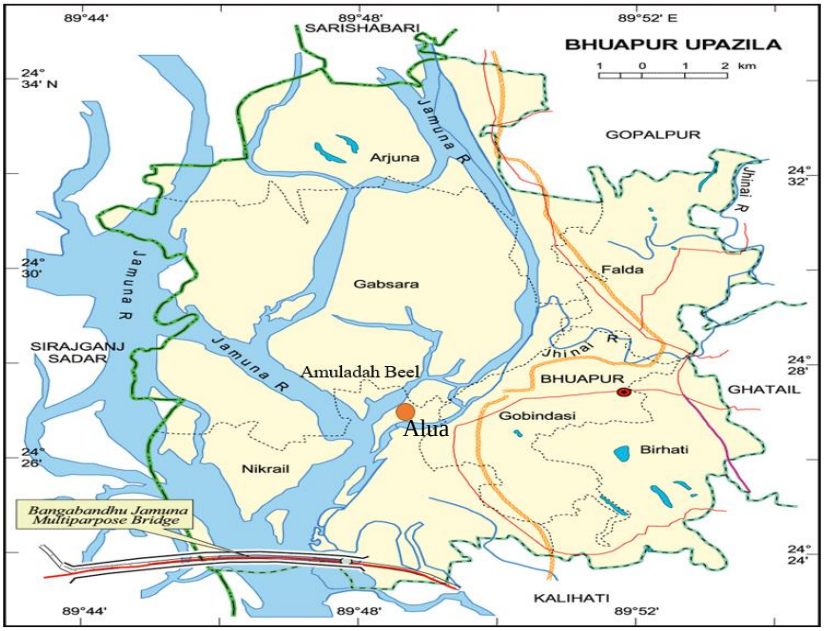

Fig. 1. The study area of Amuladah Beel

Water quality parameters

Water quality parameters (temperature, transparency, pH and dissolved oxygen) were weekly observed from the surface of water and were measured following **APHA (1989)**.

Collection and identification of fish samples

Fish biodiversity data from Amuladah Beel were collected with the assistance of local fishermen operating at the sampling sites. Sampling occurred fortnightly using traditional fishing gears. Immediately upon harvest, fishes were counted on-site. Species that posed identification challenges were preserved in 10% buffered formalin solution and were later transferred to the research laboratory at the Faculty of Fisheries, Bangabandhu Sheikh Mujibur Rahman Agricultural University. Fish fauna captured in the study area were identified based on their morphometric and meristic characteristics following **Bhuiyan (1964)**, **Rahman (1989, 2005)**, **Talwar and Jhingran (1991, 2001)**, and **Yadav (1997)**. The valid scientific names of the identified fish species were ensured by checking catalogue of life **(Roksov *et al*., 2016)**. Subsequently, identified fish species were systematically classified for further study and analysis. Data on previously available fish species from Amuladah Beel were collected from fishermen and the Upazila Fisheries office in Bhuapur, Tangail.

Data analysis

During the entire experimental duration, data were systematically collected, recorded, and organized in a computer spreadsheet. Statistical analyses were performed using MS Excel. The means along with their corresponding standard deviations (± SD) were calculated and reported. Significance levels for comparisons between samples were assessed using the Student's t-test distribution.

RESULTS

Water quality parameters

During the investigation period, water temperature in Belai Beel exhibited fluctuations ranging from 25.94 to 29.97°C (Table 1). The highest recorded temperature of 29.97°C occurred during the pre-monsoon period, whereas the lowest temperature of 25.94°C was noted in the post-monsoon period. Transparency levels fluctuated between 26.59 and 34.46cm throughout the observation period (Table 1). The highest transparency value of 34.46cm was observed during the full-monsoon period, contrasting with the lowest value of 26.59cm recorded in the pre-monsoon period. Dissolved oxygen (DO) concentrations ranged from 4.14 to 5.58mg/ l (Table 1), indicating suitable conditions for aquatic organisms. The pH values of water samples varied between 5.35 and 6.58 (Table 1), with the highest pH observed during the full-monsoon period and the lowest pH recorded in the pre-monsoon period. These fluctuations in environmental parameters across different monsoon periods illustrate the dynamic nature of Belai Beel's aquatic ecosystem, highlighting variations in conditions that can impact aquatic life and ecosystem health. Observation of water quality parameters succinctly presents the variations in water temperature, transparency, dissolved oxygen, and pH observed during the study period in Belai Beel, emphasizing the seasonal dynamics of these critical environmental factors.

Table 1. Water quality parameters in different investigation periods

Water quality Parameter	Pre-monsoon (April-June)	Full-monsoon (July-September)	Post-monsoon (October-December)
Temperature (°C)	29.97±0.78	27.43±0.67	25.94±0.65
Transparency (cm)	26.59±1.82	34.46 ±1.56	30.52 ±1.32
DO (mg/l)	4.14±0.24	5.15±0.55	5.58±0.64
pH	5.35±0.74	6.45±0.61	6.58±0.54

During certain months of the year, particularly in the pre-monsoon period, parts of the Beel were observed to dry up. However, in some areas of the Beel, sufficient water depth persisted throughout, providing shelters for fish survival. With the onset of the monsoon, fish began to disperse across the entire Beel. The primary water sources for the Beel included rainfall, supplemented by inflow from branches of the Jamuna River.

Species occurrence in Amuladah Beel

A comprehensive survey identified a total of 43 fish species belonging to 27 genera, 19 families, and 9 orders (Table 2) in the study area of Amuladah Beel. Among these, three exotic species—the silver carp (*Hypophthalmichthys molitrix*), the bighead carp (*Aristichthys nobilis*), and tilapia (*Oreochromis mossambicus*)—were documented during the current investigation. These species are widely used in aquaculture practices throughout Bangladesh. Additionally, previous fish records from Amuladah Beel were compiled (Table 3) using information obtained from local elderly fishermen and the Upazila Fisheries office in Bhuapur, Tangail.

Table 2. Species composition and conservation status of different fish species identified in Amuladaha Beel

Order	Family	Local name	Scientific name	Conservation Status	
				BD	**GB**
Osteoglossiformes	**Notopteridae**	Foli	*Notopterus notopterus*	VU	LC
		Chitol	*Notopterus chitala*	VU	NT
Clupeiformes	**Clupeidae**	Chapila	*Gudusia chapra*	VU	LC
Cypriniformes	**Cyprinidae**	Mirka	*Cirrhinus cirrhosus*	NT	LC
		Baus	*Labeo calbasu*	LC	LC
		Bata	*Labeo bata*	LC	LC
		Goni	*Labeo gonius*	EN	LC
		Rui	*Labeo rohita*	LC	LC
		Pumti	*Puntius sophore*	LC	LC
		Titputi	*Puntius ticto*	VU	LC
		Angra	*Labeo angra*	EN	LC
		Catla	*Catla catla*	LC	NE
		Mola	*Amblypharyngodon mola*	LC	LC
		Dela	*Osteobrama cotio*	VU	LC
		Darkina	*Esomus danricus*	LC	LC
		Silver carp	*Hypophthalmicthys molitrix*	EX	LC
		Bighead	*Aristichthys nobilis*	EX	LC
		Miner carp	*Cyprinus carpio var. communis*	VU	DD
		Gutum	*Lepidocephalus guntea*	EN	NE
Siluriformes	**Bagtidae**	Guitatengra	*Mystus cavasius*	NT	LC
		Tengra	*Mystus vittatus*	LC	LC
		Gulsa	*Mystus bleekeri*	EN	LC
	Heteropneustidae	Shing	*Heteropneustes fossilis*	LC	LC
	Siluridae	Pabda	*Ompok pabda*	CR	NT
	Clariidae	Boal	*Wallago attu*	VU	NT
		Magur	*Clarias batrachus*	LC	LC
Synbranchiformes	**Mastacembelidae**	Baim	*Mastacembelus armatus*	CR	NE
		Tara baim	*Macrognathus aculeatus*	CR	NE
		Guci baim	*Macrognathus pancalus*	CR	NE
Tetraodontiformes	**Tetraodontidae**	Chucia	*Tetraodon cutcutia*	VU	LC
Perciformes	**Anabantidae**	Koi	*Anabas testudineus*	LC	DD
	Ambassidae	Chanda	*Chanda nama*	LC	LC
	Gobidae	Baila	*Glossogobius giuris*	LC	LC
	Nandidae	Meni	*Nandus nandus*	NT	LC
	Osphronemidae	Cholisa	*Colisa fasciatus*	NT	LC
		Lal cholisa	*Colisa lalius*	VU	LC
	Cichlidae	Tilapia	*Oreochromis mossambicus*	EX	NT
	Badiidae	Napit koi	*Badis badis*	EN	LC
Channiformes	**Channidae**	Gozar	*Channa marulius*	EN	LC
		Taki	*Channa punctatus*	LC	LC
		Shol	*Channa striatus*	LC	LC
		Cheng	*Channa orientalis*	NT	DD
Beloniformes	**Belonidae**	Kakila	*Xenentodon cancila*	LC	NE

Conservation status: CR= Critically Endangered; **DD**= Data Deficient; **EN**= Endangered; **EX**= Exotic; **LC**= Least Concern; **NE**= Not Evaluated; **VU**= Vulnerable; **NT**= Not Threatened. (**IUCN Bangladesh, 2015; IUCN International, 2015)**.

Table 3. Checklist of previously available fishes in Amuladah Beel

Order	Family	Local name	Scientific name	Conservation Status	
				BD	GB
Cypriniformes	**Cobitidae**	Reak	*Cirrhinus reba*	DD	LC
	Cyprinidae	Banspatha	*Devario devario*	DD	LC
		Chep chela	*Chela cachius*	DD	LC
Siluriformes	**Schilbeidae**	Kajuli	*Ailia coila*	DD	NT
	Bagridae	Air	*Sperata aor*	DD	LC
		Rita	*Rita rita*	DD	LC
	Sisiridae	Baghair	*Bagarius bagarius*	DD	NT

Conservation status: CR= Critically Endangered; **DD**= Data Deficient; **EN**= Endangered; **EX**= Exotic; **LC**= Least Concern; **NE**= Not Evaluated; **VU**= Vulnerable; **NT**= Not Threatened. **(IUCN Bangladesh, 2015)**.

Composition of fish fauna

The order Cypriniformes emerged as the most predominant, comprising 37% of the total fish diversity with 16 species. Following Cypriniformes, Perciformes accounted for 19% with 8 species, while Siluriformes constituted 16% with 7 species. Channiformes represented 9% of the total with 4 species, Synbranchiformes contributed 7% with 3 species, and Osteoglossiformes made up 5% with 2 species. Beloniformes constituted 3% with 1 species, and both Clupeiformes and Tetraodontiformes each represented 2% with 1 species each **(**Fig. 2). The family Cyprinidae was the most dominant, comprising 35% of the total species with 15 species identified (Fig. 3). Following Cyprinidae, the next dominant family was Channidae, accounting for 9% with 4 species. Other families included Mastacembelidae and Bagridae, each representing 7% with 3 species, while Siluridae, Notopteridae, and Osphronemidae constituted 5% with 2 species each. Additionally, families such as Belonidae, Badiidae, Cichlidae, Tetraodontidae, Nandidae, Gobidae, Ambassidae, Anabantidae, Clariidae, Heteropneustidae, Cobitidae, and Clupidae each accounted for 2% with 1 species (Fig. 3).

The species *P. sophore* (19.18%) was the most dominant species. *P. ticto* (10.62%) second dominant species and third *M. vittatus* (8.51%) comprising with other species (Fig. 4). In the present study, six common groups of fish were identified (Fig. 5). Carp fishes comprised the highest percentage at 37%, followed by perches at 19%, catfishes at 16%, miscellaneous at 12%, snakehead at 9%, and eels at 7%. The Amuladah Beel hosts a total of 43 identified fish species, which represents approximately 14% (Fig. 6) of the total freshwater fish species reported in Bangladesh. The threatened species within the Amuladah Beel make up 31% of its total identified fish species. Of these 19 species, 9 (47%) are categorized as vulnerable (VU), 6 (32%) as endangered (EN), and 4 (21%) as critically endangered (CR) (Fig. 7).

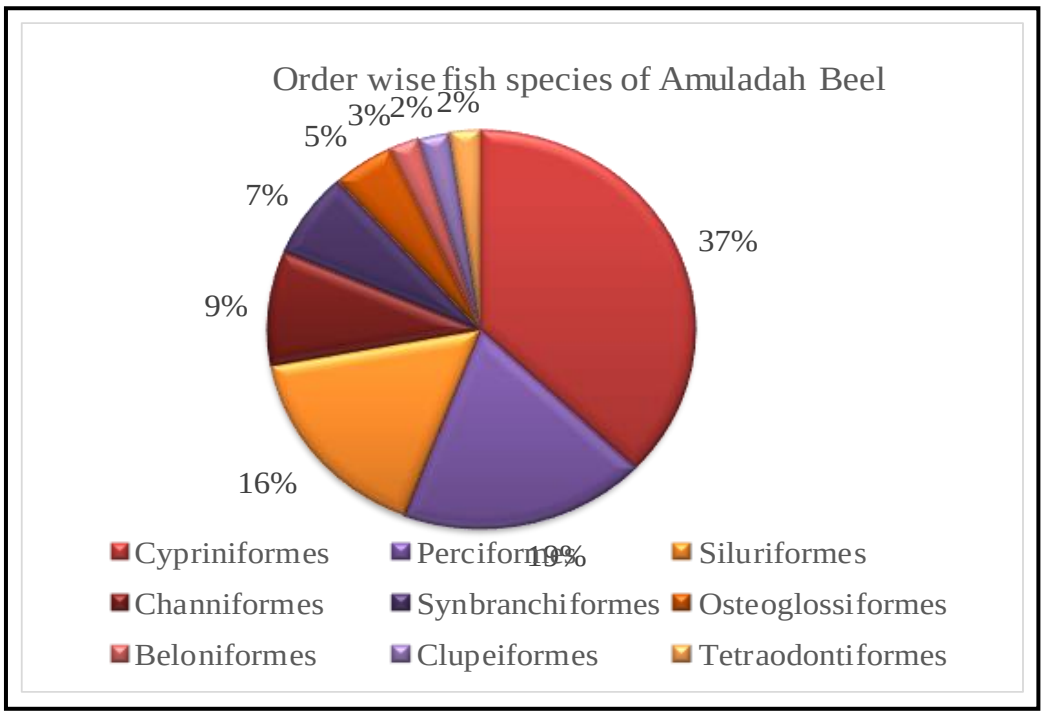

Fig. 2. Order wise percentage of available fish species in Amuladah Beel

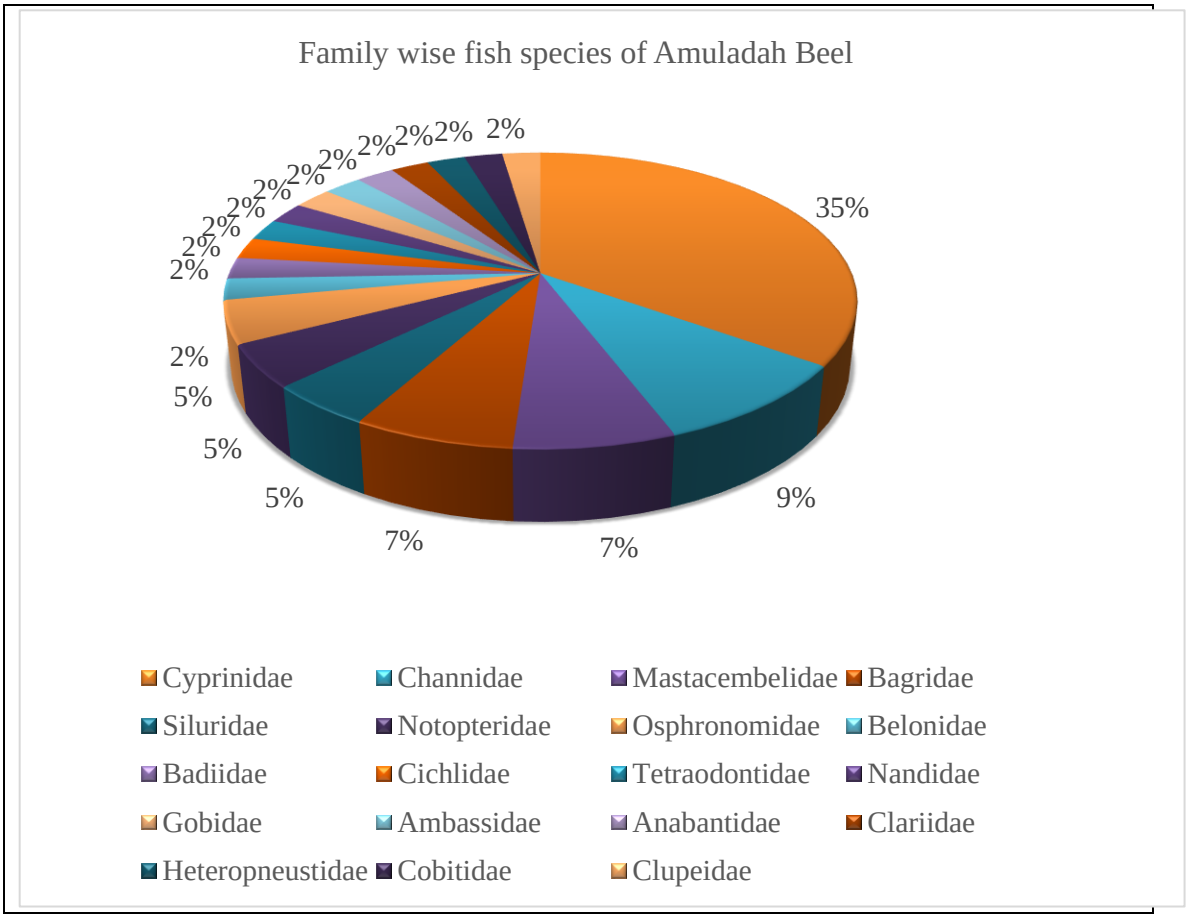

Fig. 3. Family based percentage of fish species observed in Amuladah Beel

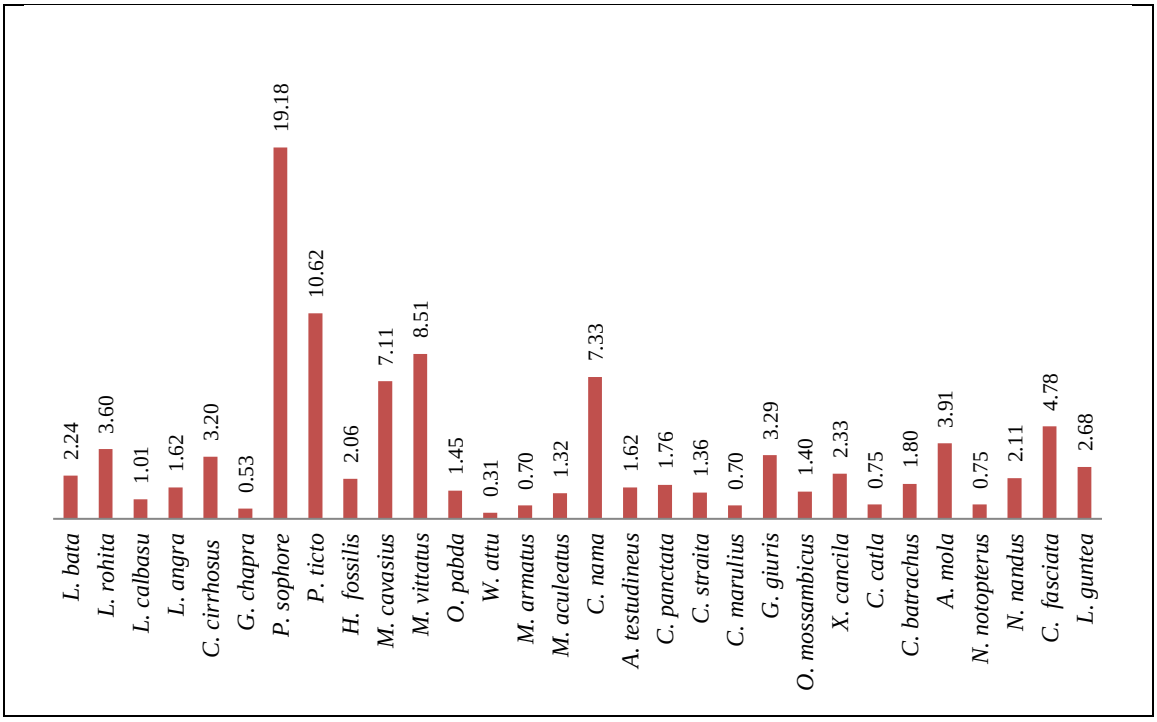

Fig. 4. Species wise percentage (%) of Amuladah Beel fish species

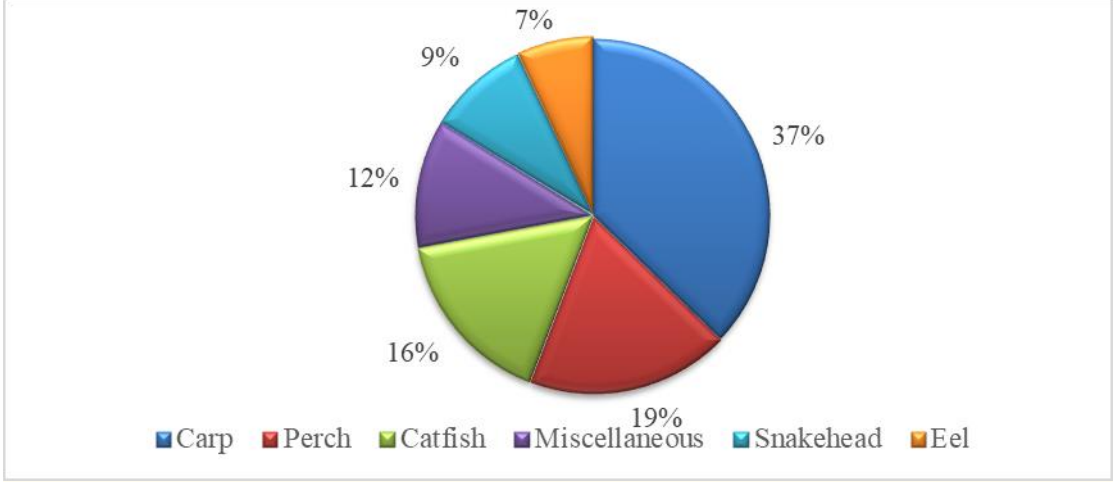

Fig. 5. Types of fish group as recorded during the period of study

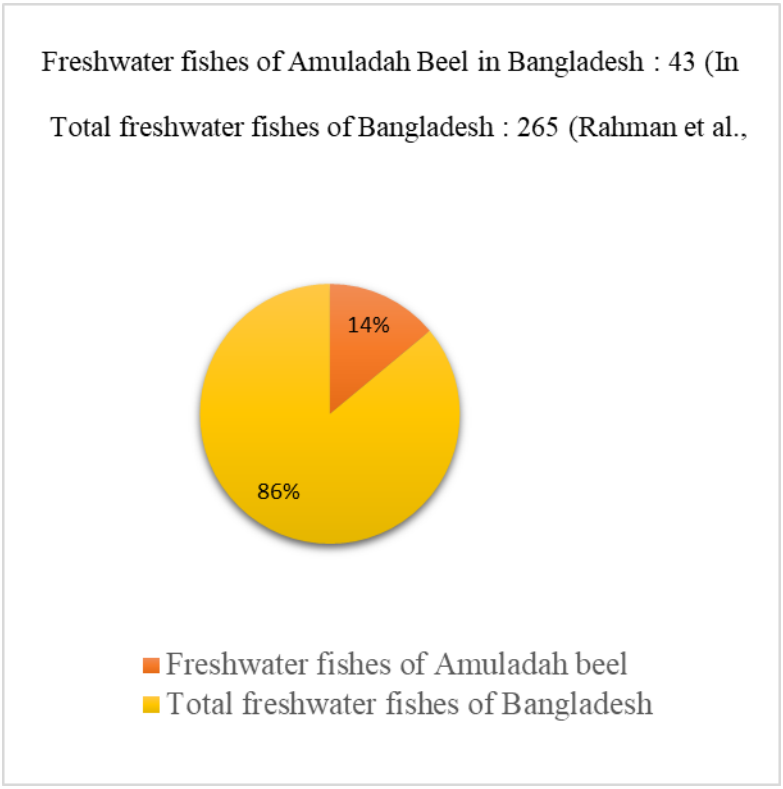

Fig. 6. Percentage of total freshwater fishes of Bangladesh available in Amuladah Beel

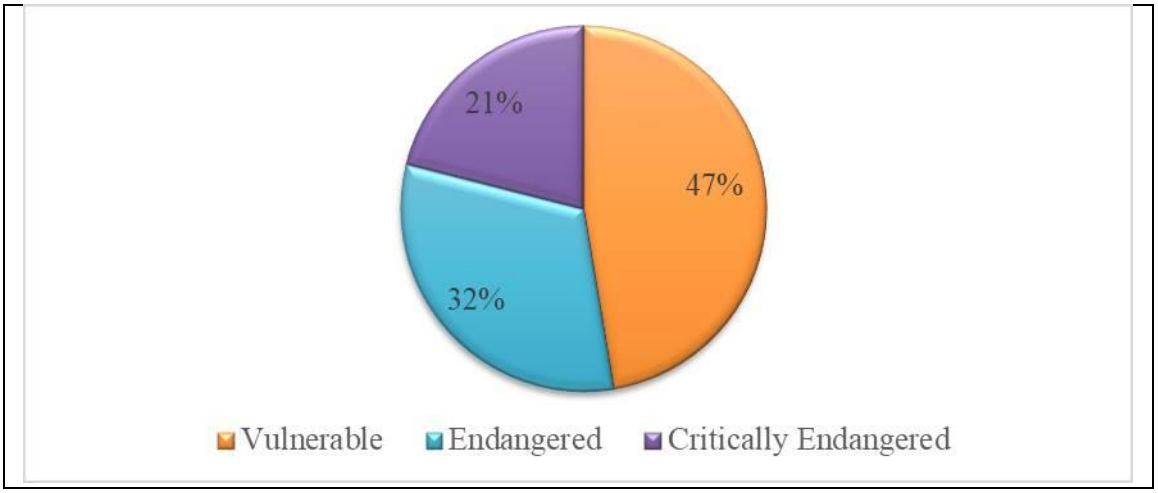

Fig. 7. Threatened Fish Species of Amuladah Beel

The total identified threatened fish species of the Amuladah Beel is 19 which is 26% (Fig. 8) of the total threatened freshwater fish species (54) recorded by **IUCN (2015)**. In Amuladah Beel, the conservation status of species shows the highest percentage classified as least concern (LC) (37%), followed by VU (21%), EN (14%), near threatened (NT) (12%), CR (9%), and exotic (7%) categories (Fig. 9A). According to **IUCN (2015)**, the majority of Global

(GB) fish species are classified under the least concern category (70%), followed by not evaluated (14%), and near threatened (9%). The data deficient category represents only 7% of the total fish species (Fig. 9B).

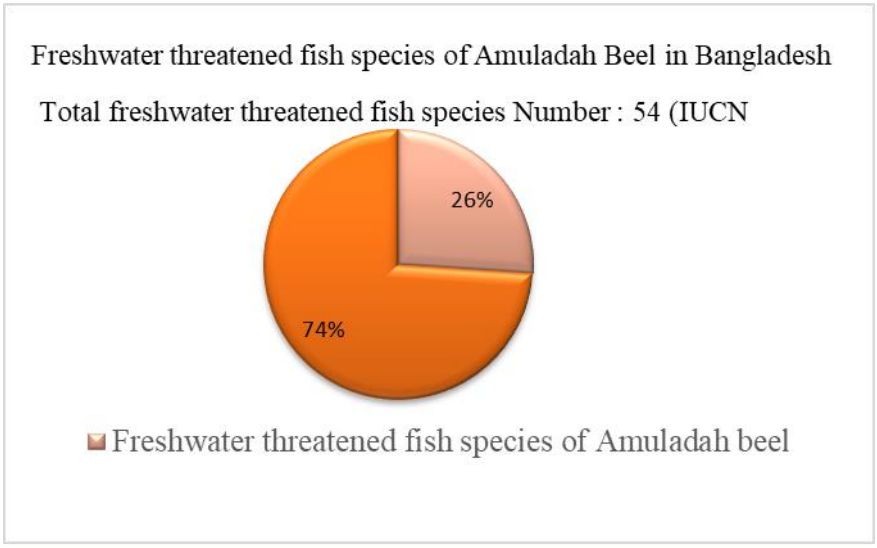

Fig. 8. Percentage of threatened fish species among total freshwater threatened fish species of Bangladesh

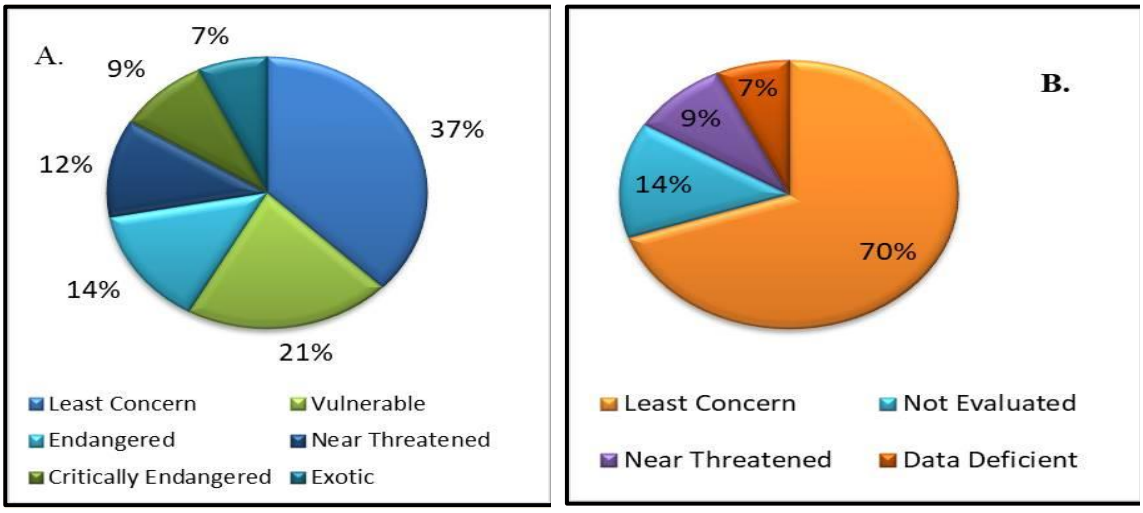

Fig. 9. Percentage of IUCN conservation status between **(A)** Bangladesh and **(B)** Global of Amuladah Beel

DISCUSSION

To the best of our knowledge, this study represents the inaugural investigation into the water quality and species composition of Amuladah Beel. During the investigation period, the highest temperature (29.97°C) was recorded during the pre-monsoon period, while the lowest temperature (25.94°C) occurred in the post-monsoon period. Mean water temperature values

ranged from 25.94± 0.65°C to 29.97± 0.78°C across different seasons. According to the Department of Environment **(DoE, 2017)**, the standard for sustaining aquatic life in river water temperature is typically between 20 to 30°C. **Uddin *et al*. (2021)** reported that the water temperature of Hail Haor in June reached its peak at 29.78°C, while it dropped in February to a low of 22.45°C. Water temperature is a critical factor influencing fish survival and growth. Deviations from these optimal temperatures can significantly impact fish productivity and metabolic functions. Based on the findings of the present study, the water temperature in Amuladah Beel was found to be within the acceptable standard limits prescribed for sustaining aquatic life. The fluctuation in river water temperature depends on various factors, such as season, geographic location, sampling time, and influx of water effluents **(Ahipathy & Puttaiah, 2006)**.

In the current study, transparency fluctuated between 26.59 and 34.46cm throughout the observation period. The highest transparency value of 34.46cm was recorded during the full-monsoon period, while the lowest value of 26.59cm was observed in the pre-monsoon period. The transparency values observed in this study fall within the range considered suitable for fish culture, which is typically between 25 and 35cm **(Boyd, 2016)**. **Hossain *et al*. (2013)** also suggested a suitable range of transparency from 24.75 to 29.50cm for aquatic environments. Transparency in water is a crucial parameter affecting aquatic ecosystems, including fish habitats and overall water quality. In the present investigation, the transparency levels were found to be within these recommended ranges.

The DO concentrations found ranged from 4.14 to 5.58mg/ l. **Rahman *et al*. (2017)** recorded that DO levels below 1ppm are insufficient to support fish life. The Bangladesh Standard for Fisheries reported that DO levels ranging from 4 to 6 mg/L are considered acceptable in open water bodies **(EQS, 1997)**. The DO levels observed during the study period were within favorable ranges, likely due to factors such as high sunlight penetration, minimal obstruction from large trees near the sampling site, and strong wind flow. Notably, DO levels were more favorable during the post-monsoon and full-monsoon periods compared to the pre-monsoon period. These findings highlight the importance of monitoring and maintaining adequate DO levels to support healthy aquatic ecosystems and sustainable fish production in the study area.

The pH values in the water samples varied from 5.35 to 6.58. The highest pH value was recorded during the full-monsoon period, while the lowest pH value was observed in the pre-monsoon period. The standard limits of pH range were 6.5 to 8.5 **(ADB, 1994; EQS, 1997; De *et al*., 2011; WHO, 2011; DoE, 2017)**, and the study showed that all of the values were within the standard limits. **Azim *et al*. (1995)** recommended a suitable pH range of 7.1 to 8.1 for aquatic environments. **Ahmed and Sarker (1997)** reported optimal pH levels for fish culture in the range of 6.0 to 6.4. Natural water typically has a pH between 6 and 8.5 **(Chapman & Kimstach, 1996; WHO, 2011)**. The pH values observed during the full-monsoon period in this study were more favorable compared to the pre-monsoon and post-monsoon periods. These findings highlight the importance of maintaining suitable pH levels in aquatic ecosystems to support healthy aquatic life and sustainable fisheries in the study area. Regular monitoring of

pH and proactive management practices are essential for preserving water quality and biodiversity.

During certain months of the year, particularly in the pre-monsoon period, parts of the beel were observed to dry up. However, in some areas of the beel, sufficient water depth persisted throughout, providing shelters for fish survival. With the onset of the monsoon, fish began to disperse across the entire beel. The primary water sources for the beel included rainfall, supplemented by inflow from branches of the Jamuna River.

In the study area of Amuladah Beel, a total of 43 fish species have been identified, representing 27 genera, 19 families, and 9 orders. Bangladesh boosts a rich diversity of freshwater fish species, with a total of 265 species reported **(Rahman, 2005)**. Bhuapur Upazila has implemented measures such as releasing fingerlings during the monsoon, enforcing fishing regulations strictly during banned seasons, and using specific sampling procedures and gear, all of which contribute to the increase in species diversity observed. Comparative studies reveal higher fish biodiversity in other wetlands across Bangladesh. For instance, **Galib *et al*. (2009)** identified 81 fish species in Chalan Beel, the largest wetland in the country. **Saha and Hussain (2002)** recorded 40 species in Salad Beel; **Ehsan *et al*. (2007)** recorded 40 species in Gharia Beel; **Haque *et al*. (2010)** recorded 37 species in Kumari Beel; **Deka and Deka (2011)** recorded 45 species in Koya Kujiya Beel; **Imteazzama and Galib (2013)** documented 63 fish species in Halti Beel; while **Hussain *et al*. (2013)** found 59 species in Ghukshi Beel; and **Siddiq *et al*. (2013)** recorded 58 species in Dogger Beel. **Akhtaruzzaman and Alam (2014)** identified 62 species across 10 orders in Ichanoi Beel, indicating slightly higher fish diversity compared to the present study area.

The relatively lower fish biodiversity observed in Amuladah Beel could be attributed to several factors. Unlike other wetlands that maintain water throughout the year, water availability in Amuladah Beel is primarily from April to December. Additionally, higher rates of water pollution from anthropogenic sources in Amuladah Beel may have contributed to the observed less diverse range of fish fauna compared to other wetlands. During the study period, the highest number of fish species was observed in the post-monsoon period, while the lowest number was recorded during the pre-monsoon period when water levels reduced or dried in some areas. In contrast, water levels were higher during the full-monsoon period due to frequent rainfall events.

Three exotic species, namely silver carp (*Hypophthalmicthys molitrix*), bighead carp (*Aristichthys nobilis*), and tilapia (*Oreochromis mossambicus*), were identified in the present investigation. These species are extensively utilized in aquaculture practices across Bangladesh. Previous studies have noted their introduction into the natural waters of Bangladesh, which can potentially threaten native fish populations **(Mukherjee *et al*., 2002; Galib & Mohsin, 2011)**. Therefore, it is essential to consider the implications of these non-indigenous species to prevent adverse environmental impacts, as emphasized by various researchers **(Önsoy *et al*., 2011; Imteazzaman & Galib, 2013)**. Continuous monitoring is crucial to promptly implement necessary measures against non-native species. This recommendation has been echoed by several researchers **(Önsoy *et al*., 2011; Imteazzaman & Galib, 2013)**. However, the study area appeared to have fewer instances of contamination

by exotic species compared to other waterbodies in Bangladesh. For example, Chalan Beel, Halti Beel, and Bookbhara Baor have recorded 9, 8, and 5 non-native fish species, respectively **(Galib *et al*., 2009; Imteazzaman & Galib, 2013; Mohsin *et al*., 2013)**. A compilation of previously available fish records from Amuladah Beel was created based on information gathered from elderly fishermen and Upzilla Fisheries office, Bhuapur, Tangail.

This initial study on the fish fauna of Amuladah Beel identified a total of 43 fish species, comprising 40 indigenous and 3 exotic species. There were no previous records of fish fauna specifically for Amuladah Beel, making it impossible to compare the present findings with earlier data. This issue is not uncommon in Bangladesh when studying fish diversity, as highlighted by previous studies **(Mohsin *et al*., 2013)**, underscoring the necessity for water-body specific investigations into fish diversity across Bangladesh. The order Cypriniformes was the most dominant, comprising 37% of the total with 16 species. Following Cypriniformes, Perciformes accounted for 19% with 8 species, Siluriformes constituted 16% with 7 species, Channiformes represented 9% with 4 species, Synbranchiformes accounted for 7% with 3 species, Osteoglossiformes comprised 5% with 2 species, Beloniformes constituted 3% with 1 species, Clupeiformes and Tetraodontiformes each represented 2% with 1 species each. The order Cypriniformes emerged as the most diverse fish group, constituting 37% of the total species and individuals in the study area, followed by Siluriformes and Perciformes. This finding aligns with previous studies by **Galib *et al*. (2009)** and **Imteazzaman and Galib (2013)**, which also identified these three groups as dominant in freshwater bodies across Bangladesh **(Rahman *et al*., 2017)**.

The family Cyprinidae was the most dominant, comprising 35% of the total species with 15 species identified (Fig. 3). Following Cyprinidae, the next dominant family was Channidae, accounting for 9% with 4 species consistent with findings by **Pramanik *et al*. (2017)**. The prevalence of Cyprinidae in freshwater fish populations of Bangladesh has been highlighted in previous studies by **Rahman (2005)**. Similar dominance of Cyprinidae in specific regions such as the River Padma in Rajshahi district and the Upper Halda River in Chittagong district has also been documented **(Alam *et al*., 2013; Mohsin *et al*., 2013; Joadder *et al*., 2015)**. Other families included Mastacembelidae and Bagridae, each representing 7% with 3 species, while Siluridae, Notopteridae, and Osphronemidae constituted 5% with 2 species each. Additionally, families such as Belonidae, Badiidae, Cichlidae, Tetraodontidae, Nandidae, Gobidae, Ambassidae, Anabantidae, Clariidae, Heteropneustidae, Cobitidae, and Clupidae each accounted for 2% with 1 species. The species *P. sophore* (19.18%) was the most dominant species. *P. ticto* (10.62%) second dominant species and third *M. vittatus* (8.51%) comprising with other species. In the present study, six common groups of fish were identified. Carp fishes comprised the highest percentage at 37%, followed by perches at 19%, catfishes at 16%, miscellaneous at 12%, snakehead at 9%, and eels at 7%. Carp fishes were found to be the most dominant group in Amuladah Beel, which aligns with findings reported by **Pramanik *et al*. (2017)**.

The Amuladah Beel hosts a total of 43 identified fish species, which represents approximately 14% of the total freshwater fish species reported in Bangladesh **(Rahman, 2005)**. Research on fish biodiversity in various regions of Bangladesh has revealed diverse

species compositions. **Rahman (2005)** documented 265 freshwater fish species across Bangladesh, encompassing 154 genera and 55 families. **Joadder *et al*. (2015)** recorded 71 species from the River Padma, including 10 orders, 26 families, and 54 genera. Similarly, **Mohsin *et al*. (2013)** identified 69 species in the Padma River at Rajshahi district, spanning 10 orders, 25 families, and 47 genera. **Galib *et al*. (2013)** reported 63 species from the River Choto Jamuna. **Alam *et al*. (2013)** documented 63 species from the upper Halda River in Chittagong, encompassing 9 orders, 24 families, and 51 genera. These studies highlight the rich diversity of fish species across different aquatic ecosystems in Bangladesh.

According to the **IUCN (2015)**, 54 native freshwater fish species in Bangladesh are classified as threatened. Among these, 19 species were identified from the Amuladah Beel, constituting 26% of the total threatened fish species in Bangladesh. The threatened species within the Amuladah Beel make up 31% of its total identified fish species. Of these 19 species, 9 (47%) are categorized as vulnerable, 6 (32%) as endangered, and 4 (21%) as critically endangered. **Alam *et al*. (2013)** reported a comparable finding in the Upper Halda River, identifying 22 threatened fish species out of 63 total species, comprising 8 species categorized as vulnerable, 11 as endangered and 3 as critically endangered. **Galib *et al*. (2013)** documented 41.27% threatened fish species in the Choto Jamuna River, with 15.87% vulnerable, 15.87% endangered, and 9.52% critically endangered, which is higher compared to the present study. **Joadder *et al*. (2015)** found 28 threatened fish species (39.43% of total) in the River Padma, including 13% vulnerable, 18% endangered and 8% critically endangered, illustrating differences compared to the findings of the present study.

The Amuladah Beel harbors a total of 19 threatened fish species, representing 26% of the 54 total threatened freshwater fish species recorded by **IUCN (2015)** in Bangladesh. Limited research has been conducted on the fish biodiversity of the Amuladah Beel compared to other regions in Bangladesh. **Jahan *et al*. (2018)** reported 7 threatened fish species from Belai Beel. **Joadder *et al*. (2015)** identified 28 threatened fish species (39.43% of the total) from the River Padma, which is part of the 54 threatened freshwater fish species of Bangladesh. **Pramanik *et al*. (2017)** documented 21 threatened fish species in the River Meghna.

In Amuladah Beel, the conservation status of species shows the highest percentage classified as least concern (37%), followed by vulnerable (21%), endangered (14%), near threatened (12%), critically endangered (9%), and exotic (7%) categories. These findings align closely with **Gain *et al*. (2015)**, who reported that the majority of fish species in the Passur River, Bangladesh, were classified as least concern and not evaluated categories (43%), with near threatened (3%) and data deficient (11%) categories also noted. **Pramanik *et al*. (2017)** recorded 68% of fish species in the River Dhonagoda as belonging to the least concern category.

According to **IUCN (2015)**, the majority of global fish species are classified under the least concern category (70%), followed by not evaluated (14%), and near threatened (9%). The data deficient category represents only 7% of the total fish species. In their study on the Padma River, **Joadder *et al*. (2015)** found that nearly three-quarters (72%) of the total species were classified under the least concern category in terms of global conservation status. Similarly, **Pramanik *et al*. (2017)** recorded 75% of fish species in the River Dhonagoda as belonging to

the least concern category globally. None of the identified fish species were found to be threatened in the global conservation aspects. It is noteworthy that some species identified as threatened in Bangladesh, such as *Ompok pabo* classified as critically endangered, were categorized as Near Threatened globally.

Conserving freshwater fish biodiversity poses a significant challenge due to the need for control over upstream drainage networks, surrounding lands, riparian zones, and downstream reaches for migrating aquatic fauna. These prerequisites are rarely fully met and demand the establishment of comprehensive management partnerships operating at appropriate scales, typically the drainage-basin level. This approach is crucial to effectively address the complex interactions affecting freshwater ecosystems and their diverse fish populations. The primary focus of this study revolves around the fish biodiversity of Amuladah Beel and the conservation challenges it faces in Bangladesh. A total of 43 fish species were documented from the Beel, providing insights into the overall biodiversity status and raising questions regarding the total species count. The presence of threatened fish species in Amuladah Beel underscores the urgent conservation concerns for fish populations in Bangladesh. The study also identified exotic fish species within the area. A significant proportion of the recorded species in the study area are considered threatened in Bangladesh, including *G. chapra*, *W. attu*, *N. notopterus*, *C. marulius*, *M. armatus*, and *O. pabda*. Analysis of biodiversity parameters across different monsoon periods (Pre-monsoon, full-monsoon, and post-monsoon) indicated a rich diversity of fish fauna, with variations observed among the different periods. The findings highlight the dynamic nature of fish diversity in Amuladah Beel throughout the monsoon seasons.

In the study area, the primary conservation challenges identified for Amuladah Beel include underwater dark-colored soil and overfishing. Aquatic weeds such as Kochuripana (*Eichhornia crassipes*), Helencha (*Enhydra fluctuans*), and Kalmilata (*Ipomoea aquatica*) contribute to the formation of this dark soil, which poses risks to bottom-dwelling fish species. This phenomenon not only diminishes natural food sources for fish and other aquatic organisms but also adversely affects species like eels, which rely on these habitats.

Several threatened fish species, including critically endangered ones, have been recorded in Amuladah Beel due to the presence of underwater dark soil. Species such as gochi (*M. pancalus*), tara baim (*M. aculeatus*), and shal baim (*M. armatus*) are particularly vulnerable. The study observed a diverse array of fish caught using various fishing gears across different monsoon periods. Among these gears, nets (especially gill nets) were identified as particularly harmful and should be subject to regulation or prohibition in the study area. Illegal fishing practices are widespread, driven by resource-poor fishers who rely on fishing for their livelihoods without viable alternatives. If left unchecked, the continued increase in legal and illegal fishing activities in Amuladah Beel could deplete its fisheries resources entirely in the near future. Effective management and conservation measures are urgently needed to ensure the sustainability of fish populations and the ecological health of Amuladah Beel.

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Ethical statement

This study adhered to ethical guidelines set forth by Bangabandhu Sheikh Mujibur Rahman Agricultural University for research involving fish species. All sampling and experimental protocols were conducted with the utmost consideration for animal welfare and environmental conservation. The investigation protocols ensure compliance with ethical standards and regulations. Measures were implemented to minimize stress to the fish and to protect their natural habitat during the study period. Data obtained from this research will contribute to the understanding and conservation of fish biodiversity in the Amuladah Beel ecosystem.

Conflict of interest statement

The authors declare that there is no conflict of interest regarding the publication of this study on goldfish artificial breeding.

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