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# ASSESSMENT OF FISH BIODIVERSITY IN THE TEESTA RIVER OF BANGLADESH

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## Abstract

The study investigated biodiversity, and the present status of the Teesta River fishery in Rangpur and Nilphamari district, Bangladesh, from November 2018 through October 2019. Questionnaire Interviews and Focus Group Discussions with Key Informant Interviews (KII) and a catch assessment survey were carried out in the study. A total of 45 fish species were identified under 17 families and ten olders. Fishes were categorized as commonly available (24.44%), moderately available (26.66%), less available (22.22%), and rarely available (26.66%). A total of 8 fishing gear were identified. The highest and lowest level of gear efficiency was recorded from Gill net and Dhoar (Fish trap) in May and June as 0.501 kg and 0.000209 kg, respectively. In October, all gear's maximum average gear efficiency (1.039 kg) was recorded, and the minimum average gear efficiency (0.309 kg) was recorded in June. Shannon-Weaver diversity index (H') was found to range from 1.11 to 2.42. Highest Margalef Species Richness (d) (3.24) was in April and the lowest (1.86) was in September. The highest Pielou's Evenness Index (J') (0.78) was documented in January, and the lowest (0.36) in August. The highest fish production was in April (592±65.30 kg/day), and the lowest in July (112±12.24 kg/day). Significant threats to fish biodiversity, habitat, and overall fish production of the Teesta River were identified. However, the establishment of the sanctuary, control of pollution, maintenance of fishing gear, and the implementation of the fish act is necessary for the conservation of fish biodiversity of this River.

***Keywords:*** Fish biodiversity, abundance, CPUE, threats, Teesta River.

## Introduction

Bangladesh is a small riverine country situated in the southern part of Asia. It is blissful with grandiose water possessions in the form of ponds, lakes, floodplains, rivers, canals, streams, haors, bells, and a long coastline convenient for high fish production. About 4.7 million hectares of inland open waters contribute 83.85% to the fisheries sector (DoF, 2017). According to Banglapedia (2015), 700 rivers flow in Bangladesh with their own sedimentary, geographical, hydrological, and biological characteristics. These rivers significantly enhance open water fish production and confirm the fishermen's socio-economic security (Rahman *et al*., 2015; Islam *et al.*, 2015).

The Teesta River is one of the most significant rivers in Bangladesh. This river, which originates in the Himalayas and flows through the Indian states of Sikkim and West Bengal before entering Bangladesh and joining the Brahmaputra, is essential in the northern region of Bangladesh. The Teesta River enters Bangladesh at the Kharibari border, situated in the Nilphamari district. The length of this river is about 315 km, where 115 km lies within Bangladesh. The mean depth of the river is 282 feet, and the maximum depth is 550 feet. (Banglapedia, 2015). According to IUCN Bangladesh (2015), the inland aquatic habitats of our country are affluent with faunal variety and bear 146 species of mammals, 175 species of reptiles, 593 species of birds, 49 species of amphibians, 142 species of crustaceans, 305 species of butterflies where freshwater finfish was 258 species. In Bangladesh, there are 64 freshwater species in a threatening condition where nine species are recorded as critically endangered, 25 as vulnerable, and 30 as endangered (IUCN 2015). This river, which originates in the Himalayas and flows through the Indian states of Sikkim and West Bengal before entering

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Bangladesh and joining the Brahmaputra, is essential in the northern region of Bangladesh. In recent times, it is also revealed that fish diversity has been declining gradually due to some manufactured and natural causes such as overfishing, sedimentation, dewatering, use of illegal fishing gears and catching of brood fishes. (Islam *et al.*, 2015; Islam *et al.*, 2016). Haque (2012) stated that many factors are responsible for the losses of fish biodiversity, such as (i) population pressure, (ii) deforestation, (iii) overexploitation of biological resources, (iv) natural disasters, (cyclones, earthquakes, flood), (v) climate change, (vi) agriculture and industrial pollution, (vii) destruction of habitat (viii) land-use change and conflicts, (ix) indiscriminate use of fertilizers, insecticides and pesticides, (x) flood control related activities destroying wetlands, etc.

The Teesta River is one of the most significant water bodies in the North part of Bangladesh for fish production and income generation of most of the fishers surrounding the water body. It is an essential habitat for the wide variety of fish species, and it is a very significant spawning and feeding ground for riverine fish species. The ecosystem of the Teesta River performs a vital role in supporting the biodiversity of fish fauna, contributes to the supply of animal protein, and takes a vital role in the country's overall economy through fish production. In the past, riverine ecosystems have suffered from passionate human interference, creating habitat losses and wasting aquatic ecosystems. As a result, some fish species have become extremely endangered, particularly in rivers where considerable require is placed on freshwaters (Rahman *et al.*, 2012; Barman *et al.*, 2014). Because of dissimilar natural and human interference, our country's rivers have been gradually losing their fish biodiversity, and the Teesta River is not unique from this. This is very fearful for the fisheries sector of our country, including the world. Teesta River's natural existing fish species should be known to conserve its natural biodiversity, and the study was guided based on this watchword. At present, the gradual reduction of aquatic biodiversity from natural water bodies is a dynamic problem in Bangladesh (Galib *et al.*, 2009, 2013; Mohsin *et al.*, 2013, 2014; Islam *et al.*, 2019). All this stated information implies knowing about the detailed biodiversity status of a water body, which will give the apparent knowledge about the present status of fish species and help to sustainable management of a water body. Some efforts have been prepared to evaluate the fish variety in different water bodies of Bangladesh (Galib *et al.*, 2013; Islam *et al.*, 2015; Pramanik *et al.*, 2017; Barman *et al.*, 2021). The present study will add some new information about the condition and causes of the destruction of the fish diversity of Teesta River, giving evident knowledge about the current situation of fish diversity in this studied river. The effect of this study will also help to take proper management initiatives and development policies by the efficient authority to conserve the fish biodiversity in the Teesta River. According to the above statements, the following objectives were deliberated for this study- to identify the present status of fish diversity in the Teesta River, to identify the fishing gears used in the Teesta River, and finally, to estimate the fish species variety in the Teesta river at Rangpur and Nilphamari District.

## Materials and Methods

### *Selection of the study area*

The study was guided in some adjacent places of Teesta River. These are Lokkitari (ward #4), Mohipur, Gongachora Sadar Upazila of Rangpur district, Dalia point (Teesta Barrage), and Dimla Upazila of Nilphamari district. The research area includes about 20 kilometers of the total area. The primary principle for selecting the study area was appropriate geographical coverage for a wide diversity of biodiversity. In the beginning, preliminary information was collected from Gongachora Upazila Fisheries Office, Nilphamari Upazila Fisheries Office concerning the fish biodiversity and fishing activities of Teesta River. The final decision was taken to select the study site based on this preliminary data. Mohipur of Gangachara Upazila (Site-1) and Dalia of Dimla Upazila (Site-2) were selected for the study area.

**Table 1. Geo-locational data of the sampling stations in the Teesta River**

| Sites | Site Name | Latitude (N) | Longitude (E) |
|---|---|---|---|
| Site-1 | Mohipur | 25°86‟74” N | 89°25‟38” E |
| Site-2 | Dalia | 26°10‟43” N | 89°03‟06” E |

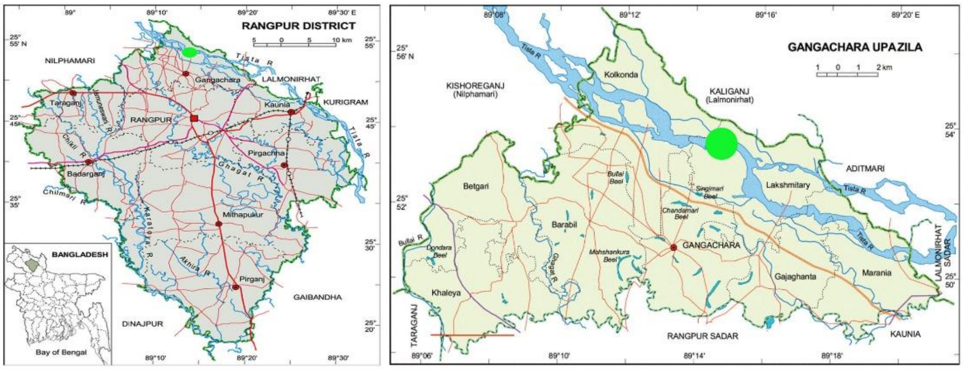


Figure (a): Site 1,(Gangachara Upazila) indicate the sampling site.

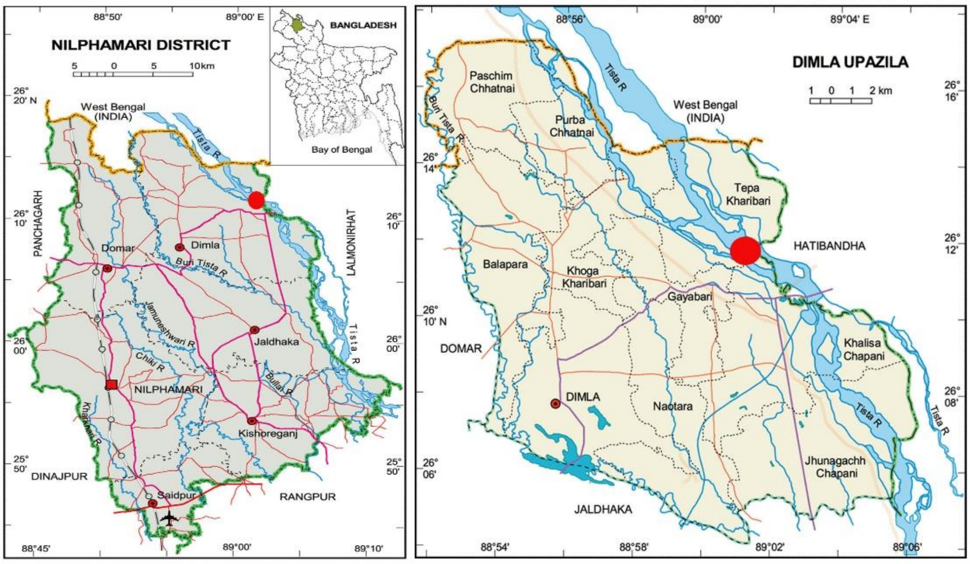


Figure (b): Site 2,(Dimla Upazila) indicate the sampling site.

**Fig. 1. Map showing the position of the study area**

***Flow chart of the methodology***

The present study was completed according to the subsequent order of methodology-

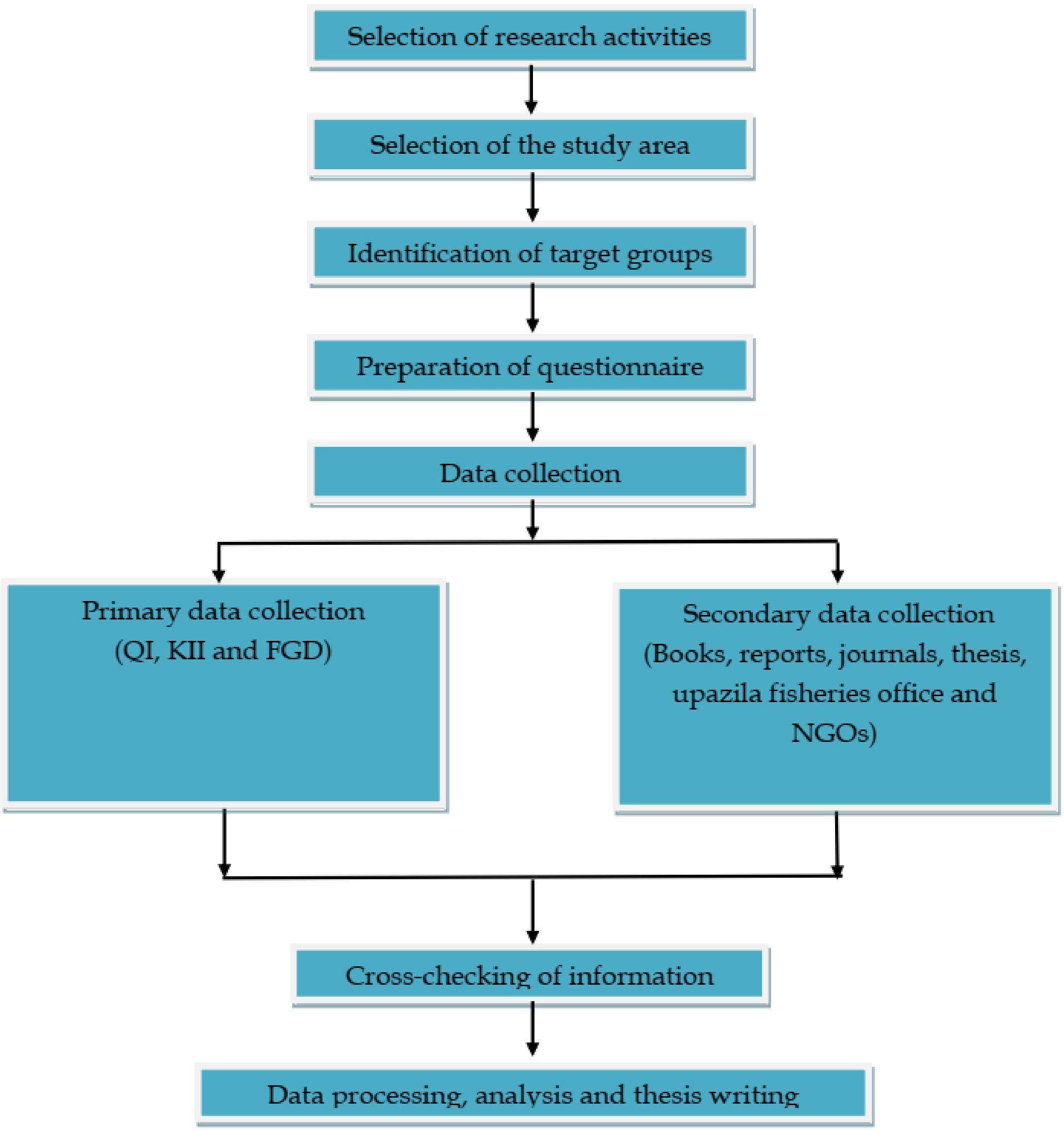


**Fig. 2. Flow chart showing research activities at a glance**

***Preparation of questionnaire and data collection***

The questionnaire is one of the most significant parts of the survey process. To fulfill the study's required objectives, manifest a draft questionnaire and pretested in the study area. In pre-examining, the target was paid to prepare any new information which was not planned to be asked and filled in the draft interview cadastre. Then the questionnaire was changed, modified, and reshuffled according to the experience gathered from the pretest. The final questionnaire was then promoted in reasonable series so that the fishermen could answer step by step. Questions related to present fish biodiversity status compared with past experiences, most available fish species, fish availability based on season, fishing gear used and causes of fish habitat change were included in the questionnaire.

The study has been conducted for one year, from November 2018 through October 2019. Data collection programs were done at two sampling stations, and most of these were deliberated as fishing grounds and fish landing centers. The primary and secondary data sources were deliberated for the present study. During the study period, an amalgamation of PRA (Participatory Rural Appraisal) tools such as QI (questionnaire interview), FGD (focus group discussion), and cross-check interviews with key informants were used. Primary data were collected from fishers and fish traders through QI, FGD, and KII. The secondary information was collected from the Upazila Fisheries Office of Gongachara and Dimla, books, journals, the internet, and thesis papers. Catch assessment information was collected two times per month from 2 pre-selected sites of Teesta River for 12 months (November 18 to October 19). Catch assessment information is collected by direct observation of fish species caught using different fishing gear types by the fishers. Then, fish were identified, counted, and weighed with the target to estimate fishing gear efficiency.

***Key stakeholders and their roles***

149 stakeholders, including fishers, fish traders, stockists, local leaders, housewives, and UFOs, participated. All the fishers depend on the Teesta River directly or indirectly for their livelihood. Most of the fishers were involved in fishing activities year-round, but some were involved in fishing activities during peak season. To know the role of different local leaders around the Teesta River, 5 local leaders were selected for focus group discussion (FGD) and Questionnaire interview (QI). Other essential stakeholders were interviewed, including Upazila Fisheries Officers (UFOs). They are an essential part of the government. They are mainly involved in enforcing fishing rules and regulations, conservation of fish biodiversity, and managing—the total fraud system to assist the nation by increasing fish production. The stakeholders' individuality and the nature of any primary dependency on the river are enlisted in Table 3.2.

**Table 2. Cataloging of key stakeholders groups and their actions in the study**

| | Sl No | Stakeholder number | Stakeholder action | Participation in study |
|---|---|---|---|---|
| 1 | Fishers | 95 | Connected fishing activities, livelihood and socio-economic condition depends on Teesta river | and FGD |
| 2 | Fish traders | 22 | Purchasing fish from fishers and other sources<br>Participate or capitalize in the fish business<br>Selling and enhancing fish in the market | Interviewed and FGD |
| 3 | Stockists (Aratder) | 10 | Gather fish from fishers<br>Selling fish to other parties | Interviewed |
| 4 | Local leaders | 05 | Connected in local politics<br>Minimize the local conflict and regulate their sub-ordinate to maintain blamelessly environment | Interviewed as Key Informant |
| 5 | Housewives | 15 | Connected in dry fish produced, net making and mending | Interviewed |
| 6 | Upazila Fisheries Officer (UFO) | 2 | Responsible for overall management for the upliftment of fisheries sector at Upazila Level. | Interviewed |

***Measurement of abundance and fish biodiversity status***

In the recent study, the diversity of fish species was appraised by the Shannon Weaver index (H′) (Shannon and Weaver, 1949); species richness by the Margalef index (d) (Margalef, 1968), and evenness by Pielou's index (J′) (Pielou, 1966) through the following formula:

**a) The Shannon-Weaver diversity index, H'=-∑Pi ln Pi**

Where ni = no. of individuals of a species, Pi = ni/N, N = Total number of individuals in the sample ln = Returns the natural logarithm of a number. This index is a popular diversity index in the ecological literature.

**b) Margalef's richness index, d = S-1 / ln N**

Where, S = Total species, N = Total individuals

**c) Pielou's evenness index, J'=H / ln S**

Where H = Shannon-Weaver index, and S = Total number of species

***Data analysis***

After collecting the data from the study area, all data were adorned sequentially and documented on a computer. Data were analyzed depending on the collected data according to the questionnaire. Then the documented data were confirmed to omit all possible mistakes and contradictions. Several forms of the tabular method were applied by using statistical implementations like averages and percentages to process all the data. Finally, data were evaluated by using Microsoft Office Excel 2007 software. For the presentation of the analyzed data, manifold tables, pie charts, and graphical figures were used in the primary documents of the thesis.

## Results and Discussion

For the appraisement of biodiversity status in Teesta River, the identified fishes were characterized as threatened conditions at different levels following IUCN Red list, 2015. These were vulnerable (VU), endangered (EN), critically endangered (CR), near threatened (NT), least concern (LC), Not evaluated (NE), and Data deficient (DD). The basis on the interview and the availability during the study period, the fishes were also characterized and appraised as commonly available (CA), moderately available (MA), less available (LA), and rarely available (RA).

During the study period, in pursuance of the speech of local fishers and direct catch observation and market visits, there were recorded 45 fish species under 10 orders and 17 families in the study area. A similar finding was recorded by Khan *et al.* (2013) carried out a study on the Teesta River, there were recorded 42 fish species under 7 common groups, among them 7 species of carps, 4 species of snakeheads, 9 species of catfishes, 3 species of eels, 7 species barbs and minnows, 4 species of perch and various species were 8. Among them, 11 species of commonly available (24.24%), 12 species of moderately available (26.66%), 10 species of less available (22.22%), and 12 species of fishes were rarely found available (26.66%). Similar work was done by Kamrujjaman and Nabi (2015) in the Bangshi River, Savar of Bangladesh, and found 29 species (40.42%) of fishes as locally rare, only 3 species (6.25%) of fishes were ubiquitous, and 16 species (33.33%) were commonly available. Flowra *et al.* (2013) in Baral River, Natore, Bangladesh and recorded available (45%), less available (33.33%), rare (13.33%), and very rare (8.33%). The recorded total number of fishes with their order and family details, present status, and IUCN status are described below in Table 3.

45 fish species under 17 taxonomic families have been recorded in the study river for 1 year. Cyprinidae was the most abundant family and was found dominant throughout the year. Among the total 45 fish species, maximum (15) fish species were recorded from the Cyprinidae family, consisting of 33.33% of the total fish population. Siluridae (8.89%) and Schilbeidae(8.89%) were the second leading family containing 4 fish species, followed by 3 species of Bagridae (6.67%), 3 species of Channidae (6.67%), 2 species of Ambassidae (4.44%), 2 species of Mastacembelidae (4.44%), 2 species of

Clupeidae (4.44%),2 species of Notopteridae(4.44%), 1 species of each family were found under, Sissoridae, Cobitidae, Cichlidae, Nandidae, Osphronimidae, Belonidae, Palaemunidae and Clariidae (2.22%) (Fig. 3.). A similar result was made by Hossain *et al*. (2017) in the Kusiara River (Fenchungonj Upazilla), Northeast Bangladesh, and found Cyprinidae as a dominant family consisting of 33.33% of total fish species noted. Rahman *et al.* (2015) found Cypriniformes as the dominant order with 32 species in the Talma River of Bangladesh. It is expressed that the Cypriniformes order was dominant in many rivers of Bangladesh (Barman *et al.*, 2021).

**Table 3. Fish species occurrence in the studied area with their IUCN (2015) status.**

| SL. No. | Order | Family | Local Name | English Name | Scientific Name | Present Status | IUCN Status |
|---|---|---|---|---|---|---|---|
| 1 | Cypriniformes | Cyprinidae | Silver carp | Silver carp | *Hypophthalmichthys molitrix* | RA | NT |
| 2 | | | Grass carp | Grass carp | *Ctenopharyngodon idella* | RA | NE |
| 3 | | | Bighead carp | Bighead carp | *Hypophthalmichthys nobilis* | RA | DD |
| 4 | | | Carpu,Carpio | Common carp | *Cyprinus carpio* | RA | LC |
| 5 | | | Kalibaus | Black Rohu | *Labeo calbasu* | CA | LC |
| 6 | | | Bata | Bata Labeo | *Labeo bata* | CA | LC |
| 7 | | | Rui | Rohu Carp | *Labeo rohita* | LA | LC |
| 8 | | | Chela | Silver Hatchetchela | *Chela cachius* | CA | VU |
| 9 | | | Mola | Mola Carplet | *Amblypharyngodon mola* | MA | LC |
| 10 | | | Dhela | Cotio | *Osteobrama cotio* | LA | NT |
| 11 | | | Soto peyali | Jaya | *Aspidoparia jaya* | MA | LC |
| 12 | | | Boirali, Borali | Borali | *Barilius barila* | CA | LC |
| 13 | | | Mirka | Mrigel | *Cirrhinus cirrhosus* | RA | NT |
| 14 | | | JatPunti | Punti Barb | *Puntius sophore* | RA | LC |
| 15 | | | Sarpunti | Olive Barb | *Puntius sarana* | RA | NT |
| 16 | | CobitidaeBagridae | Bou, Rani | Necktie Loach | *Botia dario* | RA | EN |
| 17 | | | | | | | |
| | Siluriformes | | Ayre | Long whiskered catfish | *Sperata aor* | CA | VU |
| 18 | | | Rita | Rita | *Rita rita* | LA | EN |
| 19 | | | Gulsha | Gangetic Mystus | *Mystus bleekeri* | CA | NT |
| 20 | | Siluridae | Boal | Freshwater Shark | *Wallago attu* | LA | VU |
| 21 | | | Pabda | Pabda catfish | *Ompok pabo* | RA | NT |
| 22 | | | Kanipabda | Butter catfish | *Ompok bimaculatus* | MA | NT |
| 23 | | | Madhu Pabda | Butter Catfish | *Ompok pabda* | MA | EN |
| 24 | | o r i | Baghair | Dwarf Goonch | *Bagarius bagarius* | MA | CR |
| 25 | | Schilbeidae | Bacha | BatchwaVacha | *Eutropiichthys vacha* | CA | LC |
| 26 | | | Gharua, Laira | Garua Bacha | *Clupisoma garua* | CA | EN |
| 27 | | | Batasi | Indian Potasi | *Neotropius atherinoides* | CA | LC |
| 28 | | | Kajuli, BanshPata | Gangetic Ailia | *Ailia coila* | CA | LC |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 29 | | r i i | Magur | Walking Catfish | *Clarias batrachus* | MA | LC |
| 30 | Channiformes | Channidae | Taki, Tahi, Lati, Lata | Spotted Snakehead | *Channa punctatus* | MA | LC |
| 31 | | | Shol, Shoul | Striped Snaked | *Channa striatus* | RA | LC |
| 32 | | | Cheng | Ceylon snakehead | *Channa orientalis* | MA | VU |
| 33 | Perciformes | ro ne mi | Khalisha, Khaiya | Banded Gourami | *Trichogaster fasciata* | MA | LC |
| 34 | | d i | Meni, Bheda | Mud Perch | *Nandus nandus* | LA | NT |
| 35 | | Ambassidae | Lomba Chanda | Elongate Glass-Perchlet | *Chanda nama* | MA | LC |
| 36 | | | Gol Chand | Indian Glass Fish | *Parambassis ranga* | MA | LC |
| 37 | Synbranchiformes | Mastacembelidae | BoroBaim | Tire-Track Spiny Eel | *Mastacembelus armatus* | LA | EN |
| 38 | | | GuchiBaim | Striped Spinyeel | *Macrognathus pancalus* | LA | LC |
| 39 | ro nif or m | lo ni da | Kakila | Freshwater gar fish | *Xenentodon cancila* | LA | LC |
| 40 | Clupeiformes | Clupeidae | Ilish | Hilsa Shad | *Tenualosa ilisha* | RA | LC |
| 41 | | | Kachki, Kechki | Ganges River Sprat | *Coricaso borna* | LA | LC |
| 42 | De ca po da | m on | GuraIcha | Kuncho River Prawn | *Macrobrachium lamarrei* | CA | LC |
| 43 | Osteoglossiformes | Notopteridae | Chital | Humped Featherback | *Chitala chitala* | RA | EN |
| 44 | | | Foli | Fresh water Knife fish | *Notopterus notopterus* | LA | VU |
| 45 | ch lif or m | ch lid | Tilapia | Tilapia | *Oreochromis mossambicus* | MA | VU |

*CA = commonly available, MA = moderately available, LA = less available, RA = rarely available* LC = least concern, NT = near threatened, CR = critically endangered, EN = endangered, VU = vulnerable, NE = Not Evaluated and DD = Data Deficient

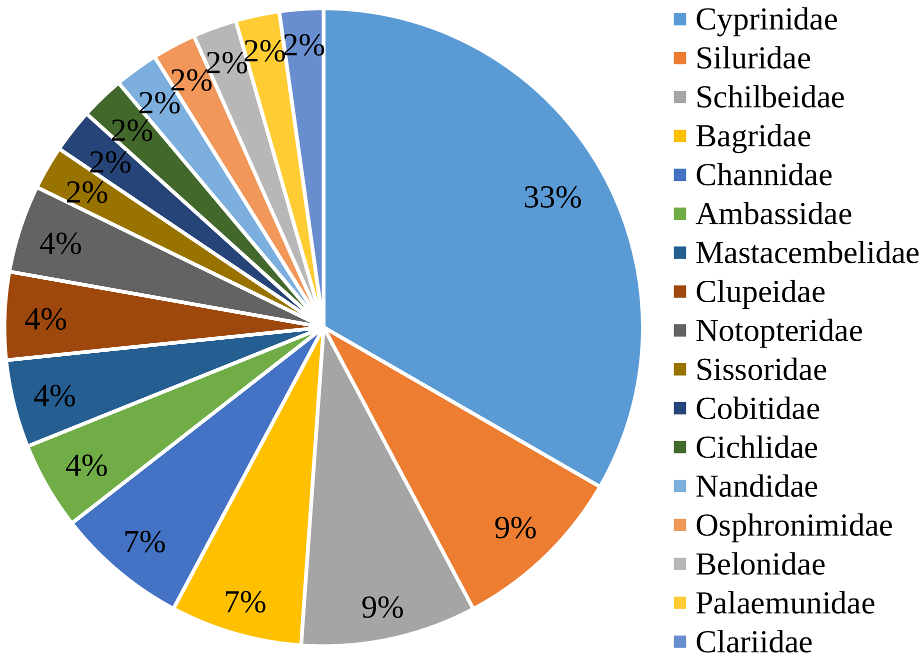


**Fig. 3. Percentage of fish species diversity recorded in the Teesta River under different families**

From Table 3, it was found that there were 10 orders of fish recorded during the study period, and Cypriniformes were the leading order amongst identified orders. Total 16 fish species were identified from Cypriniformes order, among them, Jatputi (*Puntius sophore*), Sarputi (*Puntius sarana*), mrigal (*Cirrhinus cirrhosus)*, Rani (*Botia dario*), Carpio (*Cyprinus carpio*) were rarely available; Rohu (*Labeo rohita*), dhela (*Osteobrama cotio*) were less available; Mola (*Amblypharyngodon mola*), *Grass carp(Ctenopharyngodon idella), Bighead carp (Hypophthalmicthys nobilis), Soto peyali(Aspidoparia jaya*) were moderately available; Chela(*Chela cachius*), Silver carp (*Hypophthalmichthys molitrix)*, Kalibaus *(Labeo calbasu),*Bata (*Labeo bata*), Borali(*Barilius barila*) were found commonly available as in this study area. In case of Siluriformes order, 13 species were identified among them are*(sperata aor)*, Bacha *(Eutropiichthys vacha)*, Gharua(*Clupisoma garua*), Gulsha (*Mystus cavasius),*Kajuli*(Ailia coila*) and Batashi(*Neotropius atherinoides) were commonly available;* Kanipabda *(Ompok bimacul)*, Madhu pabda (*Ompok pabda*), Baghair (*Bagarius bagarius*), Magur (*Clarias batrachus)* were moderately available; Boal (*Wallago attu), Rita (Rita rita)* were less available; Pabda (Ompok pabo) was rarely available in the study area. In case of Channiformes order, 3 species were identified. Among them, taki (*Channa punctatus*) and Cheng (*Channaorientalis*) were moderately available; Shol (*Channa striatus*) was rarely available in the study area. In case of Perciformes order, 4 species were identified. Among them, Khasila (*Trichogaster fasciata)*, Lambachanda (*Chanda nama*) and Gol chanda (*Parambasis ranga)* were moderately available; Meni (*Nandus nandus*) was found less available in this study area. In case of Synbranchiformes order, 2 species were identified. Borobaim (*Mastacembelus armatus*) and Guchibaim (*Mastacembelus pancalus*) were less available in the study area. Incase of Osteoglossiformes order, chital (*Chitala chitala*) was very rarely available; Foli (*Notopterus notopterus)* was less available in the study area. There were 2 species identified under the order Clupeiformes among them, and kachki (*Coricasu borna*) was less available. Recent Ilish (*Tenualosa ilisha*) was rarely available in the study area. In Decapoda order, Guraicha (*Macrobranchium lamarre)* was identified as commonly available in the study area. In the case of Beloniformes order, Kakila (*Xenentodon cancila*) was identified and was less available in the study area. In Cichiliformes order, Tilapia (*Oreochromis mossambicus*) was found moderately available in the study area.

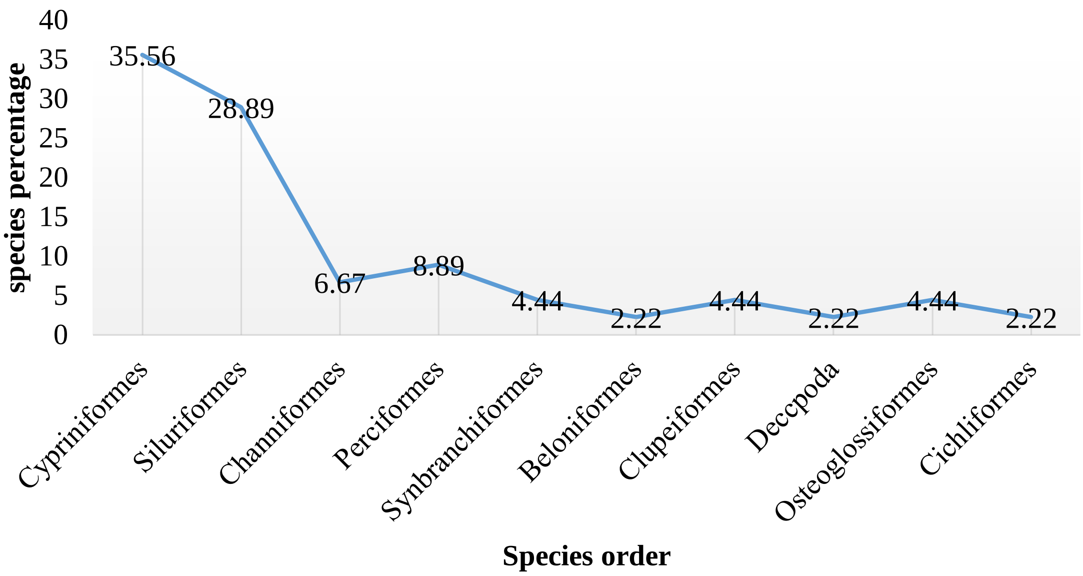


**Fig. 4. Percentage of fish species recorded in the Teesta River under different order.**

Among the identified 45 species, 11 fish species as commonly available, 12 fish species as moderately available, 10 fish species were less available, and 12 fish species of fish were rarely found available at the study site (Figure 5). The rarely available species are those fish species that pass a critical condition that will vanish or disappear soon.

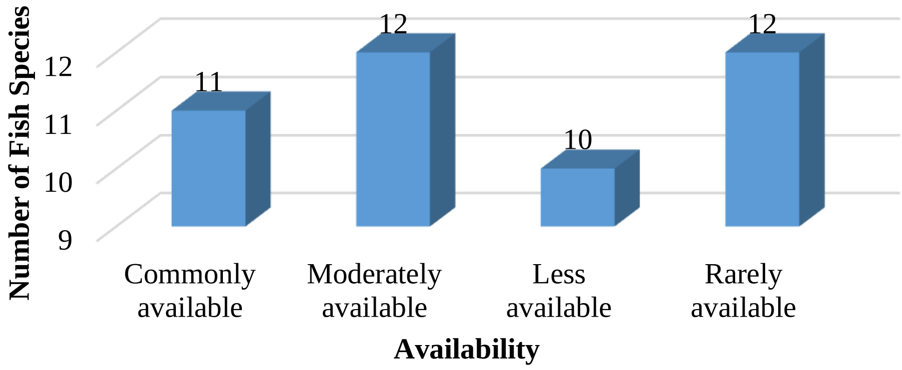


**Fig. 5. Availability status of fishes in the Teesta River.**

Among the four categories, commonly available species consists 24.44% of the total recorded fish species followed by moderately available species consists 26.66%, less available 22.22%, and rarely available species 26.66% (Figure 4.4).

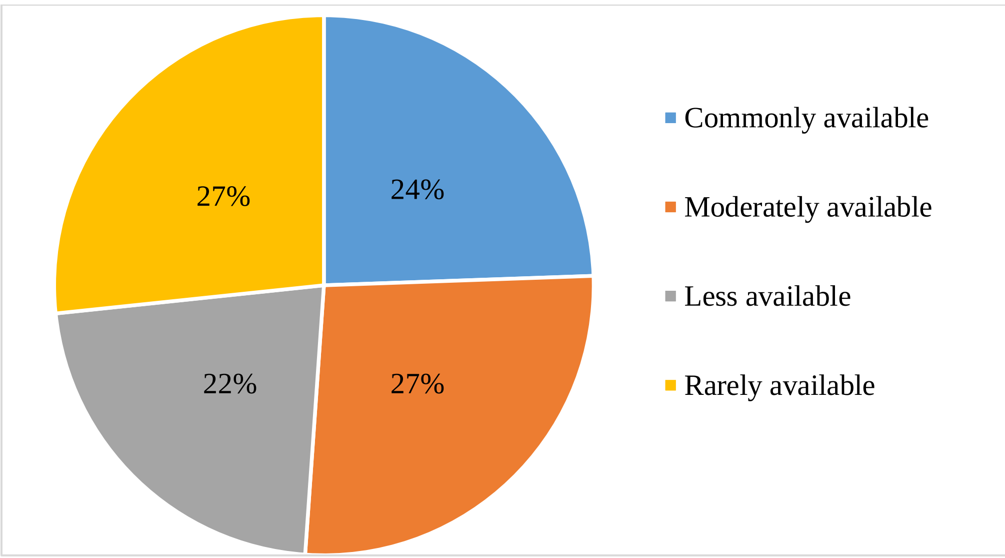


**Fig. 6. Percentage of fish biodiversity in the study area.**

Here recorded 22 species as least concern (LC), 8 species as near threatened (NT), 6 species as vulnerable (VU), 6 species as endangered (EN), 1 species as critically endangered (CR), 1 species as not evaluated (NE), and another 1 species as data deficient (DD) out of 45 fish species. It was done according to the IUCN red list, 2015. Chaki *et al*. (2014) identified and recorded thirty (30) locally threatened species, among them, 13.51% were vulnerable, followed by endangered 18.92% and critically endangered 8.11% at the Atrai River of Bangladesh.Kamrujjaman and Nabi (2015) documented 52.08% of threatened species in the Bangshi River of Bangladesh ,which recorded vulnerable 20%, endangered 36%and critically endangered 44%.

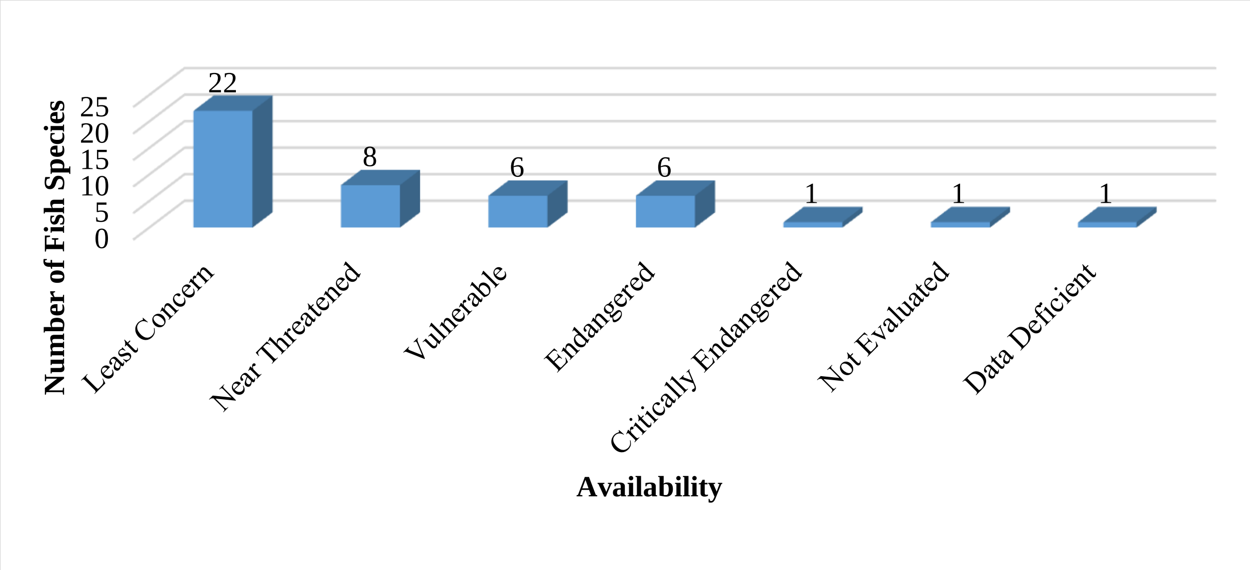


**Fig. 7. Number of fishes according to IUCN status**

In percentage, among the seven categories (IUCN) of available 45 fish species, least concern (LC) species consists 48.89%, near threatened (NT) species consists 17.78%, vulnerable (VU) species consists 13.33%, endangered (EN) species consists 13.33%, critically endangered (CR) consists 2.22%, not evaluated (NE) species 2.22% and data deficient (DD) species consists2.22% (Figure 8).

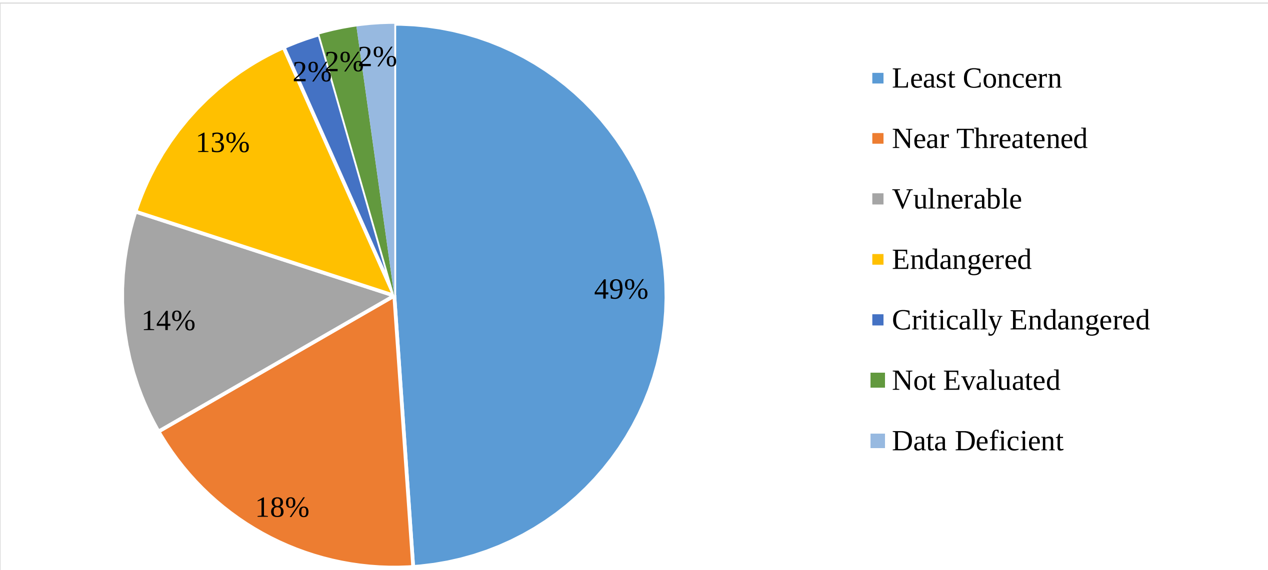


**Fig. 8. Percentage of fish according to IUCN status**

Many kinds of fishing gear were conducted in the study area, most of them were traditional types, and some were matchless for the particular locality. Types of gear, their mesh sizes, and lengths transform depending on the availability of the fish species in different seasons and depth of water body. During the study period, eight different gears under three categories were found to operate in Teesta River, with their specifications, mode of operations, and catch compositions. In the Chalan *beel* of Bangladesh, Galib *et al.* (2009) recorded twelve types of fishing nets, among them 5 types of traps, 6 types of hooks and lines, 4 types of wounding gears, and 2 FADs (Fish Attracting Devises) for harvesting of fishes. Ali et al. (2015) identified eight significant fishing gear in the Ramnabad River, used to catch fish species at different seasons.

**Table 4. Types of fishing gear used in the study area**

| Category | Type of gear | Name of gear | Mesh size (cm) | Description of the gears | Period (month) |
|---|---|---|---|---|---|
| **Fish net** | Seine net | a) Mahajal | Fine meshed | Suspends vertically in the water with its bottom side held down by weights and its top side buoyed by floats. | November to May |
| | | b) Ber jal | 0.25-1 | Having two border lines with rectangular shape. The upper borderline holds on float and the lower borderline holds on sinkers. | December to June |
| | Gill net | Current jal | 0.5-2.5 | This net like as a bag. Having 4 diagonal H poles which are affixed at the corner. Lift pole (act as like as liver) is tied at the center. | Year round |
| | Drift gill net | Chandijal | 3.5-4.5 | Rectangular shaped. It was made by polyamide monofilaments, polypropylene or nylon rope. | August to October |
| | Lift net | Dharma jal | 0.5-1 | Nets can be flat or shaped like a bag, a rectangle, a pyramid, or a cone. | August to November |
| | Cast net | Jhakijal | .5-1 | Its shape is conical. The hauling string is fixed at the narrow apical end of the cone. | November to May |
| | Drag net/ push net | Thala jal | 0.25-1 | Rectangular net but it has single wall. Upper border hold on float and lower border might or might not contain sinker. | Year round |
| **Fish trap** | Fish Trap | Dhoar | - | It is made by split bamboo with cane materials. Tubular basket shaped. This trap is setting against water current. | April to August |
| **Hook and line** | | Ship borshi | - | It is made of brass or iron. | August to October |

The fishers alluded that they use several gears to catch those fish supposed to be dominant to get caught by specific gear. Different gears are used to catch different types of fish. The maximum adverse effects of fine-meshed seine net experienced were biodiversity loss and bottom habitat degradation. The study area also encountered a dragnet and a few hook and line fishing. Day by day, the capture fishery in Teesta River is decreasing due to indiscriminate harvesting of brood fishes and small fishes in the early stage by some illegal fishing gears.

Fish catch per unit effort (CPUE) is an index of the affluence and level of absorption of fishery resources. It determines the number of fishing gear and craft that a given fishery might support sustainably. The CPUE (kg gear$^{-1}$ haul$^{-1}$) can be used to look into vulnerability to fish capture in conjunction with the estimated total yield (Ahmed and Hambrey, 2005). In the recent study, 45 species of fishes under the 10 orders and 17 families were recorded. The maximum level of CPUE (6.09 kg) was recorded from the Seine net during March, and the lowest CPUE (1.82 kg) of the seine net was recorded in December. In the case of Gill net, the highest CPUE (5.04 kg) was recorded in May, and the lowest CPUE (1.63 kg) of gill net was recorded in January. The highest CPUE (0.26 kg) of Drift gill net was recorded in September, and the lowest (0.172 kg) was recorded in August. The highest CPUE (0.769 kg) of lift net was they were recorded in July, and the lowest (0.141kg) in August. The highest CPUE (0.04 kg) of Dragnet was recorded in October, and the lowest (0.02 kg) in July. In the case of Cast, the net CPUE was 0.063 kg. The highest CPUE of dhoar (fish trap) was recorded at .0036 kg during April and 0.008 kg in May. In the case of Hook and line, CPUE was 0.01443 kg. The maximum average CPUE (1.27 kg) of all gears and the minimum average CPUE (0.032 kg) of all gears were recorded during May and October. Barman *et al.* (2021) identified 13 types of fishing gear in the Kura River and found different CPUE (kg gear-1 day-1) for four fishing grounds, respectively. Among all types of nets, the highest CPUE of 2.44 kg/gear was found immediately before pre-monsoon during June. The lowest 1.49 kg/gear was found in the dry season during January. Azadi et al. (2013) conducted a biodiversity study in the Halda River and documented that the mean CPUE for all the gears was 2.247±0.265 kg gear-1day-1 for 2007 and 2.697±0.355 kg gear-1day-1 for 2008. Total 8 gears were recorded in the Halda River, and among them, bag nets yielded the highest CPUE during 2007 at 5.957±0.704 kg gear-1day-1 and seine nets during 2008 at 7.288±1.477 kg gear-1day-1. The highest CPUE was found during March-April and September-November periods. These studies on CPUE are slightly different from the recent study due to the difference in fishing places, hooks, net sizes, lures and baits.

A total 8 mostly used fishing gears were recorded from the studied sites. Seine net, Gillnet, Dhoar (fish trap), Lift net, Dragnet, Hook and Line, Drift Gillnet, and Cast net. Figure 4.7 expresses the mean CPUE (kg gear$^{-1}$ day$^{-1}$) in the available fishing gear of Teesta River. The highest mean CPUE was found in gill net at 3.21±1.35kg/day, and the lowest was in hook and line at 0.003±0.004 kg/day. The mean CPUE in value in other available fishing gear as: seine net- 2.26±2.30 kg/day, dragnet- 0.006±0.01 kg/day, lift net- 0.13±0.2 kg/day, cast net- 0.006±0.01 kg/day and dhoar (fish trap)-0.005±0.01 kg/day.

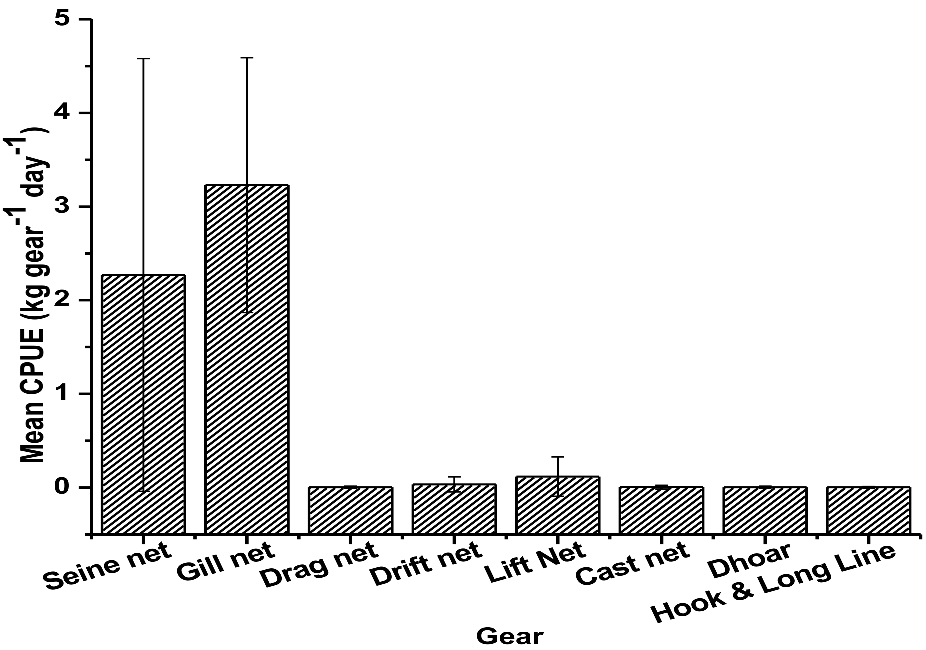


Fig.

**Fig. 9. Gear-wise mean CPUE in the Teesta River**

The CPUE of the identified 8 fishing gears in the two different sites of the Teesta River clarifying in figure 4.9. In the case of seine net, CPUE was found as 4.2±2.21 kg on site-1, 3.62±2.05 kg on site-2. In the gill net, CPUE was recorded as2.98±1.2 kg on site-1, and 3.9±1.14 kg on site-2. The CPUE of dhoar (fish trap) was recorded as 0.0069±0.0022 kg from site-1, and 0.03±0.04 kg from site-2. In the case of lift, net CPUE was found as 0.1413 ±0.04 kg from site-1, and 0.67±0.92 kg from site-2. In the case of hook and long line, the CPUE was recorded as 0.012±0.0006 kg, and 0.02 kg from site-1 and site-2, respectively. The CPUE of the cast net was found to be 0.05 kg, and 0.0625kg from site-1 and site-2, respectively. The CPUE of the drift net was found0.182±0.025 kg, and 0.15±0.09 kg from site-1 and site-2, respectively. In the case of the dragnet, CPUE was found at 0.028±0.003 kg and 0.031±0.01 kg from site-1 and site-2, respectively.

A large variety of fish species subsist in most of the fishing grounds, and each different fishing gear can catch a several diversity of species. The species composition for all fishing gears used to harvest fish in Teesta River. In the seine net following categories of fish species were caught: Siluriformes (27%), Cypriniformes (36%), Beloniformes (4%), Clupeiformes (2%), Channiformes (6%), Osteoglossiformes (4%), Perciformes (15%), Decapoda (2%), Synbranchiformes (2%), and Cichiliformes (2%). In case of gill net, the categories were: Siluriformes (38%), Cypriniformes (46%), Clupeiformes (5%), Perciformes (6%) and Synbranchiformes (5%) and in case of lift net the categories of fish species were: Cypriniformes (35.55%), Decapoda (5.55%), Siluriformes (48%), Perciformes (8.56%) and Synbranchiformes (7.33%). The fish species ordered caught by the Dhoar (fish trap) were the Cypriniformes (15.57%), Decapoda (13.29%), Siluriformes (27.29%), Perciformes (15.57%), and Synbranchiformes (27.29%). In the case of hook and longline fishing, there were five orders, namely Cypriniformes (9.70%), Decapoda (5.68%), Siluriformes (67.67%), Perciformes (8.25%), and Synbranchiformes (9%). The orders of fish caught by the Dragnet were the Decapoda (6.14%), Cypriniformes (31.52%), Siluriformes (7.14%), Channiformes (8.19%), Synbranchiformes (13.14%), Clupeiformes (5.29%), and Perciformes (28.57%). The orders of fish caught by the Cast net were the Decapoda (5.56%), Cypriniformes (43.44%), Siluriformes (18.67%), Channiformes (5.75%), Synbranchiformes (7.57%), Clupeiformes (5.53%), and Perciformes (13.56%). However, in the case of Drift gill net, there is only one order, Clupeiformes, which contributes 100%of the total fish caught by the drift gillnet in the study area. Similar work was conducted by Barman *et al.* (2021) in the Kura River, Bangladesh. He recorded a total of 13 fishing gear and 59 fish species, which shows the highest species composition as Cypriniformes (26.52%).

In the Teesta River, a total 8 number of fishing gear were identified during the study period. Fishers used their gear based on seasonal variation, water depth, and kind of fish species to be caught. The highest and lowest level of gear efficiency was recorded from Gill net and Dhoar (Fish trap) during May and June as 0.501 kg and 0.000209 kg, respectively. The maximum and minimum levels of gear efficiency for different gear were found as Seine net: 0.419kg during March and 0.147 kg during January, Gill net: 0.488 kg during May and 0.159 kg during January, Dragnet: 0.301 kg during October and 0.249 kg during July, Drift gill net: 0.152 kg during September and 0.139 kg during August, Lift net: 0.349 kg during November and 0.151 kg during July, Dhoar (fish trap): 0.000535 kg during April and 0.00225 kg during the maximum average gear efficiency (1.039 kg) of all gear were recorded during October and minimum average gear efficiency (0.309 kg) was recorded during June. The gear efficiency (kg gear$^{-1}$ person$^{-1}$ hour$^{-1}$) of the 8 most frequently used available fishing gears in two different sites of the Teesta River. The gear efficiency of the seine net was found as 0.234±0.135 kg in site- 1 and 0.352±0.239 kg in site-2, respectively. In the case of gill net, gear efficiency was recorded as 0.309±0.133 kg on site-1 and 0.414±0.138 kg on site-2, respectively. The gear efficiency of dhoar (fish trap) was recorded as 0.0005±0.0001 kg from site 1, 0.00039±0.0002 kg and 0.0005±0.0002 kg from site-2. In the case of lift net gear efficiency was found at 0.259±0.108 kg and 0.301±0.098 kg on site-1 and site-2, respectively. The gear efficiency of the drift gill net was found to be 0.149±0.023 kg, 0.109±0.051 kg from site-1and site-2, respectively. In the case of hook and long line, the gear efficiency was recorded at 0.0078±0.0006 kg and 0.0017±0.0001 kg from site-1 and site-2, respectively. In the case of the cast net, gear efficiency was recorded as 0.031±0.001 kg on site-1, and 0.49±0.002 kg on site-2, respectively.

The Shannon-Weaver diversity (*H'*), Margalef's richness (*D*) and Pielou's evenness (J') indices are presented in table 5. by the month-wise diversity.

**Table 5. Number of calculated species and individuals; and particular values of Shannon-Weaver diversity, Margalef richness, and evenness indices in each sampling month**

| Month | Number of species (S) | Total Number of individuals (N) | Diversity, H´ | Richness, d | Evenness, J´ |
|---|---|---|---|---|---|
| Nov, 2018 | 24 | 31612 | 1.45±0.06 | 2.22±0.14 | 0.46±0.01 |
| Dec, 2018 | 25 | 14459 | 1.94±0.07 | 2.50±0.28 | 0.60±0.02 |
| Jan, 2019 | 22 | 13788 | 2.42±0.07 | 2.20±0.11 | 0.78±0.03 |
| Feb, 2019 | 24 | 10729 | 2.39±0.08 | 2.48±0.09 | 0.75±0.02 |

| | | | | | |
|---|---|---|---|---|---|
| March, 2019 | 30 | 41211 | 2.28±0.08 | 2.73±0.09 | 0.67±0.03 |
| April, 2019 | 37 | 65992 | 2.04±0.06 | 3.24±0.14 | 0.56±0.02 |
| May, 2019 | 36 | 72401 | 1.80±0.06 | 3.13±0.09 | 0.50±0.01 |
| June, 2019 | 32 | 30885 | 2.40±0.09 | 2.99±0.11 | 0.69±0.02 |
| July, 2019 | 23 | 18771 | 2.18±0.10 | 2.23±0.29 | 0.69±0.02 |
| Aug, 2019 | 20 | 19779 | 1.11±0.07 | 1.92±0.06 | 0.37±0.03 |
| Sep, 2019 | 21 | 47125 | 1.57±0.03 | 1.86±0.05 | 0.52±0.01 |
| Oct, 2019 | 28 | 28609 | 1.67±0.06 | 2.63±0.12 | 0.50±0.03 |
| **Average** | 27 | 31862 | 1.92±0.39 | 2.50±0.43 | 0.58±0.13 |

* Data represented as mean ± SD

Barman *et al.* (2021) estimated H´ value between 3.454 to 3.861. The recent study's findings are slightly different from the above findings because of the different geographical locations of the study area (Barman *et al.*, 2021). The mean Shannon-Weaver diversity index (H') was found to range from 1.11 to 2.42 exhibited in (Fig. 10). For the Shannon-Weaver diversityindex (H'), the mean value was recorded as 1.92±0.39. The highest diversity index value was 2.42 in January, and the lowest value was 1.11 in August. No significant differences were found (P>0.05).

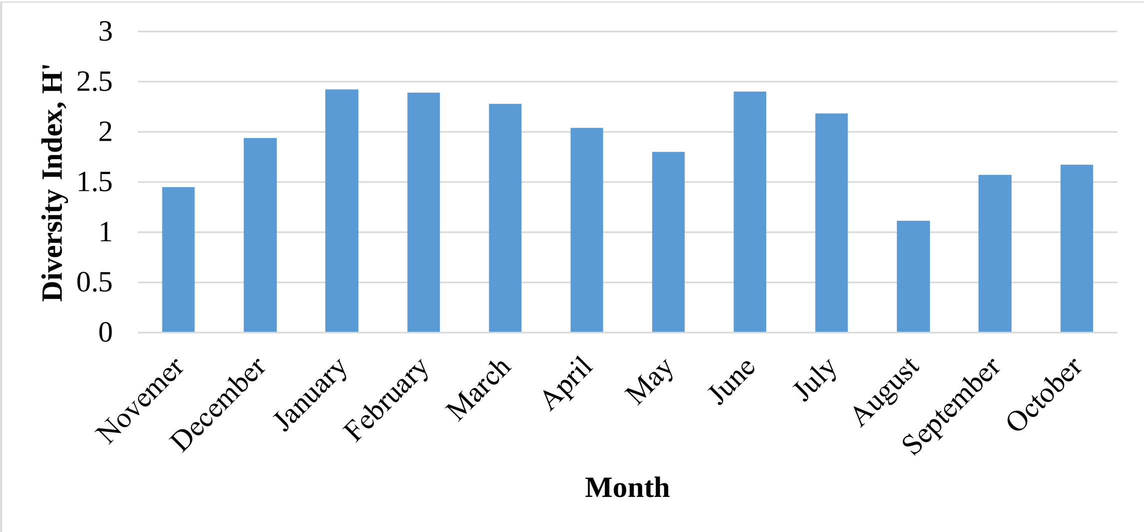


**Fig. 10. Shannon-Weaver diversity index (H') in Teesta River**

The degree of pollution was assessed and revealed (Table 6) along with values based on the assortment of the Shannon Weaver diversity index as recommended by Biligrami (1988).

**Table 6.** Shannon-Weaver diversity index (H') and pollution level given by Biligrami (1988)

| Shannon-Weaver diversity index (H') | Pollution level | Values found (Range) |
|---|---|---|
| 3.0 - 4.5 | Slight | |
| 2.0 – 3.0 | Light | 1.11 – 2.42 |
| 1.0 – 2.0 | Moderate | |

| | |
|---|---|
| 0.0 – 1.0 | Heavy |

.

All the Months showed values ranging from 1.11 to 2.42, representing moderate to light pollution. These results suggest that the overall condition of the water bodies of the Teesta River is found to be good. However, government and different NGOs interventions for protecting these endangered fish species in situ will be very supportive for the use of future generations. The highest richness index (d) value was 3.24 in April, and the lowest value was 1.86 in September, as shown in figure 11. The mean value of richness index (d) was recorded as 2.50±0.43. There were no significant differences (P>0.05).

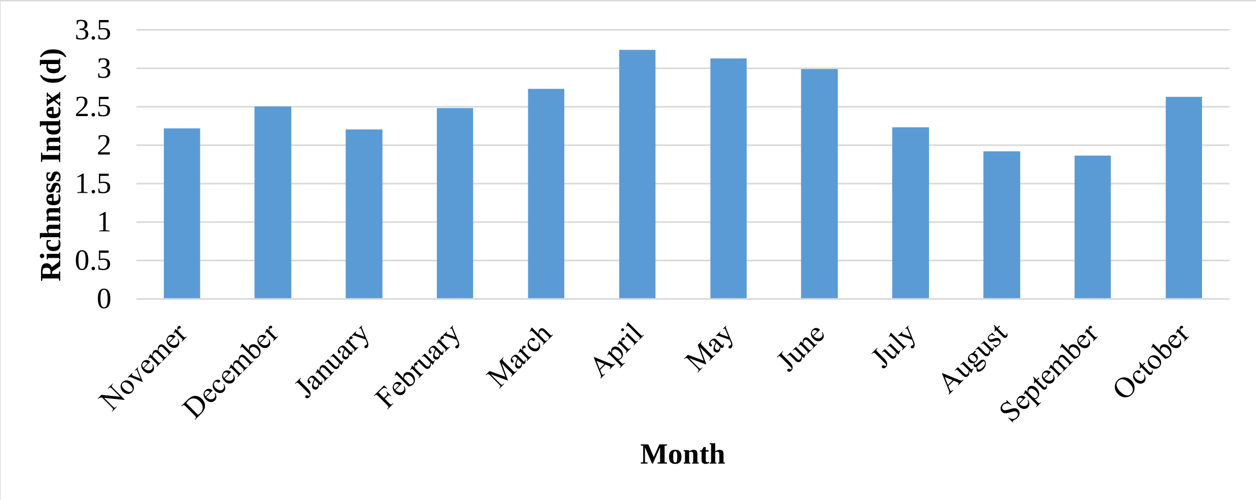


**Fig. 11. Margalef species richness index (d) in Teesta River**

The highest evenness value, 0.78, was documented in January, and the lowest value. 0.37 in August (figure 12). The mean evenness value was found as0.58±0.13. There was no significant difference (P>0.05).

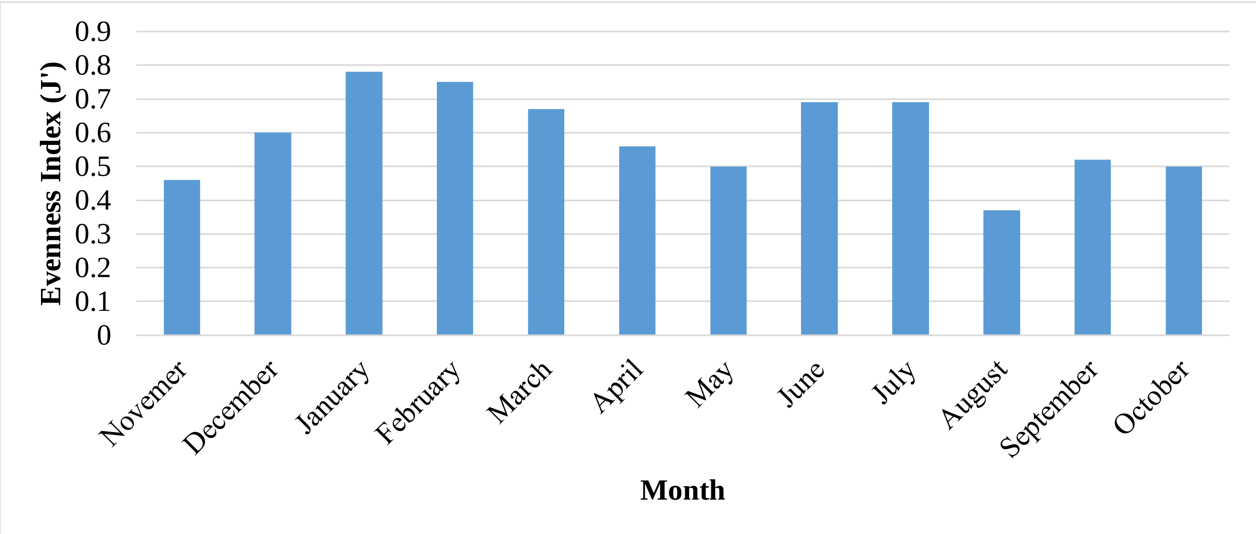


**Fig. 12. Pielous evenness index (J") in Teesta River**

The monthly variation of fish production in two sampling sites of the Teesta River is clarified in figure 13.

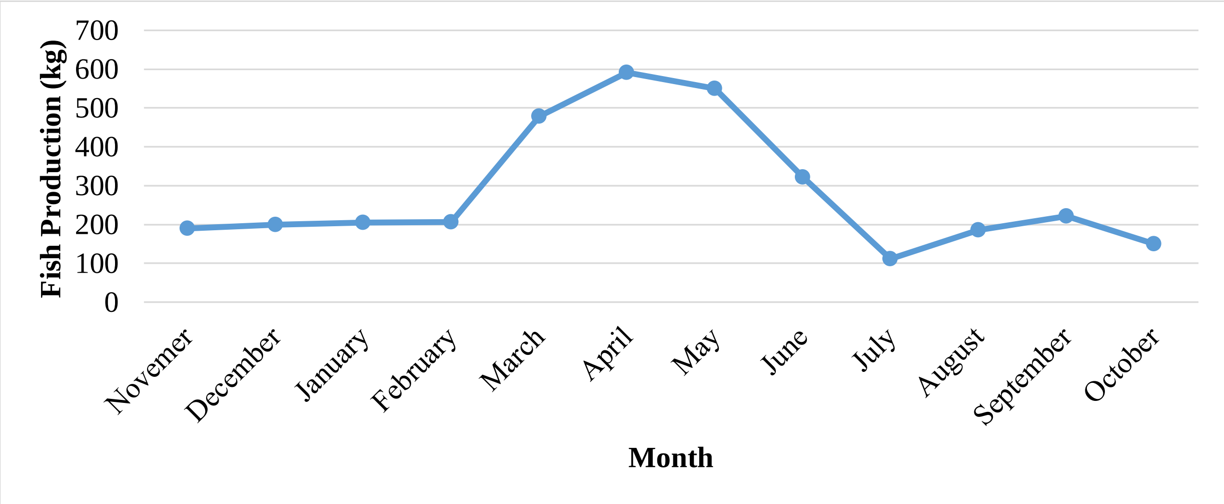


**Fig. 13. Month wise variation of fish production of the Teesta River**

The higher fish production was found in April at 592±65.30 kg/day, and the lowest production was recorded in July at 112±12.24 kg/day. April and May show significantly higher fish production than other months (P<0.05). Fish production from the other month was found as 190±17.54 kg/day in November, 200±14.89 kg/day in December, 205±17.76 kg/day in January, 207±25.80 kg/day in February, 478±19.29 kg/day in March, 550±18.72 kg/day in May, 322±22.25 kg/day in June, 186±25.75 kg/day in August, 222±23.25 kg/day in September and 150±22.25 kg/day in October.

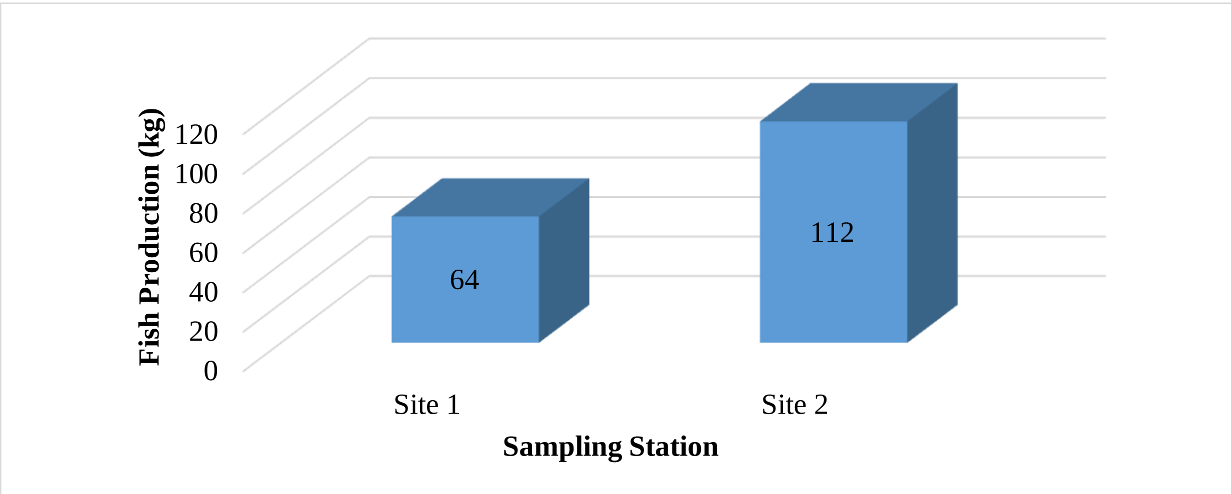


**Fig. 14. Site-wise variation of fish production in the Teesta River**

The average fish production was highest in site-2 at 112.54±62.88 kg/day, and on the other hand, site-1 was at 64.23±20.13 kg/day—site-2 gives significantly higher fish production than site-1 (P<0.05). Hossain *et al.* (2009) show a gradual reduction in fish production in Chalan Beel and recorded 12,217 tons of annual fish production during the 2005-2006 financial years, which was half of the production observed in 1982.

The main reasons for declining in biodiversity and overall availability of fishes, according to a questionnaire survey and data collected from 95 fishers adjacent to Teesta River, are:

**Table 7. Causes for Degraded in Fish Biodiversity of the Teesta River**

| SL No. | Threats to fish diversity | No. of Respondents | Percentage of Respondents |
|---|---|---|---|
| i) | Use of illegal fishing gear (eg. current jal, moshari jal etc.) | 75 | 79% |
| ii) | Siltation and sedimentation | 76 | 80% |
| iii) | Overfishing and indiscriminate fishing due to lack of knowledge | 78 | 82% |
| iv) | Kata fishing, fishing by dewatering/irrigation | 72 | 76% |
| v) | Catching of brood fish, fry, fingerlings and juvenile fis | 74 | 78% |
| vi) | Low water depth and current | 63 | 66.31% |
| vii) | Construction of Many types of development and communication infrastructures like dams, embankments, bridge etc | 63 | 66.31% |
| viii) | Increasing fishing pressure | 69 | 72.63% |
| ix) | Drought in summer season | 61 | 64.21% |
| x) | Loss of connection of river with khal, beel etc. | 52 | 54.73% |
| xi) | Creation of barriers and making obstacles in the natural movement of fishes | 54 | 57% |
| xii) | Over-doses of insecticides and pesticides in agricultural land | 46 | 48.42% |
| xiii) | To make agricultural land by filling the river | 41 | 43.15% |
| xiv) | Poor implementation of fishing rules and regulations | 24 | 25.26% |
| xv) | Use of chemical fertilizers like urea, TSP, MoPetc | 27 | 28.42% |
| xvi) | Use of river water for irrigation | 32 | 33.68% |

The findings of this present study are supported by Islam *et al.* (2015) and Barman *et al.* (2021). Islam *et al*. (2017) Reported that the fish biodiversity of Bhairab River, Jessore, Bangladesh, had been declining day by day due to fishing pressure, and overfishing was responsible for almost 38% loss and pollution and siltation caused about 27% loss of ecosystem. Almost 21% and 14% loss of ecosystem were caused by urbanization, human violation, and recreational activities, respectively.

## Conclusion

A recent study figured that the Teesta River is familiar for detaining aquatic resources and is an initiatory attempt to measure the open water fish diversity. The results of the view might not be the detailed prospectus of the open water fish diversity broadly. Teesta River is a significant threat due to climate change, habitat loss, invasive species, overfishing, siltation, urbanization, pollution, and human encroachment. These have generated a significant influence on fish biodiversity. Further, the water quality is deteriorating day by day, and the availability rate of fish species and other aquatic biodiversity is decreasing gradually. The threatened fish species found in the study area indicate a significant threat to the current conservation status of freshwater fishes in Bangladesh. Besides, counter and random surveys, good management, and conservation scheme are badly recommended to enhance natural resources and the fish biodiversity of the Teesta River in Bangladesh.

## References


Ali MM, Hossain MB, Masud MA and Alam MAW. 2015. Fish species availability and fishing gears used in the Ramnabad River, Southern Bangladesh. Asian Journalof Agricultural Research. 9(1), 12-22.

Azadi MA and Alam MAU. 2013. Ichthyofauna of the river Halda, Chittagong, Bangladesh. Bangladesh Journal of Zoology. 41(2), 113-133.

Banglapedia. 2015. National Encyclopedia of Bangladesh. Asiatic Society of Bangladesh, Dhaka.

Barman PP, Begum R, Marine SS, Barman SK and Barman AK. 2014. Fish marketing systems and socio-economic status of aratdar in Gaibandha district, Bangladesh. 1(2), 239-245.

Barman SK, Kunda M, Mazumder SK, Nahiduzzaman M, Barman PP and Das SK. 2021. Fish-diversity in the Kura river of Bangladesh: patterns and threats. Malaysian Applied Biology. 50(2), 1-14.

Biligrami KS. 1988. Biological monitoring of rivers, problems and prospect in India. Aquatic Ecotoxicology. 2, 245–250.

Chaki N, Jahan S, Fahad MFH, Galib SM and Mohsin ABM. 2014. Environment and fish fauna of the Atrai River: global and local conservation perspective. Journal of Fisheries. 2**,** 163-172.

Chowdhury MA, Karim MA, Rahman MT, Shefat SHT, Rahman A and Hossain MA. 2019. Biodiversity Assessment of Indigenous Fish Species in the Teesta River of Sylhet Sadar, Bangladesh. Punjab University Journal of Zoology. 34(1), 73-77.

DoF (Depertment of Fisheries). 2017. National Fish Week Compendium. Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh. pp. 162.

Flowra FA, Islam MA, Jahan SN, Hussain MA, Alam MM, Bashir FA, Mazlan AG and Simon KD. 2013. Status and decline causes of fish diversity of Baral River, Natore, Bangladesh. Aquaculture, Aquarium, Conservation & Legislation. 6(4), 352-357.

Galib SM, Naser SMA, Mohsin ABM, Chaki N and Fahad FH. 2013. Fish diversity of the river Choto Jamuna, Bangladesh: Present status and conservation needs. Int J Biodivers Conserv. 5(6), 389-395.

Galib SM, Samad MA, Mohsin ABM, Flowra FA and Alam MT. 2009. Present status of fishes in the Chalan beel- the largest beel (wetland) of Bangladesh. International Journal of Animal and Fisheries Science. 2(3), 214-218.

Haque ME. 2012. A Study on Wetland Biodiversity of Kishoreganj District and Its Impact on Environment, MS Thesis, Department of Environmental Science, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Hossain M A, Akter M and Iqbal M M. 2017. Diversity of Fish Fauna in Kusiara River (FenchungonjUpazilla), Northeast Bangladesh. J. Aqua Trop. 32(1-2)**,** 1-13.

Hossain MA, Nahiduzzaman M, Sayeed MA, Azim ME, Wahab MA and Olin PG. 2009. The Chalan *beel* in Bangladesh: habitat and biodiversity degradation, and implications for future management. Lakes & Reservoirs: Research & Management**.** 14, 3-19.

Islam MA, Islam MJ, Arefin S, Rashid A and Barman SK. 2016. Factors affecting the fisheries biodiversity of Ratargul swamp forest of Sylhet district, Bangladesh. IOSR Journal of Environmental Science, Toxicology and Food Technology. 10(1), 60-65.

Islam MA, Islam MZ, Barman SK, Morshed F and Marine SS. 2015. Study on present status of fish biodiversity in wetlands of Sylhet District, Bangladesh. Agriculture, Forestry and Fisheries. 4(6), 296-299.

Islam MR, Kunda M, Pandit D and Rashid AHA. 2019. Assessment of the ichthyofaunal diversity in the Juri River of Sylhet district, Bangladesh. Arch. of Agric. Environ. Sci. 4(4):488-496.

IUCN Bangladesh. 2015. Red List of Bangladesh: Freshwater Fishes. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh. 5, pp 360.

Kamrujjaman M and Nabi M R. 2015. Ichthyodiversity of the Bangshi River, Savar, Dhaka. Jahangirnagar University Journal of Biological Sciences. 4, 19-25.

Khan MR, Miah MI, Hossain MB, Begum A, Minar MH and Karim R. 2013. Fish biodiversity and livelihood status of fishing community of Tista River, Bangladesh. Global Veterinaria**.** 10, 417-423.

Margalef R. 1968. Perspectives in Ecological Theory. University of Chicago Press, Chicago.

Mazid MA. 2010. Development of Fisheries in Bangladesh: Plans and Strategies for Income Generation and Poverty Alleviation. Momin Offset Press, Dhaka.

Mohsin ABM, Haque SMM, Galib SM, Fahad MFH, Chaki N, Islam MN and Rahman MM. 2013. Seasonal Abundance of Fin Fishes in the Padma River at Rajshahi District, Bangladesh. W. J. Fis. and Mari. Sci. 5(6), 680-685.

Mohsin ABM, Yeasmin F, Galib SM, Alam B and Haque SMM. 2014. Fish fauna of the Andharmanik River in Patuakhali, Bangladesh. Middle-East Journal of Scientific Research. 21, 802-807.

Pielou EC. 1966. The Measurement of diversity in different types of biological collections. Journal of Theoretical Biology. 13, 131-144.

Pramanik MMH, Hasan MM, Bisshas S, Hossain ABMA and Biswas TK. 2017. Fish biodiversity and their present conservation status in the Meghna River of Bangladesh. International Journal of Fisheries and Aquatic Studies**.** 5(1)**,** 446- 455.

Rahman MM, Hossain MY, Ahamed F, Fatematuzzhura, Subba BR, Abdallah EM and Ohtomi J. 2012. Biodiversity in the Padma distributary of the Ganges River, Northwestern Bangladesh: recommendations for conservation. World Journal of Zoology. 7(4), 328-337.

Shannon CE and Weaver W. 1949. The Mathematical Theory of Communication. University of Illinois Press, Illinois.