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# Assessment of fish biodiversity and fishing gear efficiency of the Meghna River at Ramgati Upazila under Lakshmipur district in Bangladesh

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**Abstract**
To analyze the abundance of fish species, the efficiency of fishing gear, catch per unit effort (CPUE), catch composition and the causes of the loss in fish diversity data were collected for six months during July 2023 to December 2023 from the Meghna River, Bangladesh. There was a total of 6 fish species and 1 prawn species, belonging to 7 orders and 7 families and among them order Cypriniformes (21%) was identified most dominant order. The mean values of Shannon-Weaver diversity, Simpson's index, Margalef's richness, and Pielou's evenness indices were measured as 1.862±0.016, 0.976±0.001, 0.537±0.018, and 1.059±0.041, respectively. There is no significance difference ($p$> 0.05) was observed for the mean monthly fish catch in the present study. Numerous factors, including overexploitation, pollution, and natural causes like siltation may be responsible for a decline in biodiversity. Fish variety in Bangladesh's Meghna River can be greatly enhanced and preserved by using authorized fishing gear, enforcing fish laws and regulations effectively.

**Keywords:** The Meghna River, catch efficiency, catch per unit effort, total catch rate

## 1. Introduction
One of Bangladesh's principal rivers is the Meghna River, which is 888-kilometer-long and drains an area of 420,000 km$^2$. The Bangladesh Fisheries Research Institute (BFRI) has reported that around 400 different kinds of fish can be found in the Meghna River (Hossain, 2020) [4]. According to Pramanik *et al.* (2017) [11], overfishing is the main factor threatening fish biodiversity in the Meghna River and the use of sophisticated fishing gear, habitat loss and outdated fishing techniques are the major reasons behind it (Hossain, 2020) [4]. Bangladesh government and several non-governmental organizations (NGOs) have launched numerous programs in the Noakhali region in response to the need to improve equipment efficiency. The objective of these endeavors is to augment the employment of sustainable fishing methodologies, the accessibility of superior fishing apparatus, and enhance the capacity and knowledge of fishermen (Siddiqui *et al.* 2021) [14]. Gillnets with larger mesh sizes are one example of the kind of selective fishing gear that should be promoted in order to help replenish fish stocks and decrease the accidental capture of juvenile fish. By utilizing biodegradable fishing nets and equipment, environmental contamination may be decreased and sustainable fishing techniques may be encouraged. While the effectiveness of Noakhali's fishing gears has increased, there are still some challenges to be addressed (Siddiqui *et al.* 2021) [14]. The purpose of this study is to determine the factors contributing to the decline in biodiversity, kinds of gear, effectiveness of the gear, and CPUE of the fishing in Bangladesh's Meghna river at Ramgati Upazila, which is part of the Lakshmipur district.

## 2. Methodology
### 2.1 Study area and study period
The Meghna River is the primary waterway for the districts of Brahmanbaria, Comilla, Chandpur, Noakhali, Feni, and Laxmipur in the Meghna Division in southeastern Bangladesh (Rahman and Rahman, 2015) [12]. The current study was conducted over a period of six months

from July, 2023 to December, 2023 at Ramgati Upazila under Laxmipur district. The three research stations were selected (Figure 1) - Alexander fish market (Station 1); Tankir Ghat (Station 2); Fish landing centre Ramgati, Laxmipur (Station 3).

### 2.2 Sampling procedure and designing a questionnaire

The fundamental random sample approach was used to obtain the data (Siddiq *et al.* 2013) [21]. The sampling strategy was chosen because it ensured that the procedure is unbiased. Before data collection, a carefully thought-out questionnaire was created.

### 2.3 Data Collection

The survey asked questions about the biodiversity of fish as it stands now in comparison to past experiences, species abundance, seasonal availability of fish, types of fishing gear used, and factors influencing fish habitat changes (Aktar *et al.* 2020) [1]. A questionnaire was used to collect data from the three stations and from full-time fishermen. At each point, 10-12 fishermen were polled to get their thoughts. The secondary data came from a variety of sources, including journal articles, books, papers, and the internet.

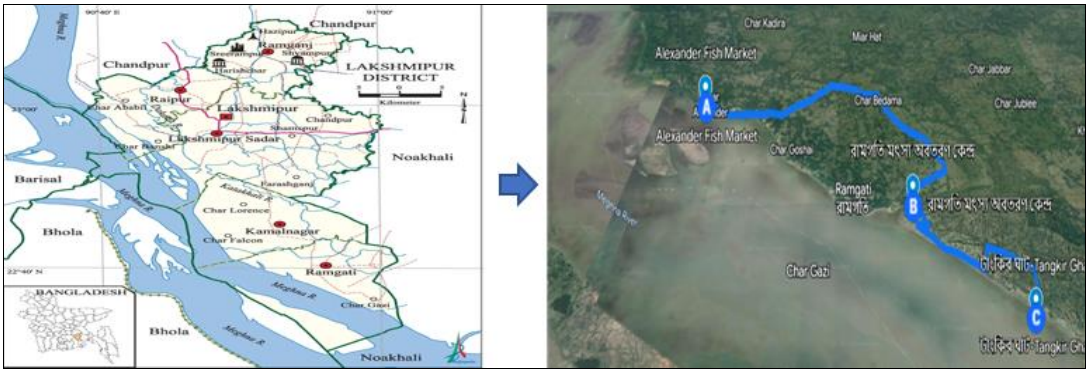



**Fig 1:** Map showing study area in the Meghna River of Bangladesh. ("Google Earth," N.D.)

### 2.4 Formulas

**2.4.1 Shannon-Weaver Diversity Index (H') (Weaver, 1963) [18] The formula:** $H' = -\sum p_i \ln(p_i)$. Where, $'p_i'$ denotes the fraction of individuals belonging to a single species; 'i' in relation to the overall population. Simpson's Index (Simpson, 1949) [16] The formula for calculating the value of 1 minus the sum of the product of each term and its previous term squared is expressed as: $1 - (\sum(x\_i * (x\_i - 1)\text{^}2))$. The equation $1 - D = 1 - \left(\sum\left(\frac{n\cdot(n-1)}{N\cdot(N-1)}\right)\right)$ represents an estimation of the likelihood that two individuals picked at random will be from distinct species. A value approaching 1 indicates a higher level of diversity, whereas values approaching 0 indicate dominance or a lower level of diversity. Margalef's Richness Index (Margalef, 1968) [7] Equation is: $d = \frac{S-1}{\ln N}$ Where, S is the number of species and N is the number of people in the sample. Pielou's Evenness Index (Pielou, 1996) [10] Equation is: $J = \frac{H'}{\ln S}$ Where, S is indeed the entire number of species and H′ is the Shannon-Weaver index.

**2.4.2 Analysis of Efficiency of gear and catches per unit of effort (CPUE):** Catch per unit effort (CPUE) is a crucial metric for evaluating the efficacy of various fishing gear varieties. $\mathbf{CPUE} = \frac{\text{Total Catch}}{\text{Total Effort}}$ (Kitheka *et al.* 2011) [6].

### 2.5 Data Analysis

Collected data were accumulated, edited and analyzed by Microsoft Excel. Using Analysis of Variance (ANOVA) methodologies, the differences in CPUE, species composition, and gear efficiency of the catch between fishing sites were examined, with significant differences ($p < 0.05$) found.

## 3. Results and Discussion

### 3.1 Fish Species Abundance

A total of 6 fish and 1 prawn species under 7 orders and 7 families were recorded from the study area during six months' study period (Table 1). *Labeo bata* (July, September, December); *Macrobrachium malcolmsonii* (October and November) and *Glossogobius giuris* (August) showed the highest percentages of abundance (21.82%, 21.01% and 20.96%); (23.40% and 22.97%) and (21.39%) respectively throughout the study period. On the other hand, four more species - *Tenualosa ilisha*, *Batasio batasio*, *Otolithoides pama*, and *Polynemus paradiseus* - contributed variable percentages of abundance (Table 1).

**Table 1:** Fish abundance (%) of Meghna River in each month from July-December

| Fish Abundance (%) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Order** | **Local Name** | **English Name** | **Scientific name** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **IUCN status (BD)** |
| (Family) | Hilsha | Hilsa shad | *Tenualosa ilisha* | 4.80 | 5.83 | 6.72 | 5.96 | 5.85 | 6.05 | NT |
| Clupeiformes | Poa | Red Jaw Fish | *Otolithoides pama* | 11.51 | 13.29 | 14.29 | 12.77 | 12.53 | 12.90 | NT |
| Siluriformes | Tengra | Eel Catfish | *Batasio batasio* | 9.59 | 11.67 | 10.92 | 10.21 | 10.02 | 10.48 | DD |
| (Bagridae) | Bata | Bata | *Labeo bata* | 21.82 | 19.45 | 21.01 | 22.13 | 21.72 | 20.96 | EN |
| Cypriniformes (Cyprinidae) | Cingri | Monsoon river prawn | *Macrobrachium malcolmsonii* | 20.58 | 16.83 | 19.17 | 23.40 | 22.97 | 18.95 | LC |
| Decapoda | Baila | Fresh Water Goby | *Glossogobius giuris* | 21.10 | 21.39 | 18.49 | 17.02 | 16.71 | 18.06 | LC |
| (Penaeidae) | Tapasi | Paradise Threadfin | *Polynemus paradiseus* | 9.59 | 10.53 | 8.50 | 8.41 | 10.21 | 11.61 | NT |

*Jul: July *Aug: August, *Sep: September, *Oct: October, *Nov: November, *Dec: December, EN: Endangered, *DD: Data Deficient, *NT: Near Threatened, *LC: Least Concern.

In the present investigation, the dominant order was Cypriniformes comprising 21% of all the number of fish species recorded. Next to Cypriniformes other orders Decapoda, Gobiiformes, Tetraodontiformes, Siluriformes, Perciformes and Clupeiformes were recorded same percentages 20%, 19%, 13%, 11%, 10% and 6% respectively from the study area (Figure 2). (*Labeo bata*) ranked as the highest with the number of 68050±3089 and followed by *Macrobrachium malcolmsonii* (66750±2870), *Glossogobius giuris* (61600±3449), *Otolithoides pama* (41650±2038), *Batasio batasio* (34000±1708), *Polynemus paradiseus* (32200±1818) and *Tenualosa ilisha* (18900±935) (Figure 3). The duration of the present research period was limited to six months, although Pramanik *et al.* (2017) [11] had conducted a year-long study in Meghna river and documented 107 fish species belonging to 13 orders and 36 families. Galib *et al.* (2013) [3] reported that the most common order of fish was Cypriniformes (34.92%) in the Choto Jamuna River which support the present findings. Conversely, Pramanik *et al.* (2017) [11] in Meghna river and Rubel *et al.* (2016) [13] in the Lohalia river the highest proportion of species belonged to the order Perciformes. These disparities in previous findings compared to the current study can be attributed to variations in the geographic locations of the water bodies, survey durations and selection of fishing equipment.

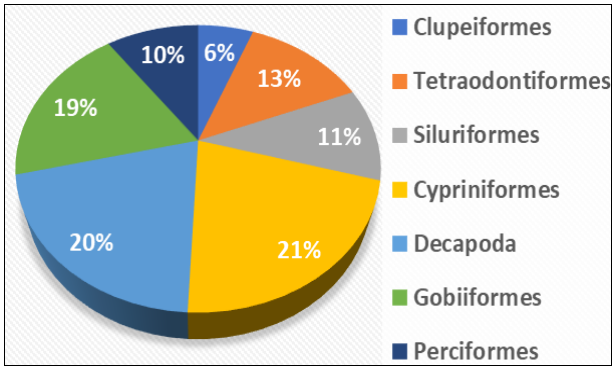



**Fig 2:** Diagrammatic representation of percent contribution in each order

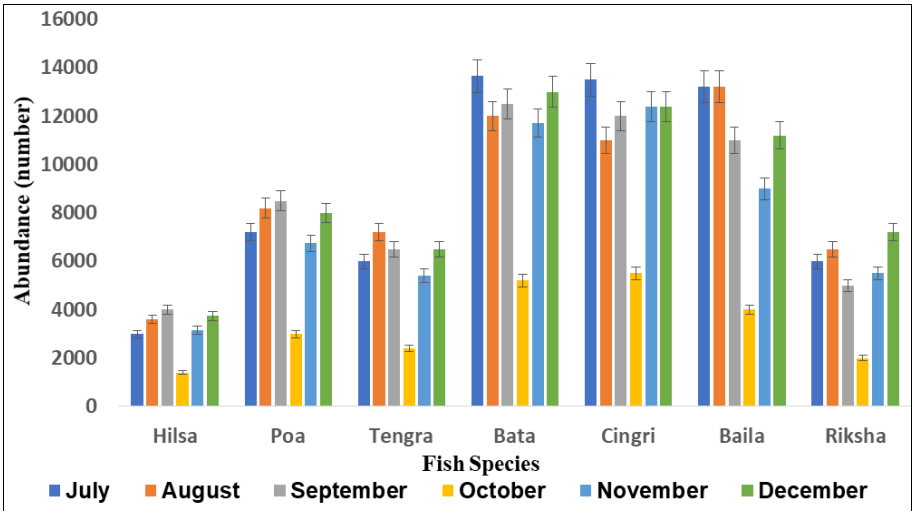



**Fig 3:** Fish abundance (in number) of Meghna River from July-December

### 3.2 Fish Species Biodiversity Status

Based on conservation status, identified 7 species were classified under 4 categories both in local and global regions. According to the IUCN red list 2000 [2] of Bangladesh, 42.85% Near Threatened (NT); 28.57% Less Concerned (LC); 14.28% Endangered (EN) and 14.28% Data Deficient (DD) were recorded in the present study (Table 1). After a year-long study Pramanik *et al.* (2017) [11] reported 11 species (10.28%) were found as Vulnerable (VU), 8 species (7.48%) as Endangered (EN) and 2 species (2%) as Critically Endangered (CR) in Meghna river. On the other hand, the current study was conducted only for 6 months (July 2023 to December, 2023) which might be the reason behind the lower number of species identified in the present study.

### 3.3 Diversity indices

The highest and lowest values of both Shannon-Weaver diversity, Simpson's index were recorded in December and October respectively. In December, the diversity and Simpson's index was measured at its highest level with a value of H = 1.878 and 1-D= 0.977, while the lowest diversity was recorded in October with a value of H = 1.849 and 1-D= 0.970 respectively. The richness index (d) reached its peak in November with a value of 0.551, and its lowest value was observed in October at 0.497. Lastly, the evenness index (J) was found to be highest in October with a value of J = 1.149, and lowest in November with a value of J = 1.037 (Table 2).

The result of Shannon-Weaver diversity (H) of the present study was consistent with the data reported by Iqbal *et al.* (2015) [5], which ranged from 1.8 to 3.40 in the Hakaluki River. The present study is corroborated by this findings, which exhibit modest variations from the current findings due to disparities in geographical areas, survey times, fishing techniques, and selection of fishing equipment in the Meghna River. The current study recorded the maximum and minimum value of Simpson's dominance index (1-D) as 0.977 in July and 0.970 in October respectively. Tikadar *et al.* (2021) [17] in the Gorai River of Bangladesh lower Simpson Dominance index from the present study. The results of this study were somewhat elevated as a result of variations in geographical location, survey duration, and sample size. The current study observed the highest and lowest Margalef's richness index with a value of 0.551 in November and 0.497 in October respectively with mean value 0.537±0.018. The

mating season for most fish species in Bangladesh typically begins in June, coinciding with the commencement of the monsoon season. However, in October, there is a 22-day period during which fishing is prohibited which might explain the lowest and highest richness values seen in October and November, respectively. The results were in good agreement with the findings of Islam (2005) [13], which reported a range of 0.110 to 0.444 in the Buriganga River estuary. Throughout the research period, the maximum Pielou's evenness index (J) value observed was 1.149 in October, while the lowest value was 1.037 in November with a mean value 1.059±0.041. Thus, the equitability index of species in the sample region and across various months indicates that the distribution of fish population in the Meghna River is more or less equally distributed. These findings closely align with the research conducted by Tikadar *et al.* (2021) [17] in the Gorai river. However, Murugan and Prabaharan (2012) [9] discovered that the maximum evenness value of 0.99. This suggest that the fauna in the monsoon and post-monsoon seasons were evenly distributed and abundant.

**Table 2:** Number of calculated species, individuals, and values of Shannon-Weaver diversity, Simpson's index, Margalef's richness and Pielou's evenness indices in each sampling month.

| Months | No of species (S) | Diversity, H' | Simpson's, 1-D | Richness, d | Evenness, J |
|---|---|---|---|---|---|
| July | 7 | 1.836 | 0.977 | 0.543 | 1.045 |
| August | 7 | 1.878 | 0.978 | 0.544 | 1.048 |
| September | 7 | 1.872 | 0.977 | 0.546 | 1.045 |
| October | 6 | 1.849 | 0.976 | 0.497 | 1.149 |
| November | 7 | 1.858 | 0.976 | 0.551 | 1.037 |
| December | 7 | 1.878 | 0.975 | 0.544 | 1.048 |
| Mean ± SD | 7 | 1.862±0.016 | 0.976±0.001 | 0.537±0.018 | 1.059±0.041 |

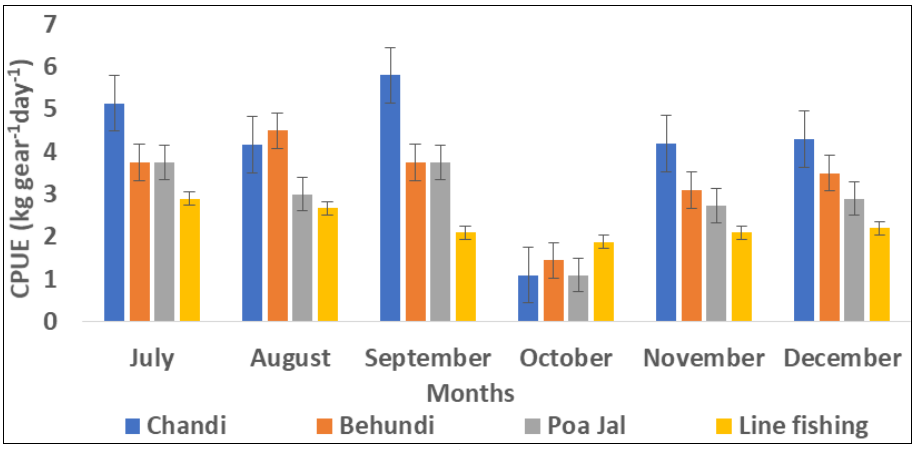
### 3.5 Fishing Gears and Catch Composition of Different Fishing Gears

There are about three types of fishing net and one type of trap were observed in throughout the study period (July 2023-December 2023) (Table 3). Mesh size of gill net, bag net, behundi net were recorded 4 to 4.5, 0.5 to 1.25 and 3.5 respectively and all the identified fishing gears were operated by 1 to 8 persons. These gears were found to operate in every month of the study period. Different species were captured by different gears enlisted in Table 3. The current study result closely aligns with the findings of Mondal *et al.* (2013) [8].

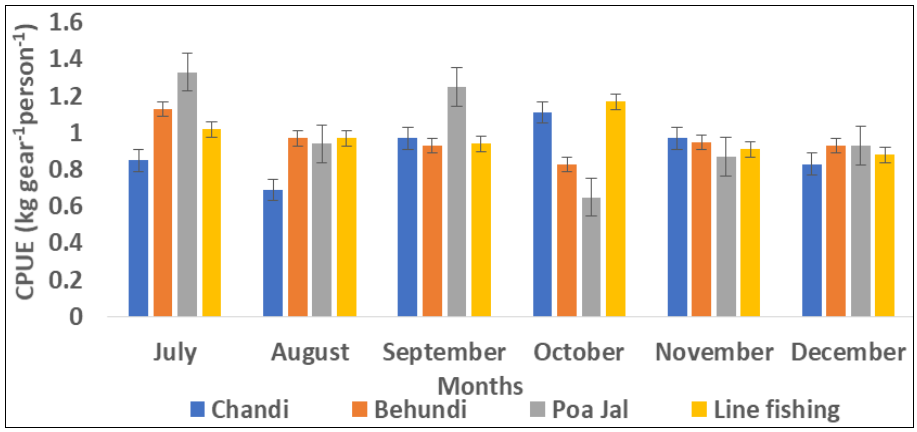
**Table 3:** Fishing gears list with species composition and operation period in the study area.

| Net Type | Local Name | Mesh (cm) | People | Species | Months |
|---|---|---|---|---|---|
| Gill Net | Chandi Jal | 4 to 4.5 | 5-8 | *Tenualosa ilisha, Otolithoides pama, Labeo bata, Mystus aor, Pangasius pangasius* | All except October |
| Bag Net | Behundi Jal, Bagan Jal, Jali Jal | 0.5 to 1.25 | 2-4 | *Amblypharyngodon mola, Puntius* spp., *Glossogobius giuris, Mystus* spp., *Penaeus* spp. | All |
| Behundi Net | Poa Jal | 3.5 | 4-5 | *Tenualosa ilisha, Otolithoides pama, Labeo bata* | All |
| Line fishing | Dorja, Dhora, Khanta, Barta | - | 1-3 | *Puntius* spp., *Wallago attu, Mystus aor, Clarias batrachus.* | All |

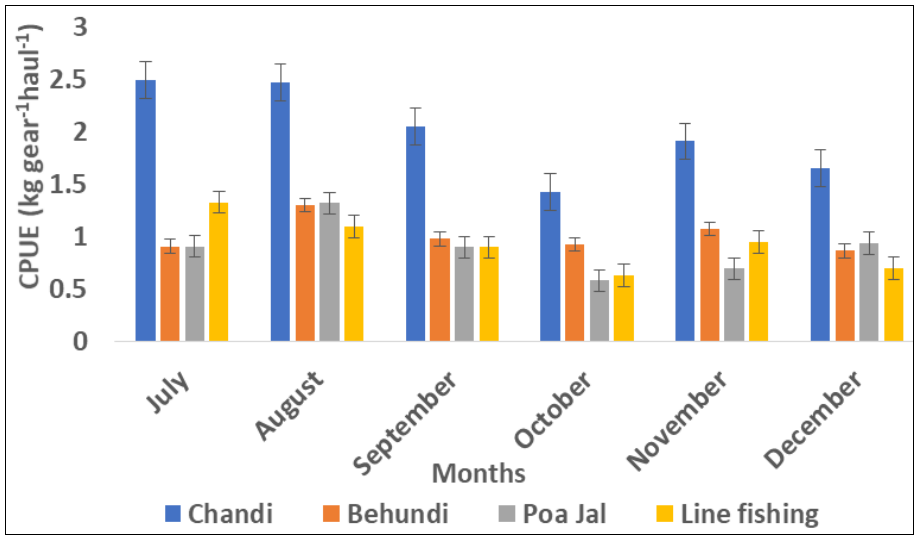
**3.6 Fishing Gear Efficiency:** In the present study, fishing gear efficiency was calculated based on kg gear$^{-1}$day$^{-1}$, kg gear$^{-1}$person$^{-1}$, kg gear$^{-1}$ haul$^{-1}$ of different months were shown as graphical representation.




a)




b)




c)

**Fig 4:** Monthly variation of fishing nets based on (a) CPUE (kg gear$^{-1}$day$^{-1}$); (b) CPUE (kg gear$^{-1}$person$^{-1}$); (c) CPUE (kg gear$^{-1}$haul$^{-1}$).

Chandi net showed higher CPUE (kg gear$^{-1}$day$^{-1}$**)** in September (5.54±0.20) and line fishing in August (3.81±0.06). But the highest value of behundi and poa net was found in July about 3.56±0.14 and 3.60±0.12 respectively. The CPUE (kg gear$^{-1}$person$^{-1}$) for all identified gears was recorded higher in July and lower in October. CPUE (kg gear$^{-1}$haul$^{-1}$) for chandi net (1.99±0.09) and line fishing (0.87± 0.06) were found maximum in the month of November but for behundi net (1.17±0.09) and poa net (1.23±0.07) was found maximum in the month of August and July respectively (Figure 4). However, there is no significance different ($p$> 0.05) in the monthly CPUE (kg gear$^{-1}$day$^{-1}$, kg gear$^{-1}$person$^{-1}$and kg gear$^{-1}$haul$^{-1}$) was observed. Aktar *et al.* (2020) [1] observed that the Gill net and Dhoar (Fish trap) had the greatest and lowest gear effectiveness levels in the Teesta River between May and June, measuring 0.501 kg and 0.000209 kg, respectively. The research region exhibited variations in the number of gears and their efficiency, which might be attributed to factors such as reliance on outdated gears, the diversity of fish species in the river, the physical characteristics of the river (Such as the existence of currents), and limited availability of alternative gears.

### 3.7 Station Based CPUE of Fishing Gears

The highest CPUE for chandi net was found at station 1, with values of 5.83±0.638 kg gear$^{-1}$day$^{-1}$, 0.97±0.026 kg gear$^{-1}$person$^{-1}$, and 2.29±0.071 kg gear$^{-1}$haul$^{-1}$ in the months of September, November and November respectively. Conversely, the lowest catch per unit effort (CPUE) values were seen at station 2 (1.1±0.095 kg gear$^{-1}$day$^{-1}$), (0.5±0.015 kg gear$^{-1}$day$^{-1}$) and station 3 (1.22±0.073 kg gear$^{-1}$person$^{-1}$) in October, August and October respectively. CPUE (kg gear$^{-1}$person$^{-1}$) was measured highest at station 1 for behundi net, and line fishing and at station 2 for poa net but the lowest value was found at station 3 for all gears. Again, the highest CPUE (kg gear$^{-1}$haul$^{-1}$) was recorded at station 1 for all types of nets identified in the study area but the lowest values were observed at station 3 (behundi net) and station 2 (poa net and line fishing). However, there was no significant difference was observed ($p$> 0.05) in the station based CPUE. The months of July, August, September, November and December had the highest CPUE, predominantly at station 1 and occasionally at station 2, as shown in this study. However, mostly the lowest CPUE were recorded for station 3 and station 2 in October (Table 4).

### 3.8 Total Fish Catch in the Study Area

The month-wise fish catch of three sampling sites of the Meghna River was recorded. The majority of fish were captured in December, with a total of 5874±727.67 kg, while the lowest number of fish were collected in October, with a total of 2245±285.55 kg. However, there was no significance difference ($p$> 0.05) was observed for the mean monthly fish catch in the present study (Figure 5).

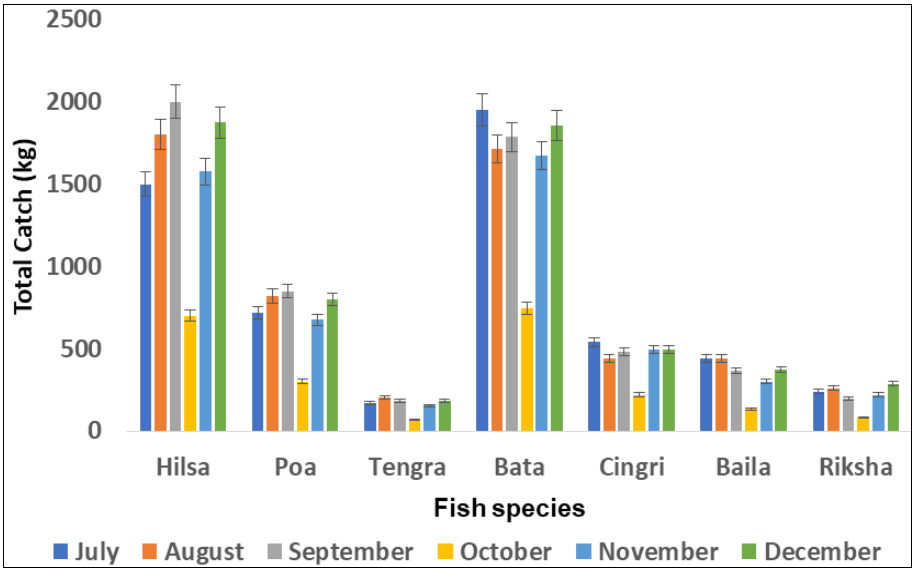



**Fig 5:** Total Fish Catch

**3.9 Decline Causes of Fish Diversity:** The challenges to fisheries biodiversity may be categorized as the alteration of river channel, over exploitation of fisheries resources, habitat loss, and degradation of water quality due to pollution. The population growth, overexploitation, and use of illicit fishing gear are contributing to a rise in fishing pressure.

## 4. Conclusion

The Meghna River is a moderately productive aquatic ecosystem with a declining population of fish species that exhibit a satisfactory level of diversity. This study aims to examine the fish diversity index, gear efficiency, CPUE, and catch composition of different fishing gears, as well as the factors contributing to the decline of fish species in the Meghna River. For preservation of fish biodiversity in the Meghna River- prohibition of the indiscriminate killing of juvenile and adult fish and controlling the use of destructive fishing methods and gear, identification of numerous local fish species' breeding seasons and patterns of migration and establish a sufficient number of fish sanctuaries and dredging up the riverbed to keep the water flowing consistently are necessary.

**Table 4:** Station based CPUE for every net during the study period (July 2023 - December 2023)

| Net | CPUE | July | | | August | | | September | | | October | | | November | | | December | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 | St. 1 | St. 2 | St. 3 |
| Chandi net | kg gear$^{-1}$day$^{-1}$ | 5.14 | 5.1 | 5.08 | 4.17 | 4.1 | 3.9 | 5.8 | 5.5 | 5.32 | 1.25 | 1.1 | 1.17 | 4.19 | 4.15 | 4.14 | 4.3 | 4.1 | 4.16 |
| | kg gear$^{-1}$person$^{-1}$ | 0.9 | 0.85 | 0.8 | 0.69 | 0.5 | 0.65 | 0.8 | 0.8 | 0.78 | 0.84 | 0.86 | 0.81 | 0.97 | 0.91 | 0.88 | 0.83 | 0.82 | 0.81 |
| | kg gear$^{-1}$haul$^{-1}$ | 1.69 | 1.7 | 1.68 | 1.39 | 1.4 | 2.05 | 1.9 | 1.8 | 1.85 | 2.11 | 2.15 | 1.22 | 2.29 | 1.94 | 1.91 | 1.66 | 1.64 | 1.65 |
| Behundi net | kg gear$^{-1}$day$^{-1}$ | 3.75 | 3.5 | 3.43 | 4.5 | 3.9 | 4.2 | 3.75 | 3.69 | 3.67 | 1.45 | 1.56 | 1.63 | 3.1 | 2.93 | 2.88 | 3.5 | 3.43 | 3.57 |
| | kg gear$^{-1}$person$^{-1}$ | 0.93 | 0.89 | 0.97 | 1.3 | 1.1 | 1.12 | 0.93 | 0.98 | 0.86 | 0.93 | 0.85 | 0.83 | 0.93 | 0.95 | 0.82 | 0.93 | 0.91 | 0.87 |
| | kg gear$^{-1}$haul$^{-1}$ | 0.88 | 0.91 | 0.85 | 1.3 | 1.1 | 1.12 | 0.93 | 0.98 | 0.86 | 0.98 | 0.93 | 0.94 | 1.1 | 1.09 | 1.08 | 0.87 | 0.88 | 0.89 |
| Poa net | kg gear$^{-1}$day$^{-1}$ | 3.75 | 3.61 | 3.45 | 3.00 | 2.5 | 2.6 | 3.75 | 3.57 | 3.69 | 1.17 | 1.25 | 1.1 | 2.73 | 2.83 | 2.69 | 2.9 | 2.85 | 2.87 |
| | kg gear$^{-1}$person$^{-1}$ | 1.25 | 1.33 | 1.21 | 0.93 | 1.1 | 0.9 | 1.1 | 1.25 | 1.17 | 0.75 | 0.87 | 0.65 | 0.69 | 0.73 | 0.78 | 1.17 | 1.01 | 1.09 |
| | kg gear$^{-1}$haul$^{-1}$ | 1.16 | 1.22 | 0.93 | 1.32 | 1.1 | 0.9 | 0.9 | 0.8 | 0.85 | 0.60 | 0.58 | 0.64 | 0.7 | 0.66 | 0.68 | 0.9 | 0.94 | 0.89 |
| Line fishing | kg gear$^{-1}$day$^{-1}$ | 2.68 | 2.62 | 2.7 | 3.8 | 3.75 | 3.9 | 2.69 | 2.43 | 2.51 | 1.88 | 1.79 | 1.69 | 2.1 | 1.9 | 2.22 | 2.2 | 2.3 | 2.45 |
| | kg gear$^{-1}$person$^{-1}$ | 1.33 | 1.21 | 1.14 | 0.79 | 0.82 | 0.9 | 1.1 | 1.25 | 1.17 | 0.74 | 0.78 | 0.74 | 0.88 | 0.95 | 0.91 | 0.79 | 0.81 | 0.88 |
| | kg gear$^{-1}$haul$^{-1}$ | 0.68 | 0.69 | 0.76 | 1.1 | 0.8 | 0.95 | 0.85 | 0.87 | 0.9 | 0.63 | 0.41 | 0.55 | 0.83 | 0.95 | 0.83 | 0.7 | 0.66 | 0.68 |

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