BIODIVERSITY AND ICHTHYOFAUNAL RICHNESS OF FISH POPULATION IN RIVER SUBANSIRI IN THE DOWNSTREAM OF THE LOWER SUBANSIRI HYDRO-ELECTRIC POWER PROJECT DAM, ASSAM, INDIA

Abstract:

The present study on fish diversity, assemblages, water quality and conservation status of Subansiri river, Assam was conducted for a period of one year in the mainstream. Altogether 55 fish species belonging to 42 genera, 24 families and 10 orders were recorded from the river. The largest group Cypriniformes contributed 3 families (12.50%), 15 genera (35.71%) and 20 species (36.36%). As per IUCN conservation status, 51 (92.72%) species were recorded as Least Concern, 2 (3.64%) species under near threatened, 1 (1.82%) species under vulnerable and 1 (1.82%) species under endangered category. The mean value with regard to Physico-chemical parameters of river Subansiriwas moderate.The Bray-Curtis similarity prepared for river Subansiri showed the highest similarity between stations 2 and 3 in the pre-monsoon season. The CCA analysis indicates that alkalinity, TDS, temperature, conductivity, pH, dissolved oxygen, transparency and velocity are the most important parameters influencingthe fish distribution and assemblage in the river.

Keywords: diversity index, dam, water quality, cluster, CCA.

I. Introduction:

The fish diversity of inland waters comprises of about 113 brackish water, 936 fresh water and also 462 exotic fishes (ICAR-NBFGR, 2019). Northeast India is recognized as an important hotspot of freshwater fishes (Kansal and Arora, 2012). The mighty Brahmaputra is a major river in India, termed as the moving ocean of the Northeast (Ajibare et.al;2019 and Parker et.al; 2016). The braided Brahmaputra through this region is famous for susceptibility to channel migration and avulsion.Many tributaries contribute to the river Brahmaputra through its path of which the largest is the River Subansiri rising from the Kangig glacier range in Tibet at an elevation of above 7090 meter above Mean Sea Level. Many tributaries contribute to Subansiri through its course, for example, Yume, Laro, Nye, Tsari, Kamla, Jiyadhol, Ranganadi and Dikrong.

In 2001, Central Electricity Authority (CEA), India has identified a potential of 15,191 MW worth 22 projects in the Subansiri river basin. The 2000 MW lower Subansiri hydroelectric power project, proposed to come up at Gerukamukh, Assam creates a real threat to the freshwater biodiversity of the downstream of Subansiri river basin by the regulation of the river through diversion, impoundment and reduced water discharge to the downstream (Dutta & Sarma, 2012). The threatened hill stream fishes *Tor tor* and *Tor putitora*are found in downstream of the Subansiri river (Hazarika, 2008). In trans-Himalayan rivers, fish species such as *Tor tor, Labeodyocheilus, Bariliusbendelisis, Anguilla bengalensis* and*Glossogobiusgiuris*travel long distances for different purposes (Talwar and Jhingran, 1991).Depending on prevailing Physico-chemical and climatological conditions, such as temperature and rainfall, these fish species migrate to the large rivers for feeding or breeding. The dammight obstructthese fishes in their purpose-specific migrations. Dam or barrage construction may result in severe "discontinuities" and changes in the River Continuum (Ward and Stanford, 1983). The Subansiri River contributes about 10 percent of the total discharge of the river Brahmaputra. The construction of the dam will impactthe downstream river and riparian people by altering the flow and the sediment regimes thus posing a potential threat to alter or change the fisheries composition of the River.There was no previous record of studies done only in the mainstream of the Subansiri river covering the aspects of ecology. This paper will also help to formulate sustainable management practices for the Subansiri river and the surrounding ecosystem.

II. Materials and methods:

Location and description of the study area-

Study Area:

The river has a total length of about 520 km and drains a basin of about 37,000 square km. In India, the total length of the river is 326 km up to its confluence with the Brahmaputra. The Subansiri river meets the Brahmaputra about 25 km downstream of Jorhat. Its length is approximately 126 km from the dam site to the confluence with Brahmaputra river near Jamuguri. In Assam alone, the total length of the river is about 130 km. It flows through the Dhemaji and Lakhimpur districts of Assam.

The entire downstream below hydroelectric power project dam was demarcated in the following three stations by doing a preliminary survey based on topography (Figure 1)

Station 1. Dam site or Gerukamukh (27º31′58.83″ N and 94º15′32.63″ E, Altitude 99 MSL), (Narrower in width, hilly area with rocky bottom)

Station 2. Chauldhowa Ghat (27º21'42.13" N and 94º12'35.95" E, Altitude 76 MSL), (Plains with stony and sandy bottom)

Station 3. Khabolo Ghat (27º1'34.02" N and 94º4'45.00" E, Altitude 65 MSL), (Muddy bottom and broader width).

Sample collection

Fish specimens were collected from 3 selected stations of river Subansiri per month using cast net (mesh size 4-10 mm and 11-14 mm) and gillnet (15-20 mm, 25-35mm)set upon for 6-8 hours with the help of local fishermen. During the time of collection of fishes, the data such as location, date, number of fishes were recorded for future references.

Preservation and identification

Fish specimens were preserved in 5-6% aqueous formaldehyde solution and were brought to the laboratory and identified following different keys of Talwar and Jhingran (1991**),** Nath and Dey (1997, 2000), Jayaram (1999, 2010), Das and Biswas (2008) and Phukan *et al.,* 2021. Nomenclature was made according to Talwar and Jhingran (1991) and Jayaram (1999, 2010). Valid scientific names were taken from www.fishbase.org and Catalog of Fishes (Eschmeyer *et al.,* 2017). Current conservation status was evaluated according to the Conservation Assessment and Management Plan (CAMP, 1998) workshop and Red Data List of the International Union for Conservation of Nature and Natural Resources (IUCN, 2021).

Diversity Index:

Fish diversity was assessed using the Margalef's richness index (Margalef, 1968), Shannon index (Shanon, 1948), Simpson index (Simpson, 1949) andBuzas and Gibson's evenness (1969).

III. Results and Discussion:

Fish Diversity:

In the present study, the occurrence of a diverse group of 55 fish species belonging to 42 genera, 24 families under 10 orders was recordedwhich reflects the ichthyofaunal richness of River Subansiri (Figure 2 & 3) (Table 1).Cyprinidae family was found to be dominant with 18 species followed by Bagridae and Channidae with 4 species, Ambassidae, Osphronemidae and Mastacembelidae with 3 species each, Schilbeidae and Siluridae with 2 species each, Cobitidae, Nemacheilidae, Amblycepitidae, Chacidae, Heteropneustidae, Sisoridae, Erethistidae, Claridae, Synbranchidae, Belonidae, Gobiidae, Badidae, Nandidae, Clupeidae, Tetradontidae and Notopteridae with 1 species each. The fish distribution of different species in Himalayan streams is influenced by water temperature, availability of food, flow rate, and substratum composition etc. (Gurjar *et. al.,*2023).The present finding is in accordance with Bakalial*et al.,*(2014) who recorded 204 species from the Subansiri River system including its tributaries, perennial hill streams, ephemeral streams, open wetlands/oxbow lakes, seasonally inundated water bodies and streamlets wherefamily Cyprinidae was dominant with 72 species. Kaushik & Bordoloi (2016) found Cyprinidae as the dominant family that contributed 20 species under 16 genera. The sequence of dominance of the recorded families in the river is in the following order Cypriniformes>Siluriformes> Perciformes >Anabantiformes>Synbranchiformes>Beloniformes = Clupeiformes = Gobiiformes = Osteoglossiformes = Tetradontiformes. We have found that the fisheries composition of River Subansiri is mainly dominated by Barils (*Bariliusbendelisis*, *Ospariusbarna*), Barbs (*Puntius terio, P. sophore, P. chola*), Loaches (*Acanthocobitisbotia, Lepidocephalichthysguntea*), carps (*Labeogonius, L. calbasu, L. bata, L. rohita, Cirrhinusmrigala*) and miscellaneous species (*Nandus nandus, Glossogobiusgiuris* and *Chaccachacca* etc.).

Ghosh *et. al,* 2024 found that in the trans-boundary river Atraiin between India- Bangladesh the species diversity was highest in the downstream and lowest in the upstream. In the present study, at sampling station 1, the highest species abundance was recorded in both pre-monsoon and monsoon season with 172 (35.46%) species each followed by 141 (29.08%) species in the post-monsoon season. At station 2 the maximum abundances were found in the pre-monsoon season with 181 (37.32%) species followed by 155 (31.96%) in the monsoon season and 149 (30.72%) in the post-monsoon season. At station 3, species abundances were found to be the maximum with 198 (38.6%) species in pre-monsoon season followed by a post-monsoon season with 158 (30.8%) and monsoon with 157 (30.6%) species. The most dominant species were the *Labeogonius* (4.11%) followed by *Ospariasbarna* (4.05%) and *Bariliusbendelisis* (3.91%) during the study period.

Diversity indices

Study and evaluation of biodiversity indices help to estimate the complexity, stability and general health of an ecosystem (Rowland *et. al;* 2020). In the present study, Shannon-Wiener index (H′) was found to be highest in the pre-monsoon season at station 2(3.66) and lowest in the post-monsoon season at station 2 (3.47). Both the highest and lowest value was recorded in station 2. Thus station 2 showed comparatively higher abundance and diversity.The Simpson index (1- λ') was found to be highest in pre-monsoon season at station 2(0.97) and lowest in post-monsoon season at station 2 (0.96).Margalef's richness index (d) was found to be highest in Monsoon at station 3 (9.09) and the lowest at station 3 (7.94) in the pre-monsoon season. Diversity index (H') and richness index (d) was found to be highest in the lower stretch of the river at stations 2 and 3. It is maybe due to the year-round moderate condition of the water quality and food availability downstream. Differences in diversity index (H') and richness index (d) occurring among stations and in seasons may be due to variation in several factors like atmospheric air current and environmental conditions (Keskin and Unsal, 1998; Hossain *et al.*, 2012), seasonal fish migration (Ryer and Orth, 1987) and variation in water regimes in different seasons. Even a high value of diversity (H') and richness (d) index at station 1 may be due to sudden disruption of water flow just below the 'Hydroelectric Power Project Dam" (Table 2,3,4). Fishes may migrate from the middle stretch to the turbulence point as the water is found to be comparatively pollution-free, less turbid and has high DO content. It is the natural tendency of fish to swim against the water current. The highest value of 0.97 of Simpson index (1- λ') and 0.83 of Buzas and Gibson's evenness index (E) indicated that the fishes are almost evenly distributed in different stations and in different seasons. Similar findings were recorded by Sarkar and Pal (2008) in the river Jaldhaka, West Bengal; Bist *et al.,*(2009) in Dangchaura along river Alakananda; Mishra and Bania (2016) in Melamchi river, Nepal.Akther *et. al.;* 2024 found lower Simpson, Evenness, and Berger-Parker indices in the Surma River, Bangladesh indicating a decline in diversity while the higher Shannon, Margalef, and Fisher's alpha indices in the same location suggest a comparatively healthier fish community, possibly due to better habitat quality or management practices.

Cluster Analysis

Cluster analysis is aimed at grouping objects based on the similarity of their attributes. It is used to group a series of sample-based on multiple variables that have been measured from each of the samples. The aim is to minimize the within-group variation and maximize between-group variation to reveal well-defined categories of objects and therefore, reduce the dimensionality of the data set to a few groups (James and McCulloch, 1990). The Bray-

Curtis similarity prepared for river Subansiri showed the highest similarity between stations 2 and 3 in the pre-monsoon season (Figure 4).

The seasonal fluctuations in weather for rainfall and temperatures during the spawning time is very crucial while some fish species manage to breed during these unfavorable rainfall conditions; moreover insufficient water levels hinder the larval development of fish (Ryan P.G & Perold V; 2021).In the present study,It is observed that station-wise seasonal abundance of species prominently forms three clusters with almost nearly 20% similarity. The first group comprises station 3 (MON) and station 3 (POM) while the second group comprises station 1 (POM), station 1(PRM) and station 1 (MON). Similarly, the third group comprises station 2 (POM), station 2 (MON), station 2 (PRM) and station 3 (PRM). Further, station 1 during pre-monsoon and station 1 during monsoon season forms a cluster with similarity nearby 40%. Also, station 2 in pre-monsoon forms a cluster with station 3 in pre-monsoon season at 40% similarity.

Next we have drawn NMDS (Non-Metric Multidimensional) plot and indicating that the results are reliable with stress = 0.1879552 and also stress plot R^2 = 0.996 tell the same fact. Interpreting a NMDs plot is reasonably straightforward and the same as for any other ordination plot; objects that are closer together on the plot are more alike than those further apart. The results are almost similar with no significant difference from Bray Curtis method of similarity (Figure 5).

Conservation status of the fish fauna of the river Subansiri

According to IUCN conservation status (2021), out of 55 species (Figure 6) recorded during the study period, 51 (92.72%) species were recorded as Least Concern, 2 (3.64%) species under near threatened, 1 (1.82%) species under vulnerable and 1 (1.82%) species under endangered category. Fishes like *Ompokpabo*and *Parambassislala* is under the near-threatened category and are found to be very less abundant in the river. Fishes namely *Wallago attu*and *Clarias magur*were found to bevulnerable and endangered respectively. Therefore, these species need special attention for conservation. Out of 105 species from the North-Eastern region, 4 were categorized as critically endangered (CR), 17 were recognized as endangered (EN), 40 were vulnerable (VU), 34 were lower risk near threatened (LR-nt), 7 lower risk least concern (LR-lc) etc. (CAMP, 1988). With the passage of time, the threat to the fishes and habitat may be much higher than at present time due to intense anthropogenic and aggressive fishing activities. Therefore, strong regulation of conservation measures eg.closures of breeding grounds, year-round vigilance and monitoring and strong enforcement of fisheries act with legal instruments are in utmost need to protect and conserve the diverse endemism of the fisheries in this river. Well-managed freshwater ecosystems can greatly contribute to Sustainable Development Goals (SDGs) like Zero Hunger, Responsible consumption and production, Life below water signifying importance of conservation and management of inland fishery resources in meeting the goals(Kantharajan*et. al;* 2022).

Water Quality Parameters:

In this study, ANOVA was used to test the significant differences between dependent variables (water temperature, pH, dissolved oxygen, total dissolved solids, alkalinity, specific conductivity, water velocity and water transparency) and independent variables (sampling seasons) of the river Subansiri. The value of water temperature in the pre-monsoon season has a significant difference from monsoon and post-monsoon season (p=0.026). The value of water pH also has a significant difference among all the seasons (p=0.001). The value of dissolved oxygen in the pre-monsoon season has a significant difference from monsoon and post-monsoon season (p=0.048) (Table 5). The value of total dissolved solids in the pre-monsoon season has a significant difference from monsoon and post-monsoon season (p=0.001). The value of specific conductivity has a significant difference among all the seasons (p=0.001). The value of alkalinity has a significant difference among all the seasons (p=0.001). The value of water velocity in the pre-monsoon season has a significant difference from monsoon and post-monsoon season (p=0.021). Similarly, the value of transparency in the pre-monsoon season has a significant difference from monsoon and post-monsoon season (p=0.023).

Canonical correspondence analysis (CCA):

In any aquatic ecosystem, the interplay between abiotic and biotic factors plays a major role in structuring the occurrence and distribution of abundance and diversity of tropical fishes (Whitefield 1999). The structure and abundance are dependent on transparency, conductivity (Rodriguez *et al.,* 1987), DO and turbidity (Winemiller *et al.,* 2000), habitat complexity (Petry *et al.,* 2003), pH, TDS, transparency and hardness (Sarkar *et al.,* 2020). These abiotic factors singly or together determine the fish assemblages, community structure, or pattern to a greater extent.

The CCA analysis (Figure 7) indicates that alkalinity, TDS, temperature, conductivity, pH, dissolved oxygen, transparency and velocity are the most important parameters influencing the fish distribution and assemblage in the river. In the present study, *Parambassislala, Channa gachua, Mastacembelusarmatus, Pachypterusatherinoides, Clupisomagarua, Chela cachius, Salmostomabacaila, Monopteruscuchia, Trichogasterfasciata*showing a positive correlation with transparency and TDS. Fish assemblages are structured by environmental variables like transparency, conductivity, depth and area (Rodriguez *et al.,* 1987). *Labeorohita, Bariliusbendelisis, Rita rita, Gagatacenia*showa positive correlation with DO and pH. Dissolved nutrient concentration is one of the best predictors of species diversity and fish abundance. DO, dissolved nutrient, turbidity, plankton densities account for 45-59% of the variation in abundance of the dominant species (Winemiller *et al.,* 2000). Likewise;*Lepidocephalichthysguntea, Glossogobiusgiuris, Ospariusbarna, Labeogonius, Parambassisranga, Acanthocobitisbotia* showing a positive correlation with velocity. *Mystustengara, Channa striata, Channa punctata, Macrognathuspancalus, Mystusvitatus, Macrognathus aculeatus, Nandus nandus,Gudusiachapra, Notopterusnotopterus*show positive correlation with temperature and conductivity. A rise in temperature can intensify the problem of eutrophication which may lead to fish kills and dead zones in the surface water (Gopal *et al.* 2010). Ficke *et al.* (2007) and Macusi*et al.* (2015) also mentioned that changing patterns of temperature and aquatic environment led to reduced fish abundance. Among many climatic factors, temperature strongly influences the fish distribution pattern, breeding behavior, survival of young ones, body metabolism, and growth rate (Jain *et al.* 2013). Species richness and catch show a positive relation to habitat complexity, DO and depth (Petry et al., 2003). pH, TDS, conductivity, salinity, transparency, depth and hardness showed significant differences among different wetlands (Sarkar *et al.,* 2020). The fish structure was found to be positively correlated with DO, pH, Transparency, total alkalinity and specific conductivity (Ravender*et al.,* 2018). The environmental parameters including DO, TDS, pH, transparency, velocity and alkalinity influenced the fish assemblage pattern in the present study as per CCA.

IV. Conclusion:

The fish diversity of river Subansiri is mainly dominated by Barils (Bariliusbendelisis, Opsariusbarna), Barbs (Puntius terio, P. sophore,P. chola), Loaches (Acanthocobitisbotia ,Lepidocephalichthysguntea), Carps (Labeogonius,

L. calbasu, L. bata, L. rohita, Cirrhinusmrigala) and miscellaneous species (Nandus nandus, Glossogobiusgiuris, Chaca chaca etc.).

The similarity and combination pattern of occurrence of fish species was found highest similarity between station 2 & 3 in the pre monsoon season as per the dendrogram for Bray- Curtis Similarity cluster analysis.

LSHEP (Lower Subansiri Hydroelectric Power Project) dam may maintain an optimum water flow round the year to support the life forms downstream. Provisions of fish ways or fish-passes in the dam in accordance with species behavior, migration pattern and type to avert the loss of stream fishes. The passes should meet the biological requirements of fish. Enforcement of Indian Fisheries Act, 1897 for conservation and management will be additional benefit to the ecosystem.

V. Major Highlights:

1. The fish fauna recorded from the Subansiri river comprised of 10 orders including 24 families, 42 genera and 55 fish species reflecting higher species richness of the river.
2. Cyprinidae family was found to be dominant in the river Subansiri with 13 genus and 18 species.
3. *Macropoduscupanus* belonging to the family Osphronemidae have been reported from the basin very first time which was confirmed by available literatures.
4. Some of the recorded indigenous fishes are enlisted by IUCN under near threatened (NT) category e.g.,*Ompokpabo* and *Parambassislala,* and fishes namely *Wallago attu* and *Clarias magur* were found to be vulnerable (VU) and endangered (EN) respectively.

VI. Figures and Tables:

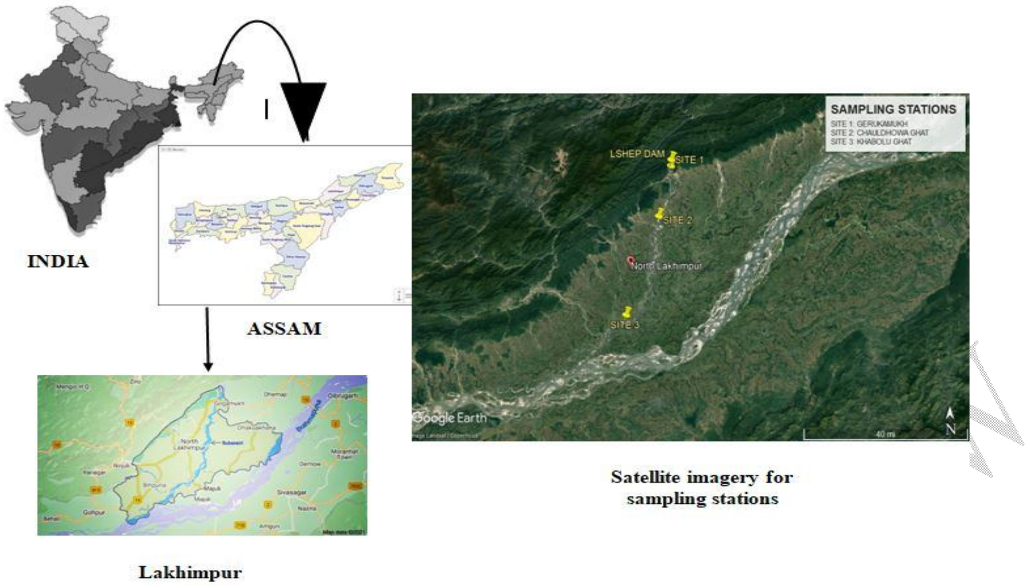


FIGURE 1: Map of the Study areas

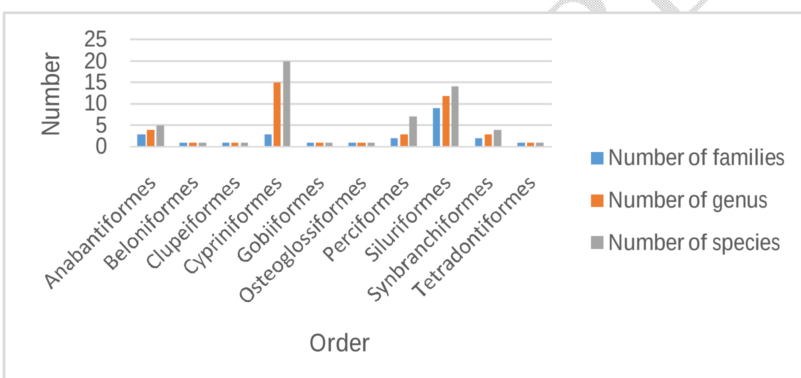


FIGURE 2: Number of Fish Families, Genera and Species under various Order

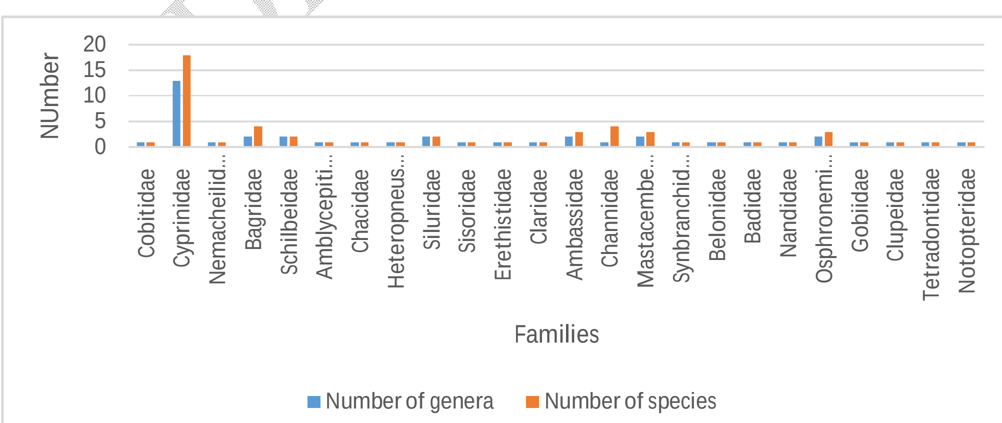


FIGURE 3: Number of Genera and Species of Fishes under various Families

Table 1: Station wise total individual of species recorded from the River Subansiri in three different seasons

Sl. No.	Species	Season									Abundance	Relative Abundance (%)
		Pre-Monsoon			Monsoon			Post-Monsson				
		S1	S2	S3	S1	S2	S3	S1	S2	S3		
1.	*Lepidocephalichthysguntea (Hamilton 1822)*	8	2	1	4	0	3	6	4	1	29	1.96
2.	*Ospariusbarna (Hamilton 1822)*	12	5	8	11	4	2	5	7	6	60	4.05
3.	*Bariliusbendelisis (Hamilton 1807)*	10	5	9	6	5	4	6	6	7	58	3.91
4.	*Cabdiomorar (Hamilton 1822)*	4	2	2	7	5	1	3	4	2	30	2.02
5.	*Chaguniuschagunio (Hamilton 1822)*	2	1	0	2	0	0	4	1	3	13	0.88
6.	*Labeogonius(Hamilton 1822)*	12	5	3	10	9	8	7	5	2	61	4.11
7.	*Labeocalbasu (Hamilton 1822)*	3	7	12	1	6	4	5	2	3	43	2.90
8.	*Labeo bata (Hamilton 1822)*	9	4	6	3	4	5	5	2	7	45	3.03
9.	*Labeorohita (Hamilton 1822)*	5	5	10	9	6	4	2	2	3	46	3.10
10.	*Cirrhinusmrigala (Hamilton 1822)*	2	6	3	2	1	1	5	4	2	26	1.75
11.	*Laubukalaubuca (Hamilton 1822)*	3	8	4	8	7	5	1	2	0	38	2.56
12.	*Salmostomabacaila (Hamilton 1822)*	2	0	5	1	2	4	3	0	4	21	1.42
13.	*Puntius chola (Hamilton 1822)*	3	2	3	1	0	2	0	0	2	13	0.88

14.	*Puntius sophore (Hamilton 1822)*	6	3	2	1	0	6	4	1	2	25	1.69
15.	*Puntius terio (Hamilton 1822)*	5	6	5	4	3	3	7	9	1	43	2.90
16.	*Amblypharyngodon mola (Hamilton 1822)*	7	10	0	3	4	2	3	1	5	35	2.36
17.	*Chela cachius(Hamilton 1822)*	3	2	5	5	4	6	2	3	0	30	2.02
18.	*Devario devario (Hamilton 1822)*	3	0	1	3	0	0	0	0	1	8	0.54
19.	*Esomusdanrica (Hamilton 1822)*	4	5	7	5	1	1	3	6	2	34	2.29
20.	*Acanthocobitisbotia (Hamilton 1822)*	6	4	7	5	4	2	3	4	2	37	2.49
21.	*Mystustengara (Hamilton 1822)*	3	4	4	0	2	3	2	4	7	29	1.96
22.	*Mystuscavasius (Hamilton 1822)*	3	2	0	1	1	8	0	4	3	22	1.48
23.	*Mystusvitatus (Bloch 1794)*	0	5	4	7	8	1	2	0	7	34	2.29
24.	*Rita rita (Hamilton 1822)*	3	4	3	6	1	4	0	1	0	22	1.48
25.	*Clupisomagarua (Hamilton 1822)*	0	2	4	4	2	0	1	0	2	15	1.01
26.	*Pachypterusatherinoides (Bloch 1794)*	1	2	0	2	1	4	4	0	6	20	1.35
27.	*Amblycepsapangi (Nath & Dey, 1989)*	1	0	0	4	0	2	1	0	0	8	0.54
28.	*Chaca chaca(Hamilton 1822)*	0	0	0	0	1	1	0	0	0	2	0.13
29.	*Heteropneustesfossilis (Bloch 1794)*	4	7	6	0	3	1	2	2	3	28	1.89
30.	*Ompokpabo (Hamilton 1822)*	1	3	1	2	4	1	0	5	1	18	1.21
31.	*Wallago attu (Bloch & Schneider 1801)*	0	2	0	1	0	2	0	1	4	10	0.67
32.	*Gagatacenia (Hamilton*	6	1	2	4	0	0	4	0	1	18	1.21

	1822)										
33.	*Eerethistes hara (Hamilton- Buchanan)*	*2*	*0*	*0*	*1*	*0*	*1*	*0*	*0*	*4*	*8*	0.54
34.	*Clarias magur (Hamilton 1822)*	*0*	*2*	*0*	*0*	*1*	*3*	*0*	*4*	*1*	*11*	0.74
35.	*Chanda nama (Hamilton 1822)*	*3*	*5*	*8*	*2*	*10*	*2*	*2*	*12*	*5*	*49*	3.30
36.	*Parambassisranga (Hamilton 1822)*	*1*	*2*	*0*	*1*	*0*	*4*	*5*	*3*	*1*	*17*	1.15
37.	*Parambassislala (Hamilton 1822)*	*2*	*3*	*4*	*1*	*0*	*1*	*0*	*1*	*7*	*19*	1.28
38.	*Channa gachua (Hamilton 1822)*	*3*	*1*	*2*	*4*	*2*	*8*	*1*	*7*	*12*	*40*	2.70
39.	*Channa punctata (Bloch 1793)*	*3*	*2*	*4*	*2*	*6*	*5*	*1*	*4*	*6*	*33*	2.23
40.	*Channa marulius (Hamilton 1822)*	*0*	*1*	*3*	*1*	*2*	*0*	*2*	*0*	*2*	*11*	0.74
41.	*Channa striata (Bloch 1793)*	*3*	*4*	*8*	*0*	*1*	*7*	*1*	*8*	*3*	*35*	2.36
42.	*Mastacembelusarmatus (Lacepede 1800)*	*1*	*3*	*8*	*2*	*1*	*2*	*3*	*1*	*5*	*26*	1.75
43.	*Macrognathuspancalus (Hamilton 1822)*	*2*	*5*	*3*	*3*	*5*	*4*	*1*	*0*	*4*	*27*	1.82
44.	*Macrognathus aculeatus (Bloch 1786)*	*1*	*4*	*2*	*0*	*1*	*2*	*3*	*4*	*5*	*22*	1.48
45.	*Monopteruscuchia (Hamilton 1822)*	*0*	*0*	*1*	*0*	*1*	*2*	*2*	*0*	*1*	*7*	0.47
46.	*Xenontodoncancila (Hamilton 1822)*	*2*	*4*	*6*	*5*	*7*	*3*	*2*	*1*	*0*	*30*	2.02
47.	*Badis badis (Hamilton 1822)*	*6*	*12*	*10*	*3*	*4*	*5*	*7*	*2*	*1*	*50*	3.37
48.	*Nandus nandus (Hamilton 1822)*	*0*	*1*	*2*	*2*	*5*	*1*	*0*	*1*	*4*	*16*	1.08

49.	*Trichogasterfasciata (Bloch & Schneider 1801)*	4	2	3	1	0	5	0	1	2	18	1.21
50.	*Trichogasterlalius (Hamilton 1822)*	2	0	1	3	6	0	5	7	0	24	1.62
51.	*Macropoduscupanus*	0	0	0	0	1	0	0	0	0	1	0.07
52.	*Glossogobiusgiuris (Hamilton 1822)*	3	9	8	14	2	2	11	4	3	56	3.78
53.	*Gudusiachapra (Hamilton 1822)*	0	2	4	0	7	9	3	1	2	28	1.89
54.	*Leiodoncutcutia (Hamilton 1822)*	1	3	0	4	3	0	2	6	0	19	1.28
55.	*Notopterusnotopterus (Pallas 1769)*	2	2	4	1	2	1	0	2	1	15	1.01
Total Number		*172*	*181*	*198*	*172*	*155*	*157*	*141*	*149*	*158*	*1483*	*100*
Percentage (%)		*35.46*	*37.32*	*38.60*	*35.46*	*31.96*	*30.60*	*29.08*	*30.72*	*30.80*	*--*	*--*

Table 2: Station wise diversity indices of Subansiri river in pre-monsoon season

Station	***(d)***	***(E)***	***(H′)***	***(1- λ′)***
Station 1	*8.54*	*0.79*	*3.58*	*0.96*
Station 2	*8.84*	*0.83*	*3.66*	*0.97*
Station 3	*7.94*	*0.83*	*3.58*	*0.96*

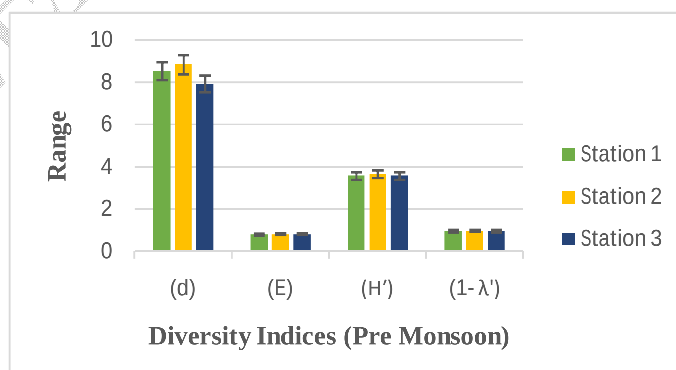


Table 3: Station wise diversity indices of Subansiri river in monsoon season

Station	***(d)***	***(E)***	***(H′)***	***(1- λ′)***
Station 1	*8.74*	*0.76*	*3.55*	*0.96*
Station 2	*8.32*	*0.79*	*3.53*	*0.96*
Station 3	*9.09*	*0.81*	*3.64*	*0.96*

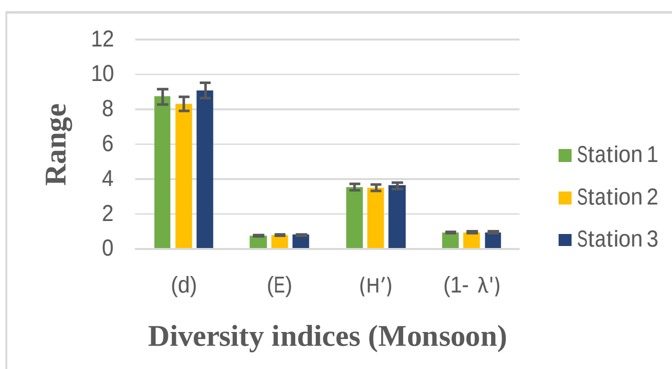
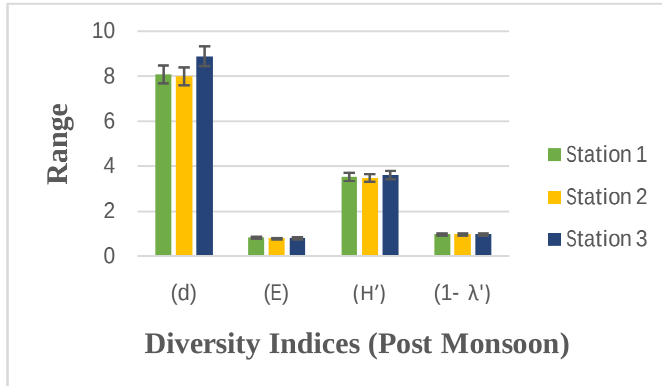


Table 4: Station wise diversity indices of the River Subansiri in post monsoon season

Station	*(d)*	*(E)*	*(H′)*	*(1- λ′)*
Station 1	*8.08*	*0.83*	*3.53*	*0.96*
Station 2	*7.99*	*0.79*	*3.47*	*0.96*
Station 3	*8.88*	*0.80*	*3.61*	*0.96*



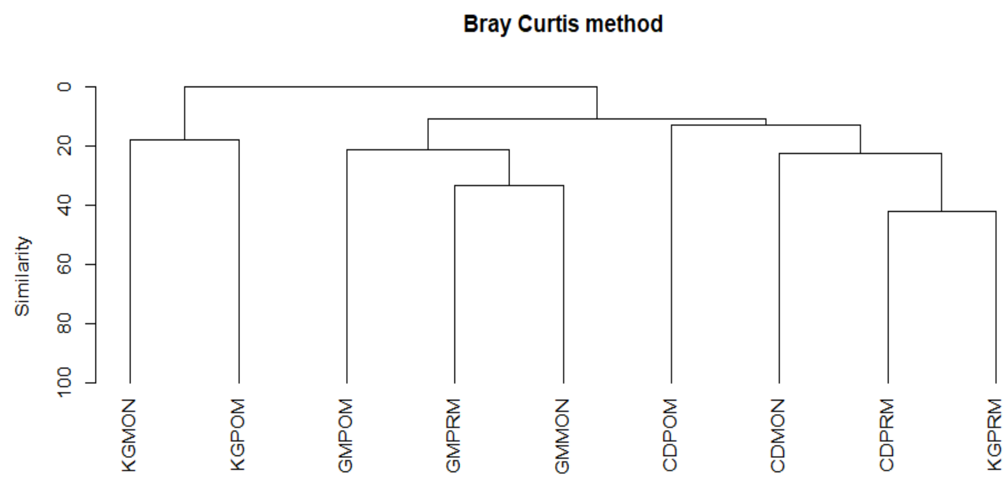


FIGURE 4:Dendrogram from Bray-Curtis similarity of Season – Station Wise Species Abundance of the River Subansiri(GMPOM=Gerukamukh Post Monsoon, CDPRM= Chawldhowa Pre Monsoon, GMPRM= Gerukamukh Pre Monsoon, GMMON= Gerukamukh Monsoon, KGPRM= Khabolughat Pre Monsoon, CDMON= Chawldhowa Monsoon, CDPOM= Chawldhowa Post Monsoon, KGMON= Khabolughat Monsoon, KGPOM= Khabolughat Post Monsoon)

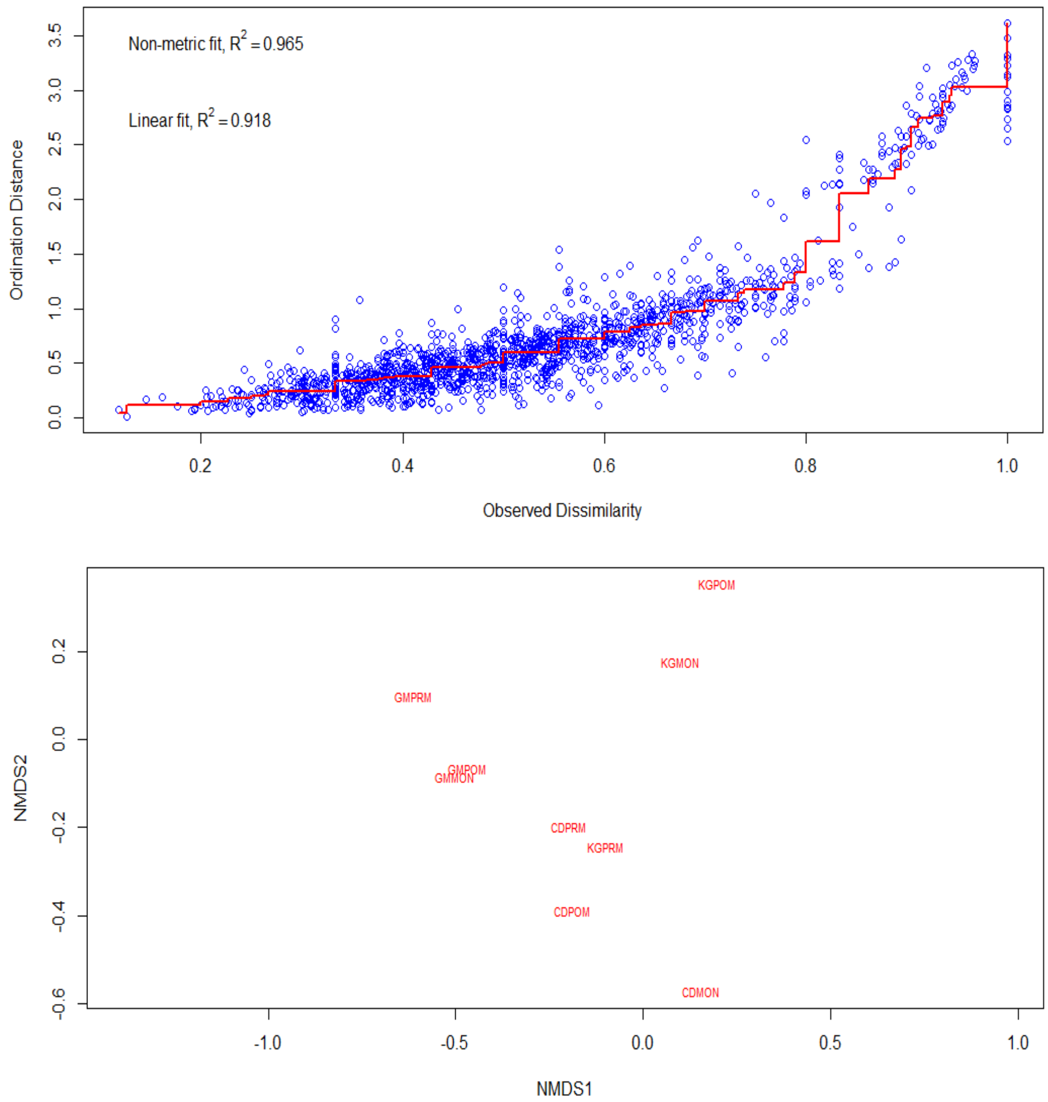
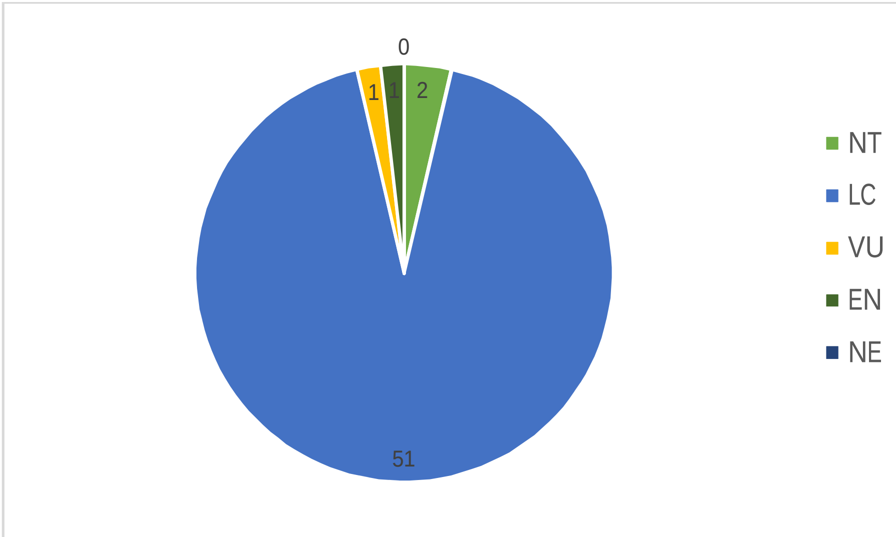


FIGURE 5: Non-Metric Multidimensional Plot (A) of 3 Stations (Monsoon, Pre-Monsoon, Post -Monsoon) and Stress Plot (B)



(NT= Near Threatened, LC= Least Concern, VU= Vulnerable, EN= Endangered, NE= Not Evaluated)

FIGURE 6: IUCN Conservation Status of the Fish fauna expressed in number

Table 5: ANOVA for Physico-chemical parameters of the River Subansiri:

Season / Water parameters	Pre-monsoon	Monsoon	Post monsoon	p-value	Variance
Water Temperature (◦C)	18.43± 0.3[a]	20.70± 0.68[b]	18.54± 0.66[ab]	0.026	4.22
Water pH	7.27± 0.09[a]	6.73± 0.01[b]	7.62± 0.06[ac]	.001	0.18
Dissolved Oxygen (mg/l)	5.21 ± 0.15[ab]	4.78± 0.02[a]	5.54± 0.17[b]	0.048	0.26
Total Dissolved solids (mg/l)	73.98± 1.26[a]	111.98± 2.86[b]	88.40± 2.78[ac]	.001	328.46
Specific Conductivity (μS/cm)	88.77± 0.64[a]	141.80± 1.71[b]	100.10± 1.34[ac]	.001	600.38
Total Alkalinity (mg/litre)	43.65± 0.43[a]	63.12± 2.71[b]	47.60± 2.81[ac]	.001	125.64
Water velocity (m/sec)	1.61± 0.01[ab]	1.74± 0.04[a]	1.55± 0.03[b]	0.021	0.01
Transparency (cm)	42.28± 0.91[ab]	37.71± 0.72[a]	43.80 ± 3.66[b]	0.023	21.67

Note: Values are mean ± SE (n=12); the mean difference are significant at the 0.05 level.

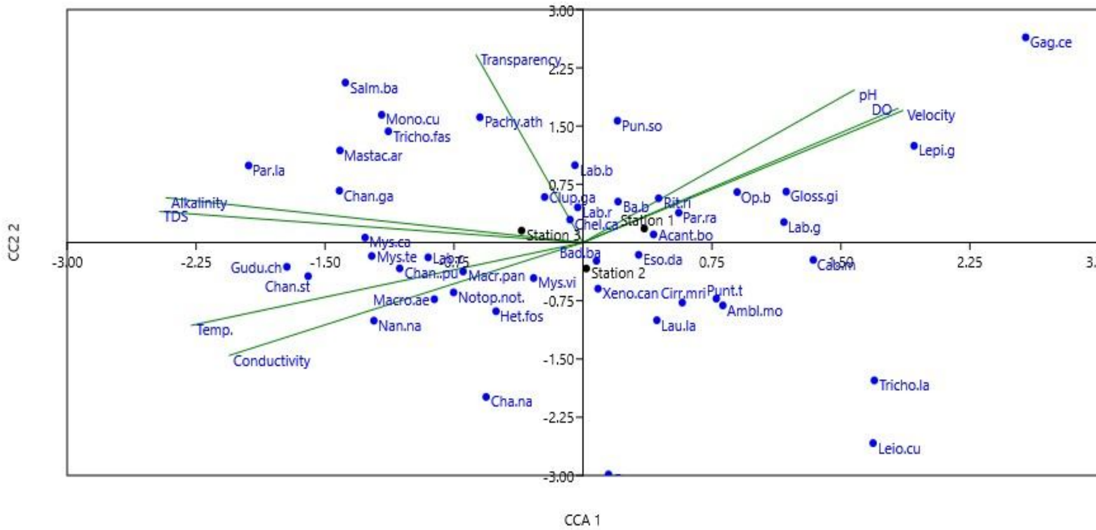


Figure 7: Canonical correspondence analysis

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