

Fish Community Structure of Sandha River: A Link Analysis towards Fisheries Management and Conservation

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Abstract

Sandha River water regime is used as a nursery, feeding and breeding places by commercially important fish species due to the presence of unique environment. Therefore, the present study has been conducted to assess water quality parameters, fish species abundance, fish diversity indices, conservation issues and management policy to guard the valuable aquatic resources of Sandha River from March 2015 to February 2016. Among the water quality parameters, temperature and pH were found at a slight rising level which possessed insignificant negative correlation with fish species abundance ($p < 0.01$). Fish diversity indices were calculated of which the value of Shannon-Wiener Index just above 3 which indicated the river ecosystem still approving good fish community structure where lower value of richness described short food webs. Garretts Ranking Technique was applied to identify the reasons behind the decline of Sandha River fish species over the periods. The study, therefore, concluded that the river has experienced with slight climate modifications and significant anthropogenic activities especially huge fishing pressure which in a feedback reduce the fisheries stock resources with time. Community-based fisheries management (CBFM) hence would be an appropriate tool to make the water resources sustainable.

Keywords: Sandha River; Water Quality Parameters; Shannon-Wiener Index; Fishing Pressure; CBFM

Introduction

Fish as a foodstuff have established an essential constitute to supply cheap source of nutrition's especially protein [1,2] for much of the world's population mainly low-revenue food-deficit countries [3]. Along with the globe, fisheries sector of Bangladesh has incredible utility in poverty alleviation, food security, nutrition supply, sources of income, employment generations, foreign exchange earnings and overall on the socio-economic development of Bangladesh [4,5]. The fisheries resources of the country are mainly captured based from inland open and closed water resources. As an outcome, the diversity of fish faunal communities is under stress due to intense exploitation by illegal fishing gears [6,7]. Environmental modifications (climate changes) also claimed as one of the leading issues for reducing fish species from open water bodies [8,9].

In nature, Pirojpur is a coastal riverine district with huge fishery resources situated at the southern part of Bangladesh. In the life and living status of fishers of Pirojpur district, Sandha River has an important job to endow with food security and sole source of returns support through fish business activities of many household families. Thus, the river has great influence to change life pattern and sustain of riverine population community the southern coastal region of Bangladesh primarily depend on resources from the river. But at the meantime, the worthwhile aquatic resources of Sandha River are in declining trends like others water resources of Bangladesh due to both anthropogenic activities and environmental alterations [4,10,11]. Very earlier study by Hanif et al. [12] identified total 26 threatened fish species from Sandha River and found environmental degradation and over-exploitation using restricted fishing gears was the important factors for threatening the ichthyofaunal community. Ship breaking activities, point and non-point sources of pollution, fishing during ban period, introduction of alien species from aquaculture ponds and pesticides from croplands, use of restricted fishing gears and finally excess fishing pressure

throughout the year causes the alternations of river bed, change the water quality parameters and in combination make the river unsuitable for fish community. As a result, diversity of fish species from Sandha River is gradually decreasing with increasing excess fishing pressure and other possible factors. Therefore, in view of the above information's, the present study has been undertaken to assess water quality parameters, fish species abundance, fish diversity indices, conservation issues and management policy to guard the valuable aquatic resources of Sandha River of Bangladesh.

Materials and Methods

Study area and duration

The present study was conducted in Sandha River, located in Swarupkathi upazilla with geographical position lies between 22°44'50" to 22°74'72" N and 90°06'13" to 90°10'36" E. (Figure 1). The river Sandha with a total length of about 50 km originating from the Meghna River near Muladi upazilla and then falls to the Bay of Bengal over through two coastal districts named Barisal and Pirojpur. The study duration was 6 months from March 2015 to February 2016.

Hydrological parameters analysis

Hydrological parameters like salinity was measured using a

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refractometer (CBF 062, Japan), pH using a pH meter (pH 211, Hanna Instruments, Italy), a temperature meter to measure temperature and a DO meter (AZ8402, China) to measure dissolved oxygen concentration. A Secchi disc (20 cm diameter) was used to measure the water transparency.

Fish specimen collection and identification

Fish specimens were collected from six selected fishing spots (St1, St2, St3, St4, St5 and St6) of Sandha River. At each sampling day, three types of fishing gears (SBN- Set Beg Net, Fixed net and cast net) were used for sampling purpose. The collected specimens were placed in ice-box with adequate ice facilities. Then, total numbers of individual species were counted in each sampling day and recorded according to months and stations. For laboratory study, 10% of the total catch was taken from each sampling station covering the representative group of fish. In the laboratory, the collected specimens were identified to species level with the help of standard taxonomic keys of [13-16].

Data analysis

Species diversity was assessed using four different indices viz., species richness, Shannon–Wiener diversity, Evenness and Dominance Indices in a spatial and temporal spectrum. Shannon-Weiner diversity index [17,18] is used for better understanding of fish biodiversity and calculated by the following formula:

$$H = -\sum \left[\left(\frac{n_i}{N} \right) \times \ln \left(\frac{n_i}{N} \right) \right]$$

N is total individuals and n_i is the number of individuals of species i .

Buzas and Gibson's evenness [19] is measured by using $E = \frac{eH}{S}$ formula; where, e is logarithm base, H is Shannon-Wiener Index and S is number of taxa.

Simpson's dominance index (D) [19,20] is measured by the following formula: $D = \sum \left[\frac{n_i(n_i-1)}{N(N-1)} \right]$; where, n_i is number of individuals of species i .

Simpson's index of diversity (1-D) is determined using $1-D = 1 - \sum \left[\frac{n_i(n_i-1)}{N(N-1)} \right]$ formula; where, N is total individuals and n_i is the number of individuals of species i .

Margalef richness index (d) [21,22] is used to measure species richness by using the formula: $d = \frac{S-1}{\ln N}$; where, S is the number of taxa and N is total individuals.

SPSS statistical package (SPSS 16.0 for Windows, SPSS Inc, Chicago, IL, USA), PAST software (2.17c) [23] and BioDiversity Pro statistics software (2.0) [24] were used for analysis purpose.

An open-ended interview schedule was used among 500 randomly selected fishermen to collect data about the reasons perceived by the fisheries regarding the decline in fish. The ranks given by the respondents were then converted into percentage position with the help of following Garretts Ranking Technique [25].

$$\text{PercentagePosition} = \frac{100 \times (R_{ij} - 0.5)}{N_j}$$

Where, R_{ij} = Rank given to i^{th} constraint by j^{th} individual, N_j = Number of constraints ranked by j^{th} individual.

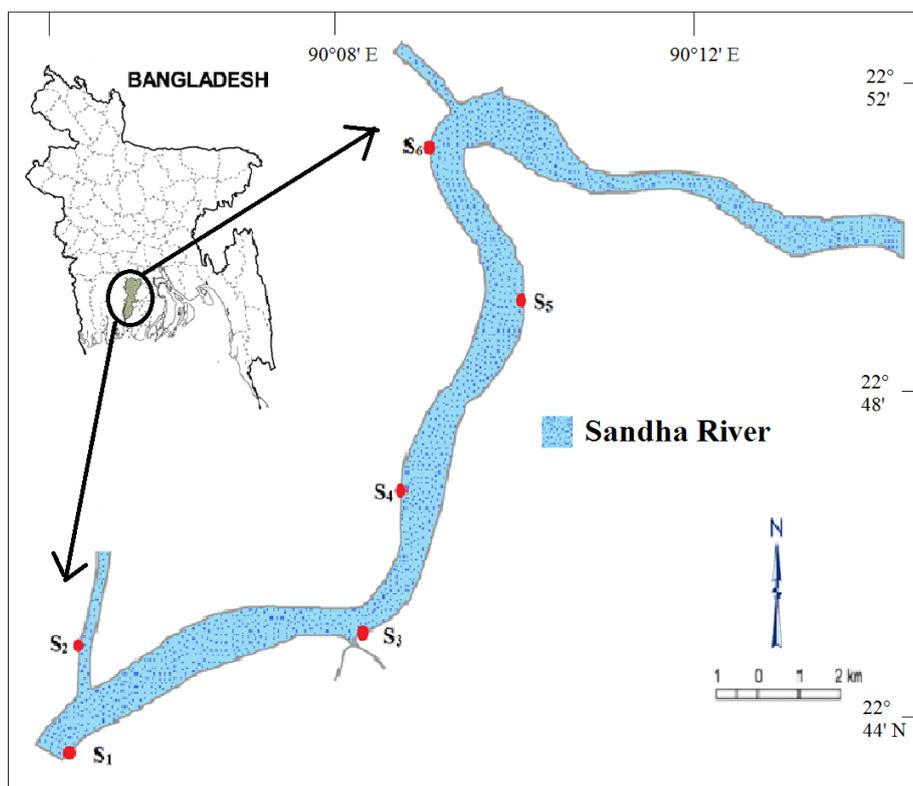


Figure 1: Location of Sandha River with six sampling zones in Bangladesh

Results

Hydrological parameters

Higher water temperature (28.35°C) was found during July 2015 which followed by May 2015 and lower temperature (21.95°C) during February 2016 (Table 1). A non-significant difference in Temperature was observed during the months of March and September ($p < 0.05$) while a significant difference was found for other four months (July, May, November, and February) ($p > 0.05$). After temperature, another important water quality parameter was pH which found maximum (7.65) during July 2015 where minimum (6.50) for February 2016. A non-significant difference in water pH was found for March, May, and September and for November and February ($p < 0.05$). Dissolved oxygen (DO) was observed maximum (6.95 mg/l) in February 2016 and minimum (5.23 mg/l) in March 2015 ($p < 0.05$). Transparency was found highest (37.17 cm) during February 2016 and lowest (26.07 cm) in the month of March 2015 ($p < 0.05$). But at stations level, a non-significant difference among the water quality parameters was shown during the whole study period ($p < 0.05$) (Table 1).

The temperature had significant positive correlation with pH where $r = 0.790$ and considerable negative correlation with DO and Transparency ($p < 0.01$) where $r = -0.690$ and -0.803 , respectively (Table 2). Water pH shown a positive correlation with temperature where $r = 0.790$ and negative correlation with DO and Transparency where $r = -0.492$ and -0.670 , respectively. DO maintained negative correlation with pH and Temperature and significant positive correlation with Transparency. Transparency had significant negative correlation with Temperature and pH where $r = -0.803$ and -0.670 and highly positive correlation with DO where $r = 0.843$ ($p < 0.01$) (Table 2). In general, pH mostly temperature dependent and vice-versa whereas

Sampling months and stations	Temperature (°C)	pH	DO (mg/l)	Transparency (cm)
Mar	25.72 ± 1.04 ^c	7.00 ± 0.09 ^b	5.23 ± 0.12 ^c	26.07 ± 0.65 ^d
May	26.68 ± 0.44 ^b	6.83 ± 0.18 ^b	5.02 ± 0.17 ^d	26.83 ± 1.17 ^d
Jul	28.35 ± 0.75 ^a	7.65 ± 0.10 ^a	5.75 ± 0.14 ^b	26.50 ± 1.05 ^d
Sep	25.55 ± 0.49 ^c	6.98 ± 0.15 ^b	5.62 ± 0.19 ^b	32.67 ± 1.03 ^c
Nov	24.22 ± 0.50 ^d	6.58 ± 0.15 ^c	6.80 ± 0.13 ^a	34.83 ± 1.17 ^b
Feb	21.95 ± 0.65 ^e	6.50 ± 0.13 ^c	6.95 ± 0.14 ^a	37.17 ± 1.17 ^a
St1	25.35 ± 2.15 ^a	6.83 ± 0.43 ^a	5.73 ± 0.86 ^a	30.73 ± 4.85 ^a
St2	25.35 ± 2.69 ^a	7.02 ± 0.41 ^a	5.90 ± 0.79 ^a	30.83 ± 4.96 ^a
St3	25.57 ± 2.13 ^a	7.00 ± 0.51 ^a	5.88 ± 0.86 ^a	30.17 ± 4.79 ^a
St4	25.65 ± 2.10 ^a	6.95 ± 0.37 ^a	5.87 ± 0.83 ^a	30.50 ± 5.47 ^a
St5	25.02 ± 2.26 ^a	6.83 ± 0.38 ^a	5.97 ± 0.78 ^a	30.83 ± 4.96 ^a
St6	25.53 ± 2.25 ^a	6.92 ± 0.44 ^a	6.02 ± 0.74 ^a	31.00 ± 4.56 ^a

Table 1: Hydrological parameters of Sandha River recorded during March 2015 to February 2016.

	Temperature	pH	DO	Transparency
Temperature	1	0.790**	-0.690**	-0.803**
pH	0.790**	1	-0.492**	-0.670**
DO	-0.690**	-0.492**	1	0.843**
Transparency	-0.803**	-0.670**	0.843**	1

**Correlation is significant at the 0.01 level (2-tailed)

Table 2: Pearson's correlation coefficient among selected water quality parameters of Sandha River.

DO partially or fully depends on Transparency and vice-versa i.e., one increased or decreased with related to others increasing or decreasing impact.

Fish assemblage's structure

A total of 55 fish species with 1968 individuals had been recorded from the catches of different fishing gears used in this experiment (Table 3). The most dominant species both from months and stations found in the Sandha River was *Corica soborna* with 177 individuals (9%) followed by *Puntius ticto* having 130 individuals (6.61%) and less dominant species were *Hypophthalmichthys molitrix* and *Dasyatis zugei* which contributed single individuals (0.05%) (Table 3 and Figure 2). One alien species named *Hypophthalmichthys molitrix* was caught during the May 2015 which indicated that the river sometimes is the place of exotic species. Out of 55 species of finfish vulnerable, endangered and critically endangered species were 8, 4 and 4 respectively recorded from Sandha River during the study period.

Fish diversity indices

Table 4 represents fish diversity indices of recorded fish species. Among the different fish diversity indices, H value was ranged from 3.011 to 3.575 for all species regardless used any months or stations. H-index of diversity had a positive correlation with 1-D index and Evenness. Among the months and stations, the 1-D index was found maximum (0.964) in St2 and minimum (0.936) during March 2015. A significant negative correlation existed among 1-D and D index of diversity where the D value was ranged from 0.036 to 0.064. Highest (0.752) evenness value of diversity was shown in March 2015 and lowest (0.616) during September 2015. Among the months, the peak value (8.471) of Margalef was calculated during July and minimum value (4.600) in March 2015.

Spatial and temporal relationship of fish assemblages

The similarity level of fish species was checked based on cluster analysis using Bray-Curtis similarity matrix (Figure 3). Three major groups were identified through Bray-Curtis similarity matrix of which the first group consists of 25 fish species; the second group had 26 fish species and the third group with 4 species only.

Correlation between water quality parameters and fish species abundance

Correlation between water quality parameters and fish species abundance was determined both from months and stations using Pearson's correlation coefficient (Table 5). On the basis of months, an insignificant negative relation was found between Temperature and fish species abundance and pH and fish species abundance with r value -0.130 and -0.164 , respectively where positive relation was measured between DO and fish species abundance and Transparency and fish species abundance ($r = 0.254$ and 0.446 , respectively). On the other hand, according to stations, Temperature, pH, and DO had a positive relation with the abundance of fish species where $r = 0.243$, 0.354 and 0.136 , individually. But Transparency had significant negative relation with the occurrence of fish species ($r = -0.712$).

Reasons behind decline of fisheries resources of Sandha River

Eight sources as observed by the fishermen community which was documented and ranked with the help of Garretts Ranking Technique (Table 6) in order to identify the reasons behind the decline of Sandha River fish species over the periods. Over-exploitation was reported as the most dynamic factor to declining fish species which ranked first (mean

Scientific Name	Species code	Mar	May	Jul	Sep	Nov	Feb	St1	St2	St3	St4	St5	St6	Species abundance	Composition (%)
<i>Chanda nama</i> *	C1	5	7	12	11	6	3	7	6	15	6	7	3	44	2.24
<i>Pseudambassis ranga</i> *	C2	0	5	7	6	5	4	2	3	10	4	5	3	27	1.37
<i>Anabas testudineus</i>	C3	3	5	6	7	0	7	2	5	18	1	2	0	28	1.42
<i>Mystus vittatus</i>	C4	9	8	5	11	17	12	14	11	9	8	7	13	62	3.15
<i>Mystus cavasius</i> *	C5	0	0	4	3	3	0	2	3	0	0	5	0	10	0.51
<i>Mystus bleekeri</i>	C6	0	8	8	7	11	5	7	4	11	12	2	3	39	1.98
<i>Sperata aor</i> *	C7	0	0	5	5	1	2	0	2	3	2	5	1	13	0.66
<i>Rita rita</i> ***	C8	0	3	6	3	4	0	3	2	5	3	2	1	16	0.81
<i>Nemachilus botia</i>	C9	6	6	9	7	6	3	7	6	5	7	7	5	37	1.88
<i>Xenentodon cancila</i>	C10	5	0	4	1	2	4	2	4	3	0	3	4	16	0.81
<i>Channa punctatus</i>	C11	3	4	3	2	5	3	3	6	4	3	2	2	20	1.02
<i>Channa striatus</i>	C12	3	5	1	3	2	0	0	1	3	4	3	3	14	0.71
<i>Tenualosa ilisha</i>	C13	16	12	11	19	7	4	9	8	22	13	10	7	69	3.51
<i>Gudusia chapra</i>	C14	9	11	17	7	9	0	7	11	6	7	9	13	53	2.68
<i>Corica soborna</i>	C15	45	23	34	21	37	17	27	26	41	35	31	17	177	9
<i>Cynoglossus cynoglossus</i>	C16	8	4	2	1	3	0	3	2	0	4	5	4	18	0.91
<i>Puntius sophore</i>	C17	0	0	7	43	33	4	18	13	17	15	19	5	87	4.42
<i>Puntius sarana</i> ***	C18	0	2	1	3	2	0	1	3	0	0	3	1	8	0.41
<i>Puntius ticto</i> *	C19	23	12	29	32	23	11	21	23	37	9	14	26	130	6.61
<i>Puntius chola</i>	C20	0	4	5	2	4	0	0	3	5	2	3	2	15	0.76
<i>Puntius terio</i>	C21	0	2	3	6	0	0	2	0	0	0	5	4	11	0.56
<i>Esomus danricus</i>	C22	11	5	2	4	3	3	5	3	7	3	6	4	28	1.42
<i>Chela cachius</i>	C23	0	6	3	9	2	0	7	3	5	0	0	5	20	1.02
<i>Salmostoma phulo</i>	C24	12	3	5	12	3	0	5	7	3	10	3	7	35	1.78
<i>Salmostoma bacaila</i>	C25	21	13	4	37	19	12	17	13	23	11	19	23	106	5.38
<i>Danio devario</i>	C26	7	6	3	23	7	5	2	13	12	11	7	6	51	2.59
<i>Labeo rohita</i>	C27	0	3	1	0	2	0	1	2	2	0	0	1	6	0.30
<i>Gibelion catla</i>	C28	0	4	2	0	0	0	2	0	1	1	0	2	6	0.30
<i>Rohtee cotio</i> **	C29	0	0	4	6	6	0	3	2	5	2	4	0	16	0.81
<i>Amblypharyngodon mola</i>	C30	0	5	13	38	5	22	3	7	33	7	4	29	83	4.22
<i>Hypophthalmichthys molitrix</i>	C31	0	1	0	0	0	0	0	0	1	0	0	0	1	0.05
<i>Dasyatis zugei</i>	C32	0	1	0	0	0	0	0	0	1	0	0	0	1	0.05
<i>Eleotris fusca</i>	C33	0	0	0	2	0	0	0	0	0	1	0	1	2	0.10
<i>Setipinna phasa</i>	C34	13	2	0	7	5	23	9	10	8	9	7	7	50	2.54
<i>Thryssa purava</i>	C35	11	3	6	17	16	12	17	7	13	4	12	12	65	3.30
<i>Glossogobius giuris</i>	C36	6	0	3	3	3	6	3	4	4	2	5	3	21	1.07
<i>Pseudapocryptes elongates</i>	C37	8	23	2	6	32	12	5	13	9	16	19	21	83	4.22
<i>Taenioides cirratus</i>	C38	26	26	7	9	21	17	17	11	9	19	27	23	106	5.38
<i>Hyporhamphuslim batus</i>	C39	3	5	3	4	2	2	7	4	5	0	0	3	19	0.97
<i>Heteropneustes fossilis</i>	C40	3	3	0	2	2	0	0	3	4	0	0	3	10	0.51
<i>Lates calcarifer</i>	C41	4	2	3	2	3	2	3	2	7	3	1	0	16	0.81
<i>Mastacembelus armatus</i> **	C42	0	1	1	1	6	4	5	3	0	2	1	2	13	0.66
<i>Macrogathus aral</i> *	C43	0	0	7	3	23	19	6	3	7	12	11	13	52	2.64
<i>Nandus nandus</i> *	C44	0	2	3	9	12	3	5	3	6	7	3	5	29	1.47
<i>Chitala chitala</i> **	C45	0	0	2	3	5	5	2	3	7	2	0	1	15	0.76
<i>Colisa fasciata</i>	C46	0	3	7	5	17	11	8	6	4	6	12	7	43	2.18
<i>Pangasius pangasius</i> ***	C47	0	1	4	1	3	0	1	2	3	2	1	0	9	0.46
<i>Silonia silondia</i> **	C48	0	0	3	3	14	9	7	3	5	8	3	3	29	1.47
<i>Ailia coila</i>	C49	0	9	7	8	6	3	2	5	7	2	6	11	33	1.68
<i>Otolithoides pama</i>	C50	12	7	7	14	12	21	11	13	22	7	14	6	73	3.71
<i>Wallago attu</i>	C51	5	3	2	2	3	1	3	5	2	3	2	1	16	0.81
<i>Bagarius arrellii</i> ***	C52	0	3	2	4	0	1	2	0	3	2	0	3	10	0.51
<i>Nangra viridescens</i>	C53	0	0	2	2	1	3	0	2	0	3	2	1	8	0.41
<i>Monopterusuchia</i> *	C54	0	1	0	2	0	0	1	0	0	0	0	2	3	0.15
<i>Tetraodon fluviatilis</i>	C55	8	3	2	3	0	0	2	1	2	5	3	3	16	0.81
		285	265	289	441	413	275	298	295	434	295	321	325	1968	100

As per IUCN of Bangladesh [26]=*Vulnerable; **Endangered and ***Critically Endangered.

Table 3: Fish species abundance in different months and stations of Sandha River during March 2015 to February 2016.

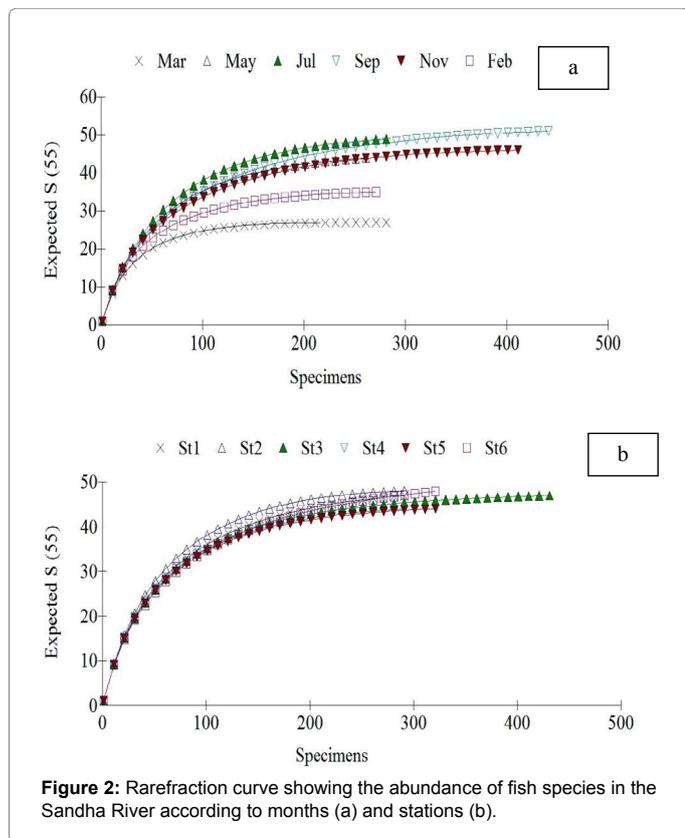


Figure 2: Rarefaction curve showing the abundance of fish species in the Sandha River according to months (a) and stations (b).

score 52.594) among the reasons behind declining of fishery resources of Sandha River. Use of destructive fishing gears (mean score 50.848) was marked another dominating factor to reduce fish stock. In Sandha River, for fishing purpose different restricted fishing gears named set bag net, gill net (current jal), push net (moia jal) are frequently used to harvest a huge quantity of fish. Fishermen usually received low credit facilities (mean score 46.914) during fishing ban period which accountable for large-scale fishery caught. Non-point and point source pollution (4th rank) was informed as one of the major reasons for the decline in fisheries resources by the fisher's community. River bank erosion, climate change, fishing during ban period and natural disaster were got mean score 44.01 (V rank), 43.978 (VI rank), 40.65 (VII rank) and 39.878 (VIII rank), respectively. All of these reasons are changed Sandha River fish stock substantially.

Discussion

Hydrological parameters

Among the water quality parameters, Temperature is the most important one which affects the survivability, growth, metabolic activities of fish [26,27]. The recommended level of water temperature was 20°C to 30°C to maintain the aquatic ecosystem [28]. But in the present study, Temperature was found a negative correlation with fish species abundance (Table 5) which indicated that water temperature is at rising level. Temperature variation from month to month was noticeable while remains same condition in the same month of different stations of the river (Table 1). Solar radiation, ship breaking activities in Swarupkathi launch ghat and overall climate change was found as governing factors to change the water Temperature from

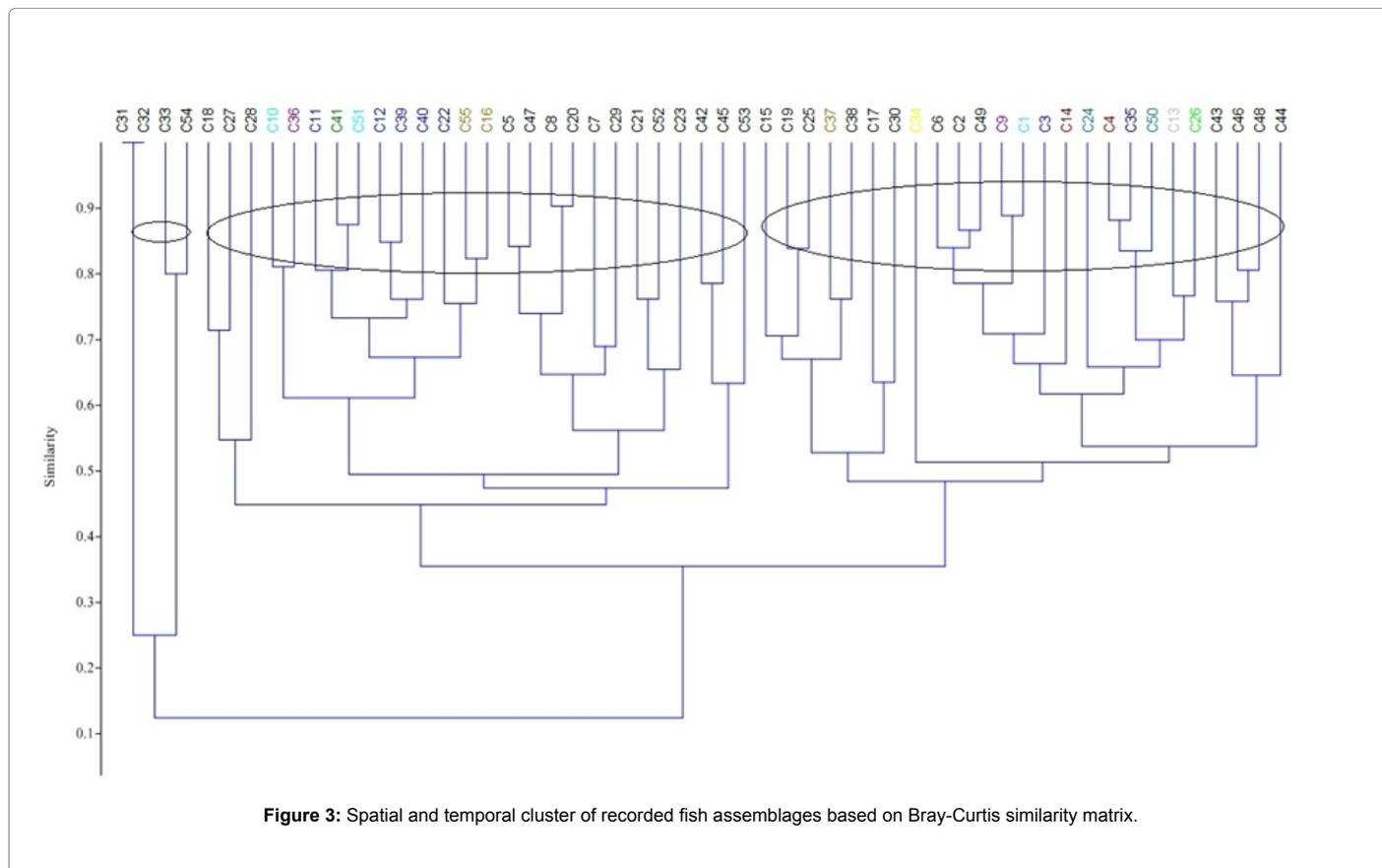


Figure 3: Spatial and temporal cluster of recorded fish assemblages based on Bray-Curtis similarity matrix.

month to month in the present study area. The temperature had a positive correlation with water pH and vice-versa (Table 2). Among the water quality parameters, pH acts an indicator of the existence of aquatic life of any water body as most of the organisms could endure only narrow and critical pH range. The optimum range of pH for freshwater fish species is usually varied from 7.5 to 8.5 [29] where pH lower than 6.5 had a negative effect on fish growth [30]. From the study, an insignificant negative correlation was observed between water pH and fish species abundance (Table 5). Dissolved oxygen concentration is the most important water quality parameter which acts as the major factor triggering the species abundance, distribution and survivability in any water body [31,32]. DO was found negatively correlated with Temperature and pH while positive relation with Transparency (Table 3). DO concentrations lower than 5.0 mg/L would adversely affect the aquatic life [33]. But the present study recorded higher DO concentration (Table 1). This statement could also be verified in the case of fish species abundance which had a positive correlation with water DO concentration (Table 5). Transparency of water body mostly depends on the season, rainfall pattern and water current. Hossain et al. [32] reported that water transparency is a function of rainfall pattern. Hossain et al. [32] and Hanif et al. [12] found salinity concentrations zero (0) due to heavy freshwater discharge from surrounding land area and also related with annual rainfall pattern which supports the present study.

Fish assemblage's structure

Fish species of any water body shows varying degrees of dependency on human intervention, natural calamities and largely on environmental degradation. In the present study, a total of 1968 individuals under 55 fish species had been recorded from the catches of different fishing gears used in this experiment (Table 3) in which the most dominant species was *Corica soborna* followed by *Puntius ticto* both from months and stations of Sandha River. The result indicated that the river acts as the harbor of SIS. The outcomes were found similar in compare with the study of Hossain et al. [15] who identified that small fish species were dominant in Meghna River. Galib [34] identified total 67 species having 9837 individuals where Hanif et al. [35] listed 65323 individuals under 95 finfish species which were much higher than the present study. Dianne et al. [36] recorded a higher number of fish species than the present study which was 137 species from 42 families in the west coast of Western Australia. Lower fish species abundance could be described on the basis of several factors reported by fishermen which were ranked according to Garretts Ranking Technique (Table 6). Most of the fishermen used Sandha River as a sole source of income due to lack of sufficient job and credit facilities as a means of employment

	Taxa_S	Individuals	H	Evenness	D	1-D	Margalef
Mar	27	285	3.011	0.752	0.064	0.936	4.600
May	44	265	3.437	0.707	0.043	0.957	7.706
Jul	49	289	3.517	0.687	0.043	0.957	8.471
Sep	51	441	3.448	0.616	0.045	0.955	8.211
Nov	46	413	3.419	0.664	0.043	0.957	7.471
Feb	35	275	3.247	0.735	0.048	0.952	6.053
S1	47	298	3.493	0.700	0.040	0.960	8.074
S2	48	295	3.575	0.743	0.036	0.964	8.264
S3	47	434	3.468	0.682	0.042	0.958	7.574
S4	44	295	3.453	0.718	0.042	0.958	7.561
S5	44	321	3.436	0.706	0.042	0.958	7.450
S6	48	325	3.429	0.643	0.044	0.956	8.126

Table 4: Fish diversity indices of recorded fish species during March 2015 to February 2016.

Correlation parameters	r value (months)	r value (stations)
Temperature	-0.130	0.243
pH	-0.164	0.354
DO	0.254	0.136
Transparency	0.446	-0.712

Table 5: Pearson's correlation coefficient between fish species abundance and water quality parameters of Sandha River.

opportunity and food security. This was set off as a vital factor of excess fishing pressure by using different types of prohibited and restricted fishing gears in the river without maintaining government rules related to aquatic species. In addition, fishing activities during fishing ban period reduce spawned fish of Sandha River. Surplus catching of fish reduces the fish stock which causes the fish as threatened gradually. Non-point pollution and point source pollution especially municipal discharge, brick build industry along the coast of the river, agricultural runoff carrying harmful chemicals, oil discharge from water mechanical vehicles could alter the food webs of the river and normal life process of fish, destroying breeding, feeding and nursery grounds of precious fish species. River bank erosion is a common scenario faced by Sandha River fishermen. Due to river erosion, fisher's community lost their property as most of the fishermen live along the coast of the river. This is act as a promoting factor to harvest a huge amount of fish. Furthermore, environmental changes are the principal aspects which cause water level rising, warming the water and destroying cold water preferring fish species. All of the factors in combination reduce the fish species to a great extent from time to time. The findings were supported by [4,36-39].

Fish diversity indices

Fish species diversity indices were calculated for both months and stations which were applied to understand as indicators of environmental and pollution stress faced by fish species. Shannon-Wiener index (H) of diversity value (ranged from 0-5) is commonly used to categorize the water quality status of any ecosystems. When H value of fish diversity is 5-4 indicating very good quality, 4-3 good quality, 3-2 moderate quality, 2-1 poor quality and very poor quality <1 [40]. In addition, H value >3 expresses clear water with a good diversity of aquatic species and value less than 3 specify polluted water [41]. In the present study, the calculated H value was found above 3 (Table 4) which suggested that the water conditions of Sandha River still transparent with a good quality ecosystem. In general, the result clear indicated that Shannon-Wiener index (H) of diversity has a positive correlation with Evenness value, Simpson's index of diversity (1-D) and Margalef richness value of fish species diversity. The value of Evenness (E) usually ranged from 0 and 1 [4,42] where the closer to 1 the more even the populations of fish that form the community. In the present findings, the Evenness value found almost closer to 1 (Table 4) which indicated the very few or no dominating species in the Sandha River. Similar result ranged for Evenness index also observed from the findings of other studies [4,32]. Simpson's dominance index (D) and Simpson's index of diversity (1-D) are negatively correlated which value ranged from 0 to 1 (0, represents no dominance/complete diversity and 1, represents complete dominance/no diversity) [4,43]. In the Sandha River, after polling all individuals the calculated value of D was shown that the river had very few dominated fish species thus with higher diversified fish community structure (Table 4). Other indices like Margalef richness has a positive correlation with food webs of an ecosystem i.e., higher richness value indicating longer food chain [41]. Margalef in the study area was ranged from 4.6 to 8.471 which indicated the river had healthy to high-quality food chains. In general, diversity

Reasons behind decline of fisheries resources of Sandha River	Rank given by respondents								Total no. of respondents	Total score	Mean score	Rank
	1 st	2 nd	3 rd	4 th	5 th	6 th	7 th	8 th				
Over exploitation	87	69	65	56	63	53	59	48	500	26297	52.594	I
Use of destructive fishing gears	82	65	55	50	65	58	63	62	500	25424	50.848	II
Inadequate credit facilities	60	55	62	60	57	67	0	139	500	23457	46.914	III
Industrial pollution	66	54	55	48	51	54	53	119	500	23308	46.616	IV
River bank erosion	47	69	43	75	32	23	37	174	500	22005	44.010	V
Climate change	49	48	53	52	53	49	50	146	500	21989	43.978	VI
Fishing during ban period	73	29	36	62	0	0	98	202	500	20325	40.650	VII
Natural disaster	27	43	31	37	48	78	83	153	500	19939	39.878	VIII

Table 6: Perception of Sandha River fisheries regarding the reasons behind decline of fish species abundance.

indices value varied depending upon the number of species as well as a number of individuals in each fish species [11,32,41].

Spatial and temporal relation of fish diversity

Similarity level between or among the species mainly used to know how much one species is similar to another one. For similarity test, cluster analysis techniques are commonly used to study the community association on the basis of distributional co-occurrence [44]. In this experiment, Bray-Curtis similarity matrix was used based on cluster analysis to find out the similarity level among the individual fish species. In the feedback, three major groups were formed of which the first group observed as dominating characters where the second group had less dominating behavior and some of them season dependent and third group recognized as mostly season dependent and some of them were alien species. The findings of the present study were more or less similar to other studies [45-48].

In general, based on statistical analysis and result of fish species diversity indices, it would conclude that Sandha River still acts as a good environment for aquatic species. But day by day, the river is experienced with more sophisticated fishing technologies which responsible for large-scale fishery caught and environmental variables especially water Temperature are at rising level which changed food webs of the river and adversely affect the life process of fish. Thus in future, in a gathering of all adverse factors, the river will turn into species if the proper initiative does not set up to manage the aquatic resources of Sandha River.

Conclusion

Water quality data, fish species abundance, the value of fish diversity indices and correlation among and between hydrological parameters and fish species abundance would provide a conducive profile of Sandha River. In conclusion, the river is now facing excess fishing pressure which modifies the riverbed, destroying fish habitat and disturbing bottom preferring aquatic species. Information's about fish species assemblages and changes their number and compositions with the response of time and environmental variables (temperature, transparency, pH and DO) could act a fundamental component to guide the aquatic resources from near extinction and sustainable use of these resources. However, an initiative like Community-based fisheries management is the most appropriate one to be adopted to manage the water resources. Other initiatives like provide alternative employment opportunities, use legal fishing gears, financial support during fish banning seasons etc. could be helpful to sustain the Sandha River fisheries resources.

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