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Research Article
Community-based Resource Management Approaches Adopted in the Three Tributaries of River Surma, North-East Bangladesh

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Abstract

Background and Objective: Freshwater fishery resources are declining in Bangladesh due to over exploitation, anthropogenic causes and inadequate management. To improve sustainability of these resources, a community-based resource management initiative was implemented by Bangladesh's Local Government and Engineering Department. Working in partnership with community-based resource management the communities implemented a variety of management interventions. The purpose of this study is to assess the impact of community-based management on fisheries production and biodiversity. **Materials and Methods:** An investigation was performed from 2008-2012 to assess the impacts of community-based management on fisheries production and biodiversity of the three tributaries-Sudam Khali river, Ghotghatia river and Abua Prokashito Nainda river-in North-East Bangladesh. A robust catch assessment was observed for 8 days per month, per site. Randomly selected samples of catch by species by gear are recorded for each gear type observed to be operated on the same day. **Results:** The study revealed that from 2008-2012 annual fisheries catch increased by 44 and 142% in Sudam Khali and Ghotghatia river tributaries respectively, but decreased by 26% in the Abua Prokashito Nainda river tributary, as compared to the baseline composition. Species diversity was higher in 2012 than in 2008 and increased by 75, 81 and 71% in Sudam Khali river, Ghotghatia river and Abua Prokashito Nainda river tributaries, respectively. **Conclusion:** The study has provided evidence that community-based resource management approaches aimed at river tributaries improve fisheries production and diversity, while also reducing the threat of climate change impacts on the poor people.

Key words: Community based resource management, fish sanctuary, communities, species abundance, sustainability, river tributaries

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

The vast areas of inland open water in the formed as: Rivers, the deepest part of the floodplain (beel), deeply flooded saucer shaped depression (haor), canal, floodplain and reservoir measures about 4.7 million hectors and is one of the vital fisheries in Bangladesh[1]. Small-scale fisheries resources are a lifeline to the 17.1 million people in subsistence fisher communities in Bangladesh[2]. Fisheries sector contributed 4.4% to national GDP, 23.4% to the agricultural GDP and 2.0% to foreign exchange earnings by exporting fish and fish products in 2012-13[2]. Fish provides 60% of national animal protein consumption[1]. There are 260 indigenous finfish species living in and around the freshwater habitats of Bangladesh[3,4]. Catch from traditional and subsistence fisheries in the freshwater sector consist of over 200 species annually. Traditional fishing is carried out using a variety of equipment in varied habitats along the river, tributaries, oxbow-lake, haor, beel, floodplain, where fish biodiversity tends to be concentrated. Rural families in Bangladesh consume up to 73 species of small indigenous fish during the course of a year harvested from their own catches[5]. Fisheries management is all about people, especially in the floodplains of Bangladesh where fisheries provide income and food to a large segment of the poorest of the poor-focusing fisheries management on communities is crucial[6]. The National Fish Policy of 1998 explicitly recognizes the use of sanctuaries as a mode of fish conservation[7]. The fish species inhabiting the rivers of South and South East Asia can be divided into numerous guilds depending on their behavior and habitat selection[8]. The local diversity of fish species can be increased through established fish sanctuaries, aquatic habitat restoration and introduction of native fish species from other areas within the region. However, some native species are always lost with the introduction of alien species from others regions. The evidence also indicates that across a range of taxonomic groups, the size and ranges of populations of many fish species are decreasing and under threat from a range of pressures, from over-fishing to pollution. The review of the status of the vertebrate fauna revealed that 54 inland fish have come under different categories of threat in Bangladesh[9].

The significant decline in fish production over the last 20 years can also be attributed to the current access right system and absence of proper conservation measures, which have largely contributed to overfishing, deforestation of swamp forestry and restricted migration of fish during spawning season[10].

Fisheries in Bangladesh use an extensive range of fishing gears and their specifications vary according to target species, types of water body, labor intensity, fabrication, cost, availability of materials and profit[11].

The aim of the present study is to generate impact information on community based initiatives in northeast Bangladesh. Specific objective of this study is to assess the impact of community-based management on fisheries production and biodiversity through a robust catch assessment The role of indigenous fish species in supporting the livelihoods of rural communities is very important and small-scale fishing of a wide range of species provides an important source of macro and micronutrients including protein, vitamins and minerals.

Sunamganj, the study area is one of the most underdeveloped districts in Bangladesh. The district consists of 0.35 million households of which 51% have no land and the main income earners are wage laborers and 35% are marginal farmers owing less than 2.5 acres of land[10]. The study area is highly prone to flooding, particularly to flash rushes down the Meghalaya hill tracts during April. The study areas in the Surma river tributaries include Sudam Khali river, Ghotghotia river and Abua Prokashito Nainda river.

MATERIALS AND METHODS

Study area, management status and methodology used: The study sites are located in the Bishwambarpur Upazila (sub-district) of Sunamganj district of North-East Bangladesh and river tributaries include: Sudam Khali river, Ghotghotia river and Abua Prokashito Nainda river. These three tributaries are the intensely flooded areas of the northeast part of Bangladesh and directly connected with the major river Surma (Fig. 1). All adjacent water bodies are connected during the monsoon. The study was designed to access the adaptive fishery management arrangement that might improve sustainability of fishery resources. The beel users groups have adopted simple conservation-based measures implemented through management committees under the CBRMP (Table 1). The management committees in the three tributaries of the river Surma develop their own resource management plans and regulations. The number of management committee's members were 7, 5 and 9 in the in the Sudam Khali river, Ghotghatia river and Abua Prokashito Nainda river respectively.

Data collection: According to the catch assessment plan, fish catch data has been collected from Sudam Khali river, Ghotghatia river and Abua Prokashito Nainda river. Species-wise catch and efforts by gear type were monitored through the regular sampling to estimate the annual total

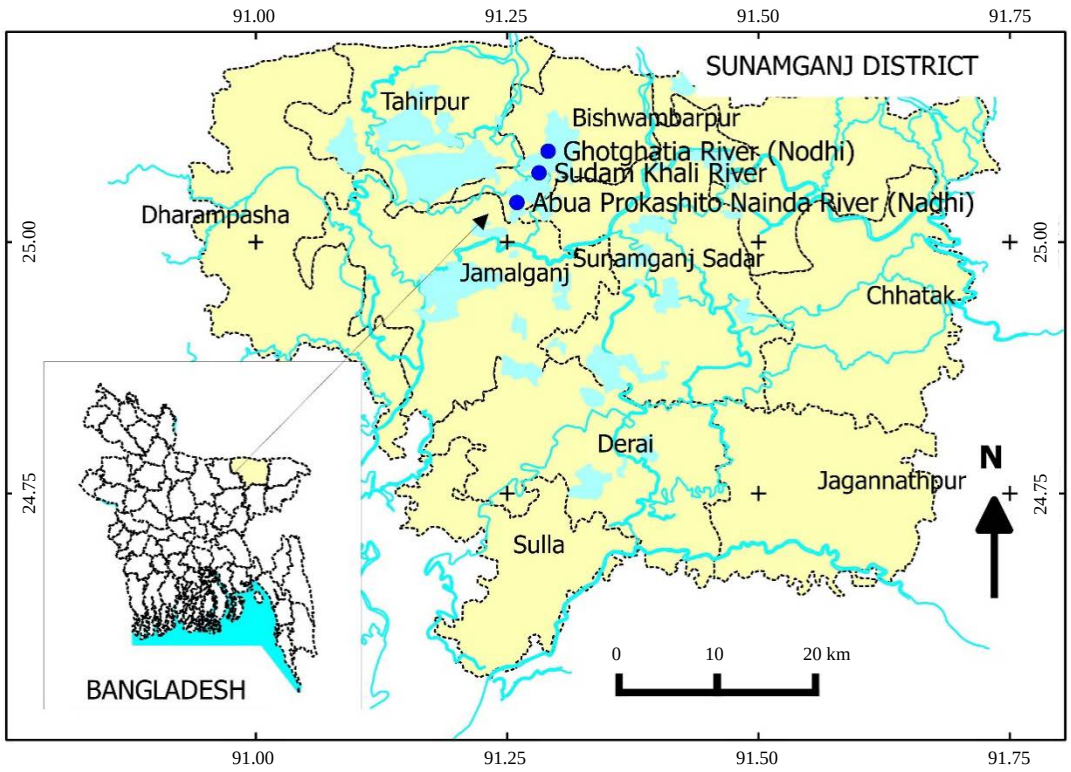

Fig. 1: Map of the study area

catch and fishing effort. During the sampling day, a census (complete count) of gears by gear type in operation was undertaken. Randomly selected samples of catch by species and effort (gear hours) by gear are recorded for each gear type observed to be operated on the same day. The daily catch of every individual fisherman and his gear was monitored at each study site. The numbers and weight of all fish species in the catch were recorded. Fishing activity was observed for eight days per month, per site, continuously from January, 2008 to December, 2012 following the minimum detectable difference method with a 95% confidence limit[12]. The gear survey involved a regular spot survey for a sample of gears in operation and the total catch from each gear type was recorded.

Data analysis: Catch statistics were recorded for each gear type. The average number of gear units per day was used to estimate total gear-wise fishing effort for that month, as well as for the whole year. Mean gear-wise catch rate was used to estimate total catch for that month, as well as for the whole year. Gear-wise, overall species distributions were calculated from annual catch statistics data. Year-wise, as well as overall species distributions, were calculated from catch statistics. Fisheries production was measured by monitoring a sample of individual catch from defined areas, which were used to estimate the total catch in each wetland site.

Annual multispecies Catch Per Unit Area (CPUA) was employed as a measure of production at each site:

$$CPUA_{s,y} = \frac{\sum_{m=Jan}^{m=Dec}\sum_{g=1}^{n} Catch_{s,y,m,g}}{MaxArea_s}$$

where, $Catch_{s,y,m,g}$ is the estimated multispecies catch by gear type e.g., during month m and year y at site s measured in kg ha^{-1} $year^{-1}$.

Fish abundance indicated by multispecies catch per person per day expressed as kg day^{-1} was employed as a measure of resource sustainability:

$$CPD_{s,y} = \frac{Catch_{s,y}}{Annual\ Fishing\ Days_{s,y}}$$

where, Annual Fishing $Days_{s,y}$ is the estimated total number of days spent fishing by the fishers at site s during y, irrespective of the gear type employed.

Table 1: Management committee and interventions under CBRMP

Name of study sites	Management status: Member user group	Member in management committee	Closed season and area	Gear restriction	Habitat restoration	Fish sanctuary
Sudam Khali river	18 (Male = 12, female = 6)	7 (Male = 5, female = 2)	Closed season during May-July each year and fishing closed around fish sanctuary	Small mesh seine nets and monofilament gill nets restricted and all destructive fishing gears and activities banned	Excavation of 4048 m^3 and 1420 swamp trees are planted	An area of 2000 m^2 fish sanctuary established in 2008 and maintained by community
Ghotghatia river (Nodhi)	21 (Male = 15, female = 6)	5 (Male = 3, female = 2)			Excavation of 9078 m^3 and 1865 swamp trees are planted	An area of 2000 m^2 fish sanctuary established in 2008 and maintained by community
Abua Prokashito Nainda river (Nodhi)	80 (Male = 48, female = 32)	9 (Male = 6, female = 3)			About 7640 swamp trees are planted	An area of 3000 m^2 fish sanctuary established in 2008 and maintained by community

The Shannon-Wiener index (H')[13] is one of several indices used to measure biodiversity and was employed to measure species-wise catch from 2008 and 2012. The index is defined as:

$$H = -\sum_{i=1}^{s} p_i \ln p_i$$

where, s is the number of species and p_i is the proportion of individuals from the ith species in the sample.

Truncated log-normal model was used to measure the species abundance and compares results between 2008 (base-year) and 2012 (impact-year). The results of observed $\log_{10}$ mean, observed species, chi-squared test, degree of freedom and p-value were estimated to describe goodness of fit. The model is defined as:

$$S(R) = S_0 e^{(-a^2R^2)}$$

where, S(R) is the number of species in the Rth abundance class, S_0 the number of species in the modal abundance class and $a = (2\sigma^2)^{1/2}$, which is the inverse width of distribution.

RESULTS

Annual catch trends: The annual catch trends for Sudam Khali river tended to increase with catches of 415, 625, 542, 439 and 596 kg ha^{-1} in the years 2008-2012, respectively. Annual catch for Ghotghatia river were 174 and 234 kg ha^{-1} during 2008-2009, which then increased sharply in 2010-1016 kg ha^{-1}. This was followed by a similar catch 983 kg ha^{-1} in 2011, however, a sharp decline was observed in 2012 with an annual catch of 421 kg ha^{-1}. The annual catch trends for Abua Prokashito Nainda river tended to decrease slowly with catches of 579, 480, 532, 469 and 430 kg ha^{-1} in the years 2008-2012, respectively. Considerable variations in fish production (kg ha^{-1}) were observed from 2008-2012 with mean catches of 523±93, 566±406 and 498±58 kg ha^{-1} (±SD) for Sudam Khali river, Ghotghatia river and Abua Prokashito Nainda river tributaries, respectively. The annual catch rate (kg ha^{-1}) for three river tributaries from 2008-2012 are shown in Fig. 2.

Overall gear intensity: In Sudam Khali river, the most common gear types were traps (36%) and gill nets (32%) followed by small lift nets (10%), hooks and lines (9%), push net (8%), long line (3%) and cast nets (2%). In Ghotghatia river,

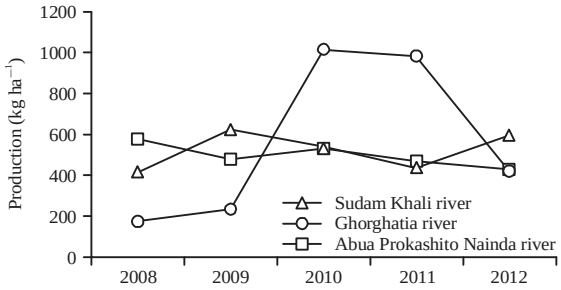

Fig. 2: Estimated annual production (kg ha^{-1}) for Sudam Khali, Ghotghatia and Abua Prokashito Nainda rivers

Table 2: Composition (%) of main species caught by all gears in the Sudam Khali river

Name of species	2008	2009	2010	2011	2012	Overall
Puntius sophore	19.93	15.32	24.08	29.48	10.80	19.92
Channa punctatus	15.72	12.98	26.87	27.16	9.89	18.52
Mastacembelus pancalus	7.74	6.93	9.78	4.80	21.01	10.05
Puntius ticto	9.03	16.32	0.71	13.09	1.16	6.13
Macrobrachium villosimanus	10.71	8.77	0.01	0.00	10.76	6.05
Heteropneustes fossilis	4.84	3.81	5.02	9.03	1.58	4.91
Nandus nandus	3.63	2.62	4.32	4.91	5.56	4.21
Colisa lalius	6.90	5.94	0.64	1.85	1.78	3.42
Chanda ranga	2.01	7.02	0.35	1.59	3.70	2.94
Glossogobius giuris	0.63	0.29	1.72	0.94	4.67	1.65

Table 3: Composition (%) of main species caught by all gears in the Ghotghatia river

Name of species	2008	2009	2010	2011	2012	Overall
Macrobrachium villosimanus	29.13	18.32	8.15	12.42	3.52	14.31
Chanda ranga	6.38	6.80	7.53	19.42	21.40	12.31
Puntius sophore	9.64	11.22	10.47	8.62	18.31	11.65
Puntius ticto	8.56	13.10	1.76	6.92	2.53	6.57
Chanda nama	3.14	1.26	4.48	4.57	8.06	4.30
Xenentodon cancila	4.87	4.63	3.88	1.60	3.55	3.71
Glossogobius giuris	5.00	5.73	2.89	2.63	1.40	3.53
Channa punctatus	4.56	5.72	1.50	1.63	3.85	3.45
Colisa lalius	5.10	3.10	0.49	3.24	1.53	2.69
Nandus nandus	4.01	4.22	2.12	1.65	1.40	2.68

Table 4: Composition (%) of main species caught by all gears in the Abua Prokashito Nainda river

Name of species	2008	2009	2010	2011	2012	Overall
Labeo calbasu	51.40	35.22	25.49	29.51	21.80	32.69
Corica soborna	4.32	13.96	14.50	9.67	17.29	11.95
Labeo rohita	11.39	6.49	10.38	1.00	1.45	6.14
Chanda lala	0.64	0.30	6.16	15.18	7.99	6.05
Gudusias chapra	1.04	5.31	5.79	4.81	10.85	5.56
Wallago attu	7.89	1.04	13.36	0.00	2.58	4.97
Labeo gonius	7.09	6.12	2.14	2.21	1.20	3.75
Cirrhinus mrigala	3.44	6.48	1.16	3.21	1.30	3.12
Mystus aor	2.03	7.50	1.08	0.26	0.01	2.17
Mastacembelus armatus	1.93	0.03	0.77	5.10	1.51	1.87

the dominant category of gear was seine nets (87%) followed by push nets (6%), gill nets (4%) and traps (2%) and other types of gear were small lift nets, long lines, hooks and lines and cast nets. In Abua Prokashito Nainda river, the most common gear types were cast nets (44%), seine nets (20%), large lift nets (15%) and gill nets (13%) and other types of gear included hook and lines, traps, long lines, spears and push nets.

Catch composition

Main species, changes in catch composition: In the Sudam Khali river, the largest contributor to fish catch by species was *Puntius sophore* (19.92%) followed by *Channa punctata* (18.52%), *Macrognathus pancalus* (10.05%), *Puntius ticto* (6.13%), *Macrobrachium villosimanus* (6.05%), *Heteropneustes fossilis* (4.91%) and *Nandus nandus* (4.21%). A total of 32, 50, 55, 53 and 56 species of fish and prawn were recorded from Sudam Khali river during 2008-2012, respectively. The percentage composition of catches by species from 2008-2012 is presented in Table 2.

In the Ghotghatia river the largest contributor to fish catch by species was *Macrobrachium villosimanus* (14.31%) followed by *Chanda ranga* (12.31%), *Puntius sophore* (11.65%), *Puntius ticto* (6.57%) and *Chanda nama* (4.30%). A total of 32, 38, 54, 56 and 58 species of fish and prawn were documented from Ghotghatia river from 2008-2012, respectively. The percentage composition of catches by species from 2008-2012 is presented in Table 3.

In the Abua Prokashito Nainda river, a total of 48, 68, 71, 74 and 82 species of fish and prawn were recorded from 2008-2012 respectively. Analysis of overall catch revealed that the largest contributor to fish catch by species was *Labeo calbasu* (32.69%) followed by *Corica soborna* (11.95%), *Labeo rohita* (6.14%), *Chanda lala* (6.05%), *Gudusia chapra* (5.56%) and *Wallago attu* (4.97%). The percentage composition of catches by species from 2008-2012 is presented in Table 4.

The study indicates that six species: *Labeo calbasu*, *Corica soborna*, *Labeo rohita*, *Chanda lala*, *Gudusia chapra*, *Wallago attu*, *Labeo gonius*, *Cirrhinus mrigala*, *Mystua aor* and *Mastacembelus armatus* contributed 78.27% of the overall production in the Abua Prokashito Nainda river. In Sudam Khali river there are six species: *Puntius sophore*, *Channa punctata*, *Macrognathus pancalus*, *Macrobrachium villosimanus*, *Nandus nandus* and *Heteropneustes fossilis* contributed 65.58% of the overall catch. In Ghotghatia river there are six species: *Macrobrachium villosimanus*, *Chanda ranga*, *Puntius sophore*, *Puntius ticto*, *Chanda nama* and *Xenentodon cancila* contributed 52.85% of the overall catch.

The study shows that the variation of species diversity of different monitored sites is likely attributable to varied habitats and varieties of fish species depending on the particular ecological niche of wetland types in the tributaries of the river Surma. The study also indicates that abundance and distribution of most species is shaped by their ecological requirements and the topography.

The study indicates that six species: *Labeo calbasu*, *Corica soborna*, *Labeo rohita*, *Wallago attu*, *Chanda lala* and *Gudusia chapra* contributed 69.11% of the overall production in Sudam Khali river. In Ghotghatia river six species; *Chanda ranga*, *Macrobrachium lamarrei*, *Puntius sophore*, *Chanda lala*, *Gudusia chapra* and *Chanda nama* contributed 51.76% of the overall catch. In Abua Prokashito Nainda river six species: *Puntius sophore*, *Channa punctata*, *Macrognathus pancalus*, *Macrobrachium villosimanus*, *Nandus nandus* and *Heteropneustes fossilis* contributed 62.95% of the overall catch.

Fish biodiversity based on catch monitoring data: A comparison of fish biodiversity (number of species) was made using observations in three tributaries of river Surma. Increases in fish biodiversity over time were observed at all three tributaries of the river Surma (Fig. 3). The results from this study clearly show that sustaining fish populations have been established in all three tributaries and there has been a move away from the traditional top-down approach to the promotion of community-based management in Bangladesh.

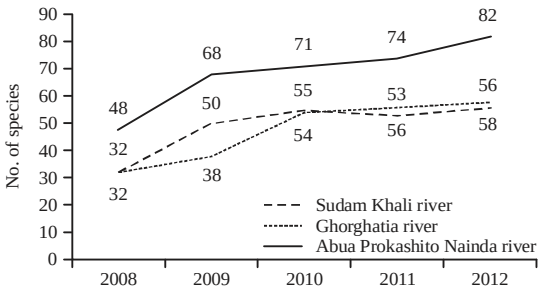

Fig. 3: Trends in fish biodiversity observed over time in three tributaries of river Surma

Estimated trends of catch (kilogram per person per day): Annual variations of average catches (kg) per gear per day, number of person days and catch per person per day for different gears in the three tributaries of the river Surma from 2008-2012 are presented in Table 5. Generally, in the Ghotghatia river an average catch rate (kg) per gear per day and fish catch per person per day was higher compared to the Sudam Khali river and Abua Prokashito Nainda river, possibly due to the higher fish abundance and higher number of professional fishers. However, annual fishing effort (number of person days) decreased in Sudam Khali river and Abua Prokashito Nainda river. In Ghotghatia river, fisher density increased in 2010 and 2011, however, fisher density dramatically decreased in 2012. This assessment suggests exploitation in the three tributaries of the river Surma, decreased in recent years.

A comparison of CPUA to fisher density showed that in the Sudam Khali river, fisher density decreased over time and annual CPUA increased. In Ghotghatia river, fisher density increased in 2010 and 2011 when compared to 2008 and 2009 and was accompanied by an increase in annual CPUA. However, in 2012 this changed rapidly when the fishing moved to over exploitation resulting in decreased CPUA in 2012 with decreased fisher density. In Abua Prokashito Nainda river, fisher density and annual CPUA showed a decreasing trend. This changed when the fishing moved to over exploitation during 2008, 2009 and 2010. An annual plot of CPUA versus fishery density in the Sudam Khali river, Ghotghatia river and Abua Prokashito Nainda river from 2008-2012 is presented in Fig. 4.

Table 5: Trend in average catches (kg) per gear per day and catch per person per day

Name of rivers tributaries	Study years	Average catches per gear per day (kg)	No. of person days	Catch per person per day (kg)
Sudam Khali	2008	0.78	640	0.40
	2009	0.38	591	0.37
	2010	1.43	526	1.43
	2011	0.66	570	0.64
	2012	2.71	417	2.71
Ghotghatia	2008	2.20	608	1.30
	2009	2.29	436	1.19
	2010	2.76	1370	0.94
	2011	6.98	1004	2.06
	2012	4.71	588	1.35
Abua Prokashito Nainda	2008	1.16	4463	0.71
	2009	3.63	3475	1.51
	2010	4.01	4554	1.47
	2011	2.06	2727	0.93
	2012	2.60	2733	1.14

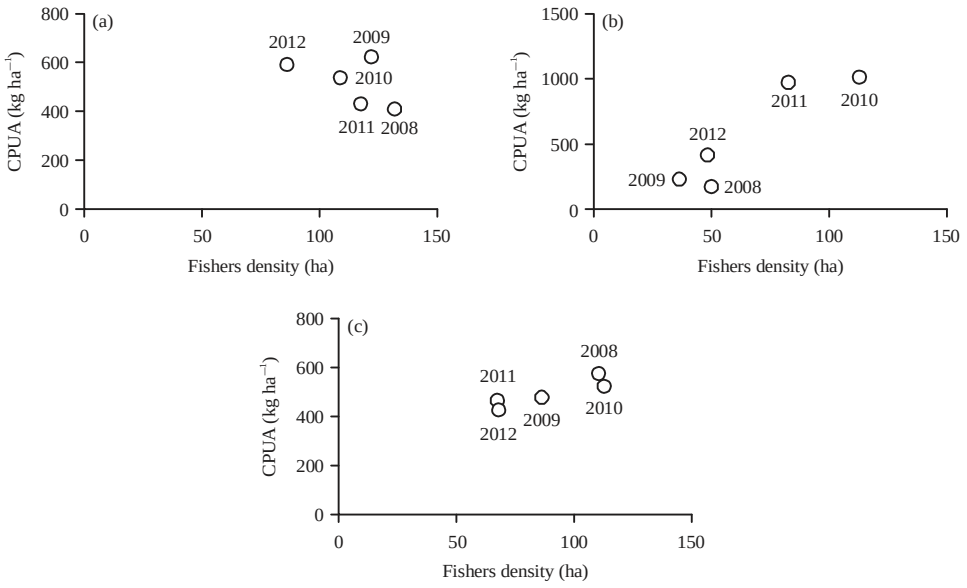

Fig. 4(a-c): Annual plot of CPUA versus fisher density in the (a) Sudam Khali river, (b) Ghotghatia river and (c) Abua Prokashito Nainda river from 2008-2012

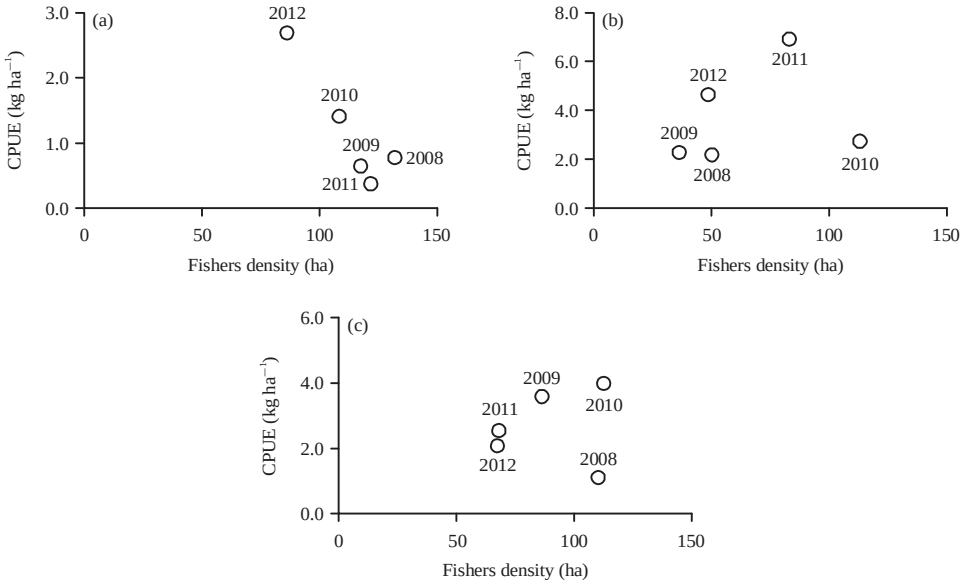

Fig. 5(a-c): Annual plot of CPUE versus fisher density in the (a) Sudam Khali river, (b) Ghotghatia river and (c) Abua Prokashito Nainda river from 2008-2012

Annual CPUE versus fisher density was plotted for Sudam Khali river, Ghotghatia river and Abua Prokashito Nainda river (Fig. 5). In Sudam Khali river, the CPUE increased in 2012 with a corresponding fisher density 86 persons per hectare. However, fisher densities were higher from 2008-2011 with a decrease in CPUE. In Ghotghatia river, the CPUE decreased in 2008 and 2009 with decreased fisher density. However, the CPUE increased in 2011 and 2012 with a corresponding fisher density of 113 and 83 persons per ha, respectively. In Abua Prokashito Nainda river, fisher density increased in 2008 and CPUE was decreased. However, CPUE increased in 2009 and 2010 with fisher density of 86 and 113 persons per hectare, respectively. However, CPUE decreased in 2012 while fisher density also decreased.

The Shannon-Wiener diversity index (H') in the Sudam Khali river was estimated at 1.149, 2.357, 2.849, 2.71 and 2.415 for years 2008-2012, respectively. The diversity indexes (H') in the Ghotghatia river were estimated at 1.388, 2.36, 2.161, 2.345 and 2.002 in the years 2008-2012, respectively. The diversity indexes (H') in the Abua Prokashito Nainda river were estimated at 0.316, 1.001, 1.208, 1.81 and 1.78 in the years 2008-2012, respectively. Mean diversity index (H') was found to be 2.296, 2.051 and 1.223 in the Sudam Khali river, Ghotghatia river and Abua Prokashito Nainda river, respectively. Annual variations of fish biodiversity index (H') in the three tributaries of the river Surma from 2008-2012 are presented in Fig. 6.

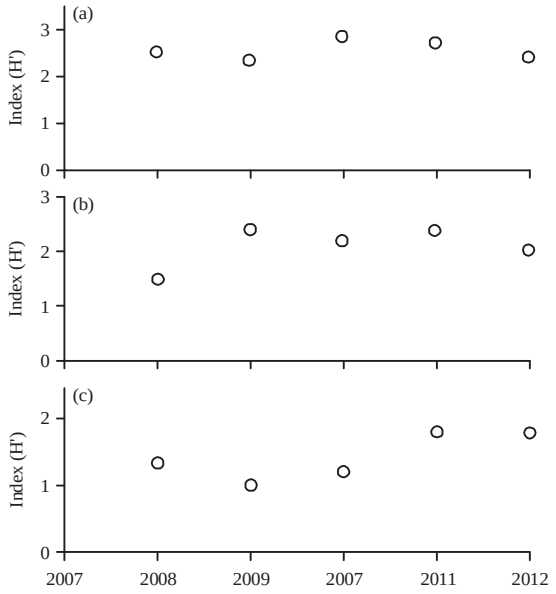

Fig. 6(a-c): Estimates of biodiversity index (H') plotted as a function of time over 5 years, (a) Sudan Khali river, (b) Ghotghatia river and (c) Abua Prokashito river

Truncated log normal model: Comparison of species abundance between 2008 and 2012 based on truncated log normal model shows that species abundance is relatively higher in three tributaries of river Surma in 2012 than in 2008 (Fig. 7). Goodness of fit truncated log normal test is presented in Table 6. Truncated log normal model provides an extremely useful measurement of abundance when a complete abundance class of species in the community is obtained.

Responsibility for management of the three tributaries has been transferred to communities and they effectively implemented a variety of management interventions to increase fish production, biodiversity and protect principal species. A number of studies published in recent years have

Table 6: Goodness of fit for fish/shrimp species abundance distribution models

Name of site	Goodness of fit values	2008	2012
Sudam Khali river	Observed $\log_{10}$ mean	3.013	2.563
	Observed species	32	56
	Chi-square	4.691	16.353
	Degree of freedom	7	13
	p-value	0.6975	0.2305
Ghotghatia river	Observed $\log_{10}$ mean	3.299	2.613
	Observed species	32	58
	Chi-square	8.383	10.661
	Degree of freedom	7	10
	p-value	0.2996	0.3844
Abua Prokasito Nainda river	Observed $\log_{10}$ mean	2.721	2.455
	Observed species	70	82
	Chi-square	21.193	22.631
	Degree of freedom	11	16
	p-value	0.0314	0.1239

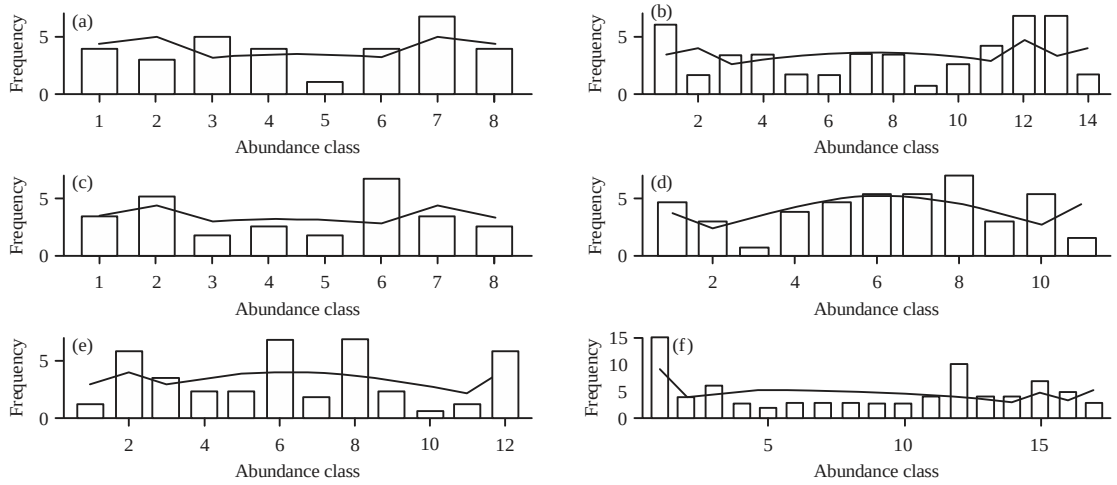

Fig. 7(a-f): Truncated log normal model for three rivers tributaries of Surma river in 2008 and 2012, (a, b) Sudan Khali river, (c, d) Ghotghatia river and (e, f) Abua Prokashito river

identified key conditions that contribute to the successful management and sustainability of fisheries resources through community-based resource management.

DISCUSSION

The study showed increasing trends of production, abundance and biodiversity which allows us to derive assumptions on the overall sustainability of fishery in the three tributaries of the river Surma. Mustafa[11] reported that production increased over the duration, due to the community management approach, which encourages participation of fishers, beneficiaries and communities in managing the renewable fishery resources. Katon *et al.*[14] reveals that as a result of community-based resource management fish species richness improved from 126 species belonging to 19 families in 1988-138 species belonging to 28 families in 1998. Azher *et al.*[15] reported that higher fish production associated with higher species richness. Mustafa and Brooks[16] stated that income derived from fishing activities is influenced by several factors, such as catch rates of different species, ownership of gear, family participation in the work process, number of active fishing days and fish price.

The analysis of effort data indicated that maximum fishing pressure has been reached for Ghotghatia river and the fisher's communities should reduce fishing intensity and conduct responsible organized catches during the post-monsoon. Halls and Mustafa[17] reported that the fishing capacity was different in some water bodies and the closed season or the sanctuaries were similarly effective so, future study is needed to make a harmonized strategy for scientific and sustainable fisheries production. In the Abua Prokashito Nainda river, the study noted the highest abundance of orange fin labeo (*Labeo calbasu*) in this river. According to IUCN[9] orange fin labeo is an endangered species. Study reveals this river is also a habitat for six critically endangered fish species (*Bagarius bagarius*, *Clupisoma garua*, *Eutropiichthys vacha*, *Labeo pangusia*, *Rita rita* and *Tor tor*) according to IUCN[9], so adaptive community-based attempts should be continued for their conservation.

Halls and Mustafa[17] reported that the mean CPUA slope coefficient, representing annual rates of change in fish production were found to vary significantly ($p<0.05$) with habitat type. Sayeed *et al.*[18] described that the production per haul in katha (reserve harvest) fishing in different catchments in the Chalan beel, Bangladesh, year and months had significant differences due to seasonal variation, water depth and biological condition of fishes. Out of Bangladesh's 260 freshwater species[4], more than 40% are now threatened with national extinction[9] and may soon follow the path of other wetland fauna and flora.

To address the question: "Does community based fisheries management bring sustainable benefits to fishers communities?" Mustafa and Halls[19] found that trends in fish abundance, indicated by annual average daily catch rates by fishers were upward at 72% of the 64 monitored sites with an average increase of 17% year^{-1}. Donda[20] reported that in Malawi, resource user participation in fisheries management or co-management have in some cases promoted sustainable utilization of resources and fishing communities have claimed tangible benefits in their fishing activities. Mustafa[11] reported that biodiversity index (H') increased in the river Titas (G-G part) from 1997-2002 due to the community management approach. Besides, disconnecting the river channel from its floodplain has obvious negative impacts on biodiversity[21,22].

CONCLUSION

The study has provided compelling evidence that community-based resource management approaches aimed at the poor and vulnerable are effective in the study sites, resulting in improvements to key management performance indicators including yield, fish abundance and fishing effort. The approach should be extended beyond pilot sites and be adopted as a key strategy for development of inland water fisheries resources in Bangladesh.

SIGNIFICANCE STATEMENT

Responsibility for management of the three tributaries has been transferred to adjoining fishing communities. A variety of management interventions to increase fish production, biodiversity and protect principal species was effectively implemented at community level. The study has produced compelling evidence that community-based resource management does improve fisheries management performance and enhances sustainable use of inland fisheries resources, which in turn improves livelihoods and food security of the poor.

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