Impact of Co-management on Fish Biodiversity in Dhali-Baila Beel, Kangsha-Malijhee, Sherpur District

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Abstract

Community-based co-management is an effective tool for the sustainable management of open water bodies. Through this approach, the management of fisheries resources in open water bodies is led by local communities, with the support of local administrators. This paper discusses the present status of fish biodiversity, as well as the impacts of co-management on fish biodiversity at Dhali-Baila Beel (a MACH site) and Shaitandaha Beel (a non-MACH site) in Sherpur District of Bangladesh. Data were collected through field visits, observations, consultations with community members and key informants, focus group discussions, and one-on-one interviews using questionnaires. Forty-four fish species were recorded at the MACH site and 15 fish species were found at the non-MACH site. The average fish production was 313 kilograms per hectare at the MACH site, and 196 kilograms per hectare at the non-MACH site. Eleven fish species were found to be endangered at the non-MACH site, compared to only one species at the MACH site. Furthermore, eight fish species were revived at the MACH site and no fish species was revived at the non-MACH site. Destructive fishing gear was used less frequently for fishing at the MACH site than at the non-MACH site. In addition, 95 percent of respondents are aware of the establishment of the fish sanctuary; 88 percent acknowledge a need for better enforcement of the Protection and Conservation of Fish Act; 89 percent recognize the accomplishments of the fingerling stocking program; and 100 percent feel that the implementation of alternative income-generating activities has had a positive impact on biodiversity conservation overall. The results of this research indicate that fish biodiversity at the MACH site is richer than at the non-MACH site, and that the impacts of co-management on fish biodiversity conservation in this important wetland ecosystem have been positive overall.

Introduction

Bangladesh is a country of numerous rivers, *haors* (floodplain areas that are inundated during the monsoon season), *baors* (oxbow lakes, where water remains throughout the year), *beels* (deeper depressions where water remains throughout the

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year) and canals. The country also has rich fishery resources. About 4.64 million hectares, or 33 percent of the total area of Bangladesh, are occupied by inland fisheries resources. The fisheries sector plays an important role in the economy of Bangladesh, contributing 3.74 percent of the annual gross domestic product and comprising 22.23 percent of the total agricultural sector and 2.70 percent of all export earnings. Furthermore, fish supplies 58 percent of the nation's animal protein. About 10 percent of people in Bangladesh are directly or indirectly dependent on the fisheries sector for their livelihoods (DoF 2011). But fish production is gradually declining in Bangladesh due to a number of factors, including natural degradation through siltation and the loss of natural breeding grounds, as well as human interventions like catching young and undersized fish, unregulated use of insecticides and pesticides, and construction of bridges, embankments, dams, and culverts that disturb the aquatic ecosystem. These activities have negatively affected the breeding, growth, and development of natural fish populations, resulting in depleted fish stocks and reduced animal protein supplies. Moreover, intensive fishing, the conversion of wetlands into agricultural lands, and the use of agrochemicals continually reduce and degrade fish habitat. According to the International Union for Conservation of Nature (IUCN), among the 260 freshwater fish species in Bangladesh, 54 are threatened, 12 are critically endangered, 28 are endangered, and 14 are vulnerable (IUCN 2000).

In the fisheries context, co-management is defined as "a management arrangement whereby government and user groups share responsibility for managing and utilizing fishery resources with the goal of achieving a balance between economic and social goals, and within a framework of preserving ecosystem and fishery resources" (Nielsen 1996). Co-management represents an important tool for realizing the sustainable management of inland fisheries resources. Since 1998, the Management of Aquatic Ecosystems through Community Husbandry (MACH) project has been working in different wetlands to conserve biodiversity through a community-based co-management approach and promoting a sustainable supply of food for the poor of Bangladesh. As a result of MACH's accomplishments, more than 50,000 people have benefited from ecosystem and biodiversity preservation, most directly through increased fish production and improved nutrition and incomes (MACH 2004). At MACH sites where fish production had previously been in decline, production increased by 39 percent from 2000 to 2003, from 144 kilograms per hectare to 200 kilograms per hectare (MACH 2004). Through a community-based fisheries co-management project in Mitamoin Upazila of Kishoreganj District, six sanctuaries were established in Dopi Beel and nine in Mohisherkandi Boranpur Beel (Azher *et al.* 2007b). Due to numerous co-management activities, fish production in these two beels was three times greater than in Borodhiga Beel and Chotadhiga Beel, where co-management activities were not implemented (Azher *et al.* 2007a).

Dhali-Baila Beel of Jhenaigati Upazila in Sherpur District is a target area of the Integrated Protected Area Co-management (IPAC) project at the Kangsha-Malijhee

site, which is rich in fish biodiversity. In this area, many people's livelihoods are fully dependent on wetland resources. The MACH project has been working there for more than 10 years. The project formed a resource management organization (RMO) and a resource users group (RUG) to promote proper management and sustainable use of wetland resources. Staff members and officials from the RMO, RUG, MACH project, local government, Department of Fisheries (DoF), and local administration are all directly involved in the co-management of Dhali-Baila Beel.

The main objective of this research is to study the present status of fish biodiversity and to examine how co-management contributes to its conservation at Dhali-Baila Beel in Jhenaigati Upazila of Sherpur District. More specifically, this study seeks to compare fish biodiversity at a MACH site (Dhali-Baila Beel) to that of a non-MACH site (Shaitandaha Beel).

Background

The study area is located in north-central Bangladesh in the Jhenaigati and Sreebordi Upazilas of Sherpur District (Figure 1). Geographically, these areas are a part of the Garo and Tura Hills and include the catchments of the upper Kangsha and Malijhee river systems. The areas were once covered with natural sal (*Shorea robusta*) forests, but these have now disappeared and only managed secondary forests remain. The wetland/floodplain of Jhenaigati Upazila comprises approximately 8,000 hectares during the wet season, diminishing to only about 900 hectares in the dry season. The floodplain contains 47 beels, of which 18 are perennial (MACH 2004). The total area is about 231 square kilometers and the population is approximately 165,000. The total area of Sreebordi Upazila is about 252 square kilometers and the population is approximately 242,320. The floodplain area of Sreebordi Upazila contains 15 beels that cover nearly 150 hectares during the wet season.

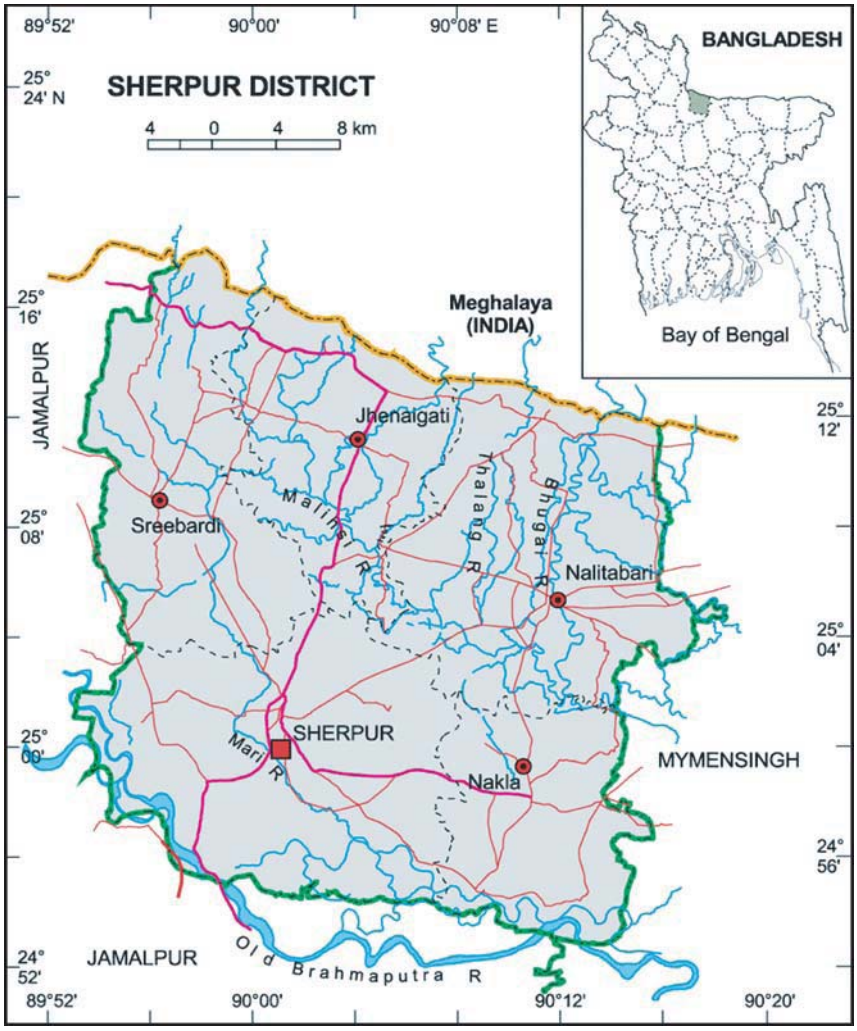

Figure 1: Map of the study area, Sherpur District, Bangladesh (Source: Banglapedia 2006)

The study site is a flash-flood prone area. Farmers suffer heavy damage to their crops from the Shomeswari, Malijhee, and Chellahkhaly rivers more than once each year as water spills over the banks, flooding large portions of the area. Employment opportunities are limited. Villagers in this area who reside near water bodies are mostly fishers and depend primarily on fishing for their livelihoods. The socio-economic condition of the people is poor.

Dhali-Baila Beel is situated in the southwest corner of Jhenaigati Upazila,

approximately 12 kilometers from the Upazila headquarters in Jhenaigati Sadar Union. Shaitandaha Beel is situated in the southeast corner of Sreebordi Upazila, approximately 10 kilometers from the Upazila headquarters in Kurikahonia Union. The surveyed villages of Sarikalinagar and Darikalinagar are adjacent to Dhali-Baila Beel and Indilpur and Garjaripa are adjacent to Shaitandaha Beel.

Methods

After discussions with DoF officials and IPAC staff members, and after reviewing MACH/IPAC reports, I chose four villages Sarikalinagar, Darikalinagar, Indilpur, and Garjaripa for my study sites. Of these villages, the two adjacent to Dhali-Baila Beel (Sarikalinagar and Darikalinagar) are MACH sites, while the two adjacent to Shaitandaha Beel (Indilpur and Garjaripa) are non-MACH sites. The main criteria for selecting these villages were: (1) they are predominantly surrounded by the beel area and are easily accessible, and (2) a high number of subsistence fishers and MACH beneficiaries reside in them.

I gathered both primary and secondary data, using four different techniques for primary data collection. These included field visits and observations, group consultations with community people and key informants, focus group discussions, and one-on-one interviews using semi-structured questionnaires. I gathered secondary data by consulting relevant published and unpublished documents, including reports from the DoF, the Department of Agricultural Extension, the Local Government and Engineering Department, and other relevant organizations. While collecting data from fishers in all villages, I defined fishers as people who use any type of fishing gear for fishing (because of time limitations I could not sample by gear type), and who are long-term residents who have been fishing in the study area from at least 1998 to the present.

At the beginning of the study, I discussed with the local inhabitants and key informants in each village about the background of the area and local communities, the current beel conditions, the local co-management activities, and the present livelihood conditions. At the MACH sites, I first introduced myself to the target groups in my study villages at the RMO/RUG offices in Darikalinagar and Sarikalinagar and informed them about the purpose of my visit and survey.

At the MACH site, I completed two focus group discussions and three individual interviews with community members in each village per visit. One discussion was held with the RMO members, another discussion was conducted with the RUG members. I also selected two members from one of the Dhali-Baila RMOs, five members from one of the Dhali-Baila RUGs, and three subsistence fishers from each village for individual interviews. These interviews were conducted at the RMO office, at the RUG office, and on the bank and in adjacent villages of the beel. The

interviewees were selected randomly from the group members and the subsistence fishers. Interviews took 20 to 30 minutes for each group and 15 to 20 minutes for each individual. At the non-MACH sites, I interviewed five subsistence fishers in each of the two villages, Indilpur and Garjaripa, using the prepared questionnaire. All interviewees were selected randomly. Each interview took 15 to 20 minutes for each individual.

Data were collected two times per month between August 2011 and December 2011. Focus group discussions were designed to help me learn more about co-management objectives, overall beel management activities, the benefits of participating in co-management, and the problems and recommendations of each group.

Information was collected from the study area through a focus group discussion and one-on-one interviews with the subsistence fishers using prepared questionnaires in order to gather knowledge about fish production (kilograms per hectare), and species composition at the MACH and non-MACH sites, and about the impact of co-management on fish biodiversity at Dhali-Baila Beel (the MACH site). A summary of the research activities is shown in Table 1.

The monthly production (i.e. catch) of fish was calculated using the following formula:

$P = A \times D \times F$

Where, P = Production per month
A = Amount (kg) of fish caught per fisher per day
D = Average fishing days per fisher per month
F = Average number of fishers per day

The average production (kilograms per hectare) was derived from the total monthly production divided by total area of the beel.

Table 1: Summary of the research activities

Management regime	Research activities	Location	Number of interviews/ discussions	Number of interviewees	Total interviewees
MACH site	Discussions	Darikalinagar	9	63	179
		Sarikalinagar	9	63	
	Interviews	Darikalinagar	27	27	
		Sarikalinagar	26	26	
Non-MACH site	Interviews	Indilpur	45	45	90
		Garjaripa	45	45	

Results and Discussion

Fish Production

In order to determine the fish production of Dhali-Baila Beel, the MACH site, I conducted interviews with 179 respondents, including the RMO and RUG members and the subsistence fishers of Darikalinagar and Sarikalinagar villages, using a prepared questionnaire. To contrast this with fish production at the non-MACH site, Shaitandaha Beel, I conducted interviews with 90 subsistence fishers of Garjaripa and Indilpur villages using the same questionnaire.

These efforts showed that the average fish production was approximately 313 kilograms per hectare in Dhali-Baila Beel and 196 kilograms per hectare in Shaitandaha Beel. A maximum fish production of 523 kilograms per hectare and 284 kilograms per hectare were recorded in September, while a minimum production of 119 kilograms per hectare and 103 kilograms per hectare were recorded in December at Dhali-Baila Beel and at Shaitandaha Beel respectively. The high fish production in September may be due to the fact that this is the peak fishing season, while the low catch per hectare in December may have occurred because fishing resources are often depleted at this time. Data for the high and low production at Dhali-Baila Beel match closely with the data (279 kilogram per hectare) recorded in the catch monitoring study conducted by IPAC (2012).

The average monthly fish production at Dhali-Baila Beel is 313 kilograms per hectare, which is significantly higher than both Shaitandaha Beel's 196 kilograms per hectare and the MACH baseline survey's report of 144 kilograms per hectare (MACH 2004). It is also similar to the results (279 kilogram per hectare) of the IPAC catch monitoring report (IPAC 2012). Fish production data from Dhali-Baila Beel and Shaitandaha Beel are shown in Figure 2.

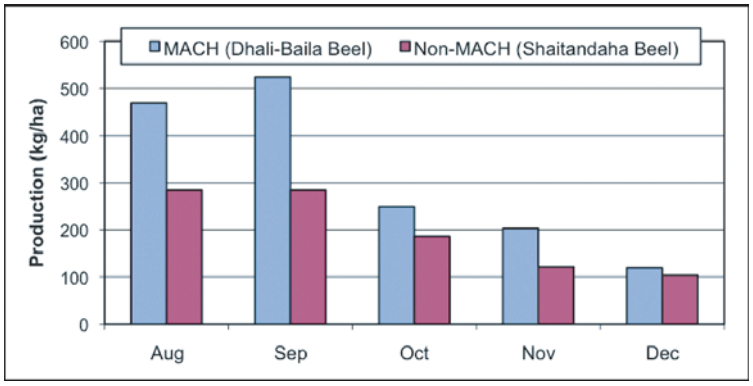

Figure 2: Fish production at the MACH and non-MACH sites

Fish Species Composition

During the study period, I recorded a total of 44 and 15 species of fish in Dhali-Baila Beel and Shaitandaha Beel, respectively. Furthermore, highs of 23 and 8 fish species were found in December, and lows of 17 and 7 fish species were found in November at Dhali-Baila Beel and Shaitandaha Beel, respectively. These numbers were supported by eight interviewees. More species were harvested in December because the receding water in the water bodies makes it easier for fish to be caught by different types of gear and traps. There was no noticeable difference in the gear used in the two beels; fish were caught using various types of fishing gear and traps like gill nets, seine nets, long lines, spears, cast nets, push nets, and lift nets in both beels during the study period. The fish species that were recorded in the study period at Dhali-Baila Beel and at Shaitandaha Beel are given in Table 2.

Table 2: Fish species recorded at Dhali-Baila Beel and Shaitandaha Beel

Local name	Scientific name	Dhali-Baila Beel (MACH site)	Shaitandaha Beel (non-MACH site)
Boal	*Wallago attu*	√	√
Tengra	*Mystus vittatus*	√	√
Baila	*Glossogobius giuris*	√	-
Taki	*Channa punctatus*	√	√
Rui	*Labeo rohita*	√	√
Mrigal	*Cirrhinus cirrhosus*	√	√
Mani/beda	*Nandus nandus*	√	-
Deshi puti	*Puntius sarana*	√	-
Mola	*Amblypharyngodon mola*	√	√
Phulchela	*Salmostoma phulo*	√	-
Narkal chela	*Salmostoma bacaila*	√	-
Chanda	*Chanda nama*	√	√
Carpeo	*Cyprinus carpio*	√	-
Air	*Aorichthys aor*	√	-
Guzi	*Aorichthys seenghala*	√	-
Darkina	*Esomus danricus*	√	√
Titputi	*Puntius ticto*	√	-
Borobaim	*Mastacembelus armatus*	√	√
Cheng	*Channa orientalis*	√	√
Pabda	*Ompok pabda*	√	-
Batai/Batasi	*Pseudeutropius atherinoides*	√	√
Guchibaim	*Macrognathus pancalus*	√	√
Dhela	*Osteobrama cotio*	√	-
Kalibaush	*Labeo calbasu*	√	-
Chingri	Chingri (prawn)	√	√
Bujuri	*Mystus tengara*	√	-
Chapila	*Gudusia chapra*	√	-
Cheka	*Chaca chaca*	√	-
Darkina	*Rasbora daniconius*	√	-
Foli	*Notopterus notopterus*	√	-
Gutum	*Nemachilus botia*	√	-
Grass carp	*Ctenopharyngodon idella*	√	-
Ghonoa	*Labeo gonius*	√	-
Kajuli	*Ailia coila*	√	-
Kakila	*Xenentodon cancila*	√	-
Magur	*Clarias batrachus*	√	-
Shoal	*Channa striatus*	√	-
Shing	*Heteropneustes fossilis*	√	-
Kuche	*Monopterus cuchia*	√	-
Gulsha	*Mystus cavasius*	√	-
Koi	*Anabas testudineus*	√	√
Kholisha	*Colisa chuna*	√	-
Catla	*Catla catla*	√	-
Chela	*Chela bacaila*	√	√
TOTALS		44	15

The total number of fish species recorded at Dhali-Baila Beel during the study period was 44, which is comparable to the IPAC study results (32 species) (IPAC 2012). This is significantly more than the 15 species recorded at Shaitandaha Beel. The total number of fish species found at MACH and non-MACH sites during each month of the study period is shown in Figure 3.

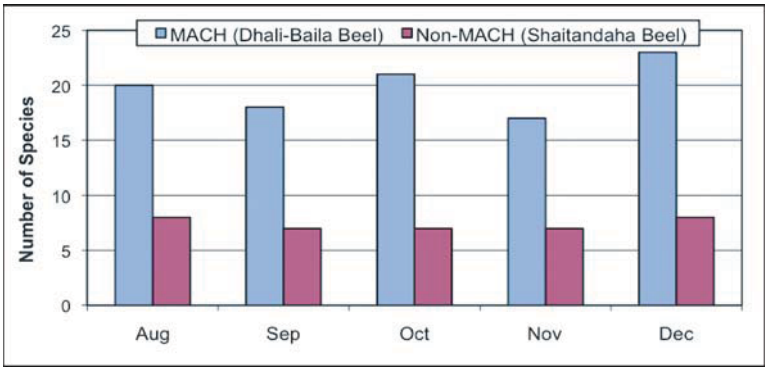

Figure 3: Fish species found at the MACH and non-MACH sites

A greater number of small *chingri* (prawns) were caught at Shaitandaha Beel compared to other species. Graaf *et al.* (2001) argue that the presence of a high proportion of shrimp in floodplain catches is an indicator of a fishery that has been severely damaged, as it lacks appropriate conditions for the breeding and recruitment of larger beel-resident fish. Therefore, this could be an indicator of the poor state of fish biodiversity at Shaitandaha Beel.

Endangered Fish Species

In my study, the interviews with community members revealed that one fish species is endangered at Dhali-Baila Beel and 11 fish species are endangered at Shaitandaha Beel. The fish species that are endangered at Dhali-Baila Beel and Shaitandaha Beel are shown in Table 3.

Table 3: Species of fish endangered at Dhali-Baila Beel and at Shaitandaha Beel

Local name	Scientific name	Dhali-Baila Beel	Shaitandaha Beel
Gozar	*Channa marulius*	√	√
Mani/beda	*Nandus nandus*	-	√
Deshi puti	*Puntius sarana*	-	√
Shoal	*Channa striatus*	-	√
Pabda	*Ompok pabda*	-	√
Kalibaush	*Labeo calbasu*	-	√
Chital	*Notopterus chitala*	-	√
Gulsha	*Mystus cavasius*	-	√
Koi	*Anabas testudineus*	-	√
Kholisha	*Colisa chuna*	-	√
Magur	*Clarias batrachus*	-	√
TOTAL		1	11

Using a questionnaire, I collected information from members of the RMOs, RUGs, and subsistence fishers on the incidence of endangered fish species in my study area. At the non-MACH site, I found that, out of 179 respondents, 21 respondents (12%) said that deshi puti *i*s non-existent, 56 (31%) said mani/beda *i*s non-existent, 47 (26%) said that shoal is non-existent, 20 (11%) said gozar is non-existent, six (3%) said koi is non-existent, and a few respondents said kalibaush, gulsha, pabda, kholisha, and magur are all non-existent. In contrast, at the MACH site, eight (4.5%) of the respondents said that gozar is non-existent. Respondents' perceptions of the incidence of endangered species at the MACH site and non-MACH site are shown in Figure 4.

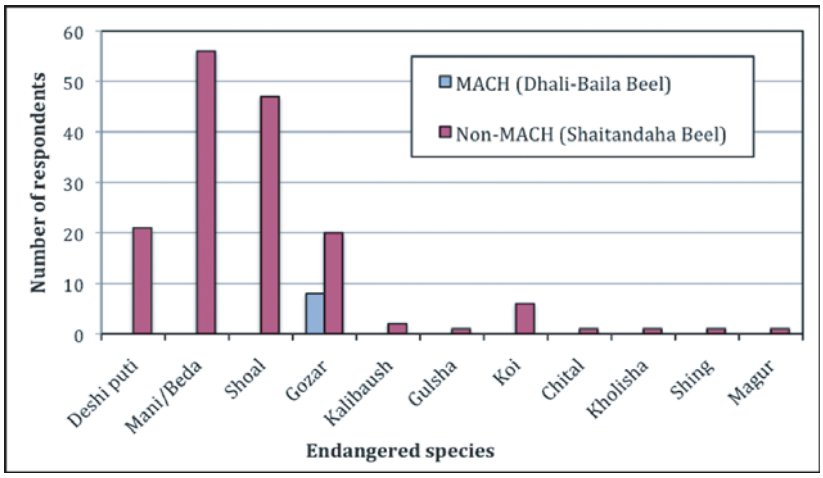

Figure 4: Perceived incidence of endangered fish species at MACH and non-MACH sites

Eleven fish species were recorded as endangered at Shaitandaha Beel during the study period, which is significantly greater than the number at Dhali-Baila Beel. A smaller number of endangered fish species indicates better management of water bodies and suggests a positive impact of co-management on fish biodiversity in general.

Revived Species of Fish

My interviews with members of the RMOs, RUGs, and subsistence fishers revealed that eight species of fish were revived and are currently caught in sufficient quantity at the MACH site. Eight fish species (N*andus nandus, Puntius sarana, Amblypharyngodon mola, Ompok pabda, Labeo calbasu, Notopterus notopterus, Heteropneustes fossilis,* a*nd Channa marulius)* were recorded as revived at Dhali-Baila Beel, and none were recorded revived at Shaitandaha Beel. This too suggests that co-management could be contributing to the better management of water bodies and having positive impacts on fish biodiversity.

Use of Destructive Gear

I found that destructive fishing gear was used less frequently for fishing at the MACH site than at the non-MACH site during my study period. In August, September, and December two (MACH site) and three (non-MACH site) uses of destructive gear use were recorded and in October and November one (MACH) and two (non-MACH) uses of destructive gear were recorded. The lower use of destructive gear at the MACH site is also a potential indicator of the positive influence of co-management on sustainable management of water bodies and fish biodiversity conservation. The number of uses of destructive gear at the MACH and non-MACH sites is shown in Figure 5.

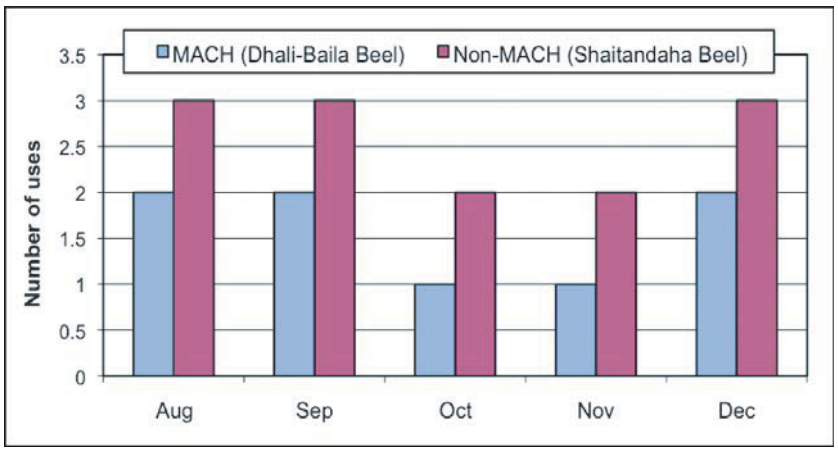

Figure 5: Number of uses of destructive gear at the MACH and non-MACH site

Impact of the Fish Sanctuary on Fish Biodiversity Conservation

To gauge the impact of the sanctuary on fish biodiversity conservation, I asked the respondents (RMO and RUG members and subsistence fishers) whether they perceive any positive impacts of the sanctuary on fish biodiversity conservation. None of the 179 respondents perceived a negative impact, 170 (95%) perceived a positive impact, and nine respondents (5%) gave no comment. The perceptions of community members of the impacts of the sanctuary on fish biodiversity are summarized in Table 4.

Table 4: Community perceptions of the impact of the sanctuary on fish biodiversity

Month	Positive (%)	Negative (%)	No comment (%)	Total respondents
August	39 (100)	0 (0)	0	39
September	35 (87.5)	0 (0)	5 (12.5)	40
October	38 (95)	0 (0)	2 (5)	40
November	100	0 (0)	0	40
December	18 (90)	0 (0)	2 (10)	20
Average	95%	0%	5%	35.8

Impact of Enforcement of the Fish Act on Fish Biodiversity

I collected some information about local community members' perceptions of the impact on fish biodiversity of enforcement of the Protection and Conservation of Fish Act through a questionnaire. I found that, of the 179 respondents, none (100%) perceived negative impacts, while 157 (88%) perceived positive impacts, and 22 (12%) gave no comment (see Table 5).

Table 5: Perceptions of the impact of enforcement of the Fish Act on fish biodiversity

Month	Positive (%)	Negative (%)	No comment (%)	Total respondents
August	36 (92)	0 (0)	3 (8)	39
September	34 (85)	0 (0)	6 (15)	40
October	38 (95)	0 (0)	2 (5)	40
November	35 (87.5)	0 (0)	5 (12.5)	40
December	16 (80)	0 (0)	4 (20)	20
Average	88.0%	0%	12.0%	35.8

Impact of Fingerling Stocking on Fish Biodiversity

I collected information about local community members' perceptions about the impact of stocking of fingerlings on fish biodiversity. Out of the 179 respondents, none perceived a negative result and 159 (89%) perceived a positive result, while 20 (11%) had no comment (Table 6).

Table 6: Community perceptions of impact of fingerling stocking on fish biodiversity

Month	Positive (%)	Negative (%)	No comment (%)	Total respondents
August	38 (97)	0 (0)	1 (3)	39
September	40 (100)	0 (0)	0 (0)	40
October	38 (95)	0 (0)	2 (5)	40
November	33 (82.5)	0 (0)	7 (17.5)	40
December	28 (70)	0 (0)	12 (30)	40
Average	89%	0%	11%	39.8

Impact of AIGAs on Fish Biodiversity Conservation

I gathered some information on local community members' perceptions of the impact of alternative income-generating activities (AIGAs) on fish biodiversity conservation by asking them whether they think AIGAs are helpful or not in promoting the conservation of fish biodiversity. I found that all 126 respondents (28 per month from August to November, and 14 in December) felt there was a positive impact on fish biodiversity conservation (Table 7).

Table 7: Community perceptions of the impact of AIGAs on fish biodiversity

Month	Positive (%)	Negative (%)	No comment (%)	Total respondents
August	28 (100)	0 (0)	0 (0)	28
September	28 (100)	0 (0)	0 (0)	28
October	28 (100)	0 (0)	0 (0)	28
November	28 (100)	0 (0)	0 (0)	28
December	14 (100)	0 (0)	0 (0)	14
Average	100%	0%	0%	25.2
			TOTAL =	126

Conclusion

This research was designed to study the impacts of co-management on freshwater fish production and fish biodiversity in Dhali-Baila Beel, by comparing this MACH site with a non-MACH site (Shaitandaha Beel), and to study the impact of co-management on local people's behavior, as well as their perceptions of co-management at the MACH site. It was conducted over a six-month period, from July to December 2011.

Average monthly fish production (i.e. catch) was estimated to be 313 kilograms/hectare in Dhali-Baila Beel and 196 kilograms per hectare in Shaitandaha

Beel. A maximum fish production of 524 kilograms per hectare and 284 kilograms per hectare were recorded in September 2011, and a minimum production of 119 kilograms per hectare and 103 kilograms per hectare were recorded in December 2011 at Dhali-Baila Beel and Shaitandaha Beel, respectively. The high fish catch in September may be due to the fact that it is the peak fishing season and the low catch in December might be because this is the lean fishing season when fish stocks have been depleted. The data for the highest and lowest production at Dhali-Baila Beel closely match the data recorded in the catch monitoring study conducted by IPAC (IPAC 2012). The average fish catch at Dhali-Baila Beel is significantly higher than that of Shaitandaha Beel. The total number of fish species recorded at Dhali-Baila Beel during the study period was 44, which is comparable to the IPAC (2012) study results (32 species) and significantly higher than the 15 species recorded at Shaitandaha Beel.

In terms of biodiversity conservation indicators, 11 fish species were recorded as locally endangered at the non-MACH site and only one such species was identified at the MACH site during the study period. Thus, the number of endangered species at the non-MACH site is significantly greater than at the MACH site. Furthermore, eight revived species were recorded at the MACH site whereas no revived species were found at the non-MACH site. These findings indicate the effective management of these water bodies and suggest that co-management has had a positive impact on fish biodiversity in the area. In addition, fishers used less destructive types of fishing gear at the MACH site than at the non-MACH site. These findings could be an indication of the enhanced management of the protected beels in particular, and suggest that co-management has had a positive impact on fish biodiversity conservation in the area in general.

I interviewed RMO and RUG members, as well as subsistence fishers, about their perceptions of the impacts of the fish sanctuary, enforcement of the Protection and Conservation of Fish Act, and the stocking of fingerlings on fish biodiversity at the MACH site. Out of 179 respondents, 95 percent perceived positive impacts from the sanctuary, 88 percent perceived positive impacts of enforcement of the Protection and Conservation of Fish Act, and 89 percent perceived positive impacts of stocking fingerlings on fish biodiversity in respect to fish production and species composition at the MACH site. Moreover, 100 percent of the respondents perceived positive impacts of AIGAs on fish biodiversity conservation. This reveals strong support for co-management, and for the conservation of these sites and their fish resources.

The major findings of the study are: (1) the fish biodiversity at the MACH site is richer than that at the non-MACH site, and (2) the impact of co-management on local people's behaviors and perceptions at a MACH site is overwhelmingly positive. This suggests that, overall, the social and biological impacts of co-management have been positive at the protected (MACH) sites. According to these findings, I would recommend that community-based co-management of fisheries resources should be

expanded to include non-MACH sites and continued at MACH sites over the long term through the existing system of RMOs and RUGs to ensure the effective conservation of fish biodiversity in this area, as well as in other open water bodies of Bangladesh.

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