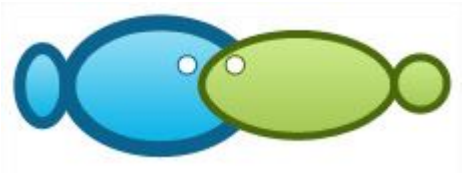

Role of co-management in wetland productivity: a case study from Hail haor in Bangladesh

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Abstract. This study provides an overview of the current resources and fisheries status of the Hail haor, and identifies the scope of opportunities to evolve existing fisheries management strategies, focusing on fish biodiversity conservation. Hail haor is one of the largest, most important wetland in the North East Bangladesh, and covers an area of about 18,000 ha during the monsoon season. A fish catch survey was carried out in the fishing season (April to June 2013) in the studied areas. A total of 1310 individuals was found, representing 54 fish species. To preserve this wetland, the government introduced a co-management system in 1998 through a project entitled "Management of Aquatic Ecosystems through Community Husbandry (MACH)". Through this project some Resource Management Organizations (RMOs) were formed by involving all resource users and stakeholders from the adjacent haor regions. RMOs in Hail haor serve as a platform for bringing together community people and concerned stakeholders to work towards sustainable development of this haor. We compared the performance of Borogangina and Dumuria RMOs who are responsible for managing the major part of the Hail haor. The results of the survey report revealed that the Borogangina RMO performed better (score 80.60) than Dumuria RMO (score 66), because of superior communication with authorities and more effective organizational capabilities. Nevertheless, resource users in both RMOs benefitted after establishing the co-management system in the Hail haor. Several management strategies were suggested by the stakeholders including continuing co-management, increasing monitoring, and the findings are discussed in the context of overall developments in the Hail haor fisheries and community development, and also biodiversity management.

Key Words: inland fishery, haor, livelihoods, resource management, biodiversity, conservation, NGO.

Introduction. Fish are a critical natural resource, yet global catches have peaked while human populations and demand for seafood continue to rise (FAO 2012; Gutiérrez et al 2011). This increasing pressure has coincided with most fisheries worldwide being fully exploited or requiring rebuilding (Worm et al 2009). In the past several decades, researchers have examined the circumstances under which common pool resources and fisheries in particular, can be successfully managed (Costanza et al 1998; Gutiérrez et al 2011; Ostrom 1990). A critical challenge to conservationists is how to reconcile biological conservation, poverty alleviation, and sustainable resource use in tropical aquatic ecosystems (Mills et al 2011; Obura 2012). Most top-down fisheries management measures aimed at addressing these challenges are inappropriate for small-scale fisheries (Ruddle & Hickey 2008). However, communities of resource users, including fishers, have

developed rules and restrictions that can reduce the risk of resource over-exploitation (Berkes et al 2000). Governments and research institutions may recognize and support these local rules in co-management arrangements, which can reduce conflicts among users and managers, improve compliance with management recommendations, and enhance enforcement of management rules (Begossi 2010; Carlsson & Berkes 2005).

Community-based co-management (hereafter co-management) occurs when fishers and managers work together to improve the regulatory process (Gutierrez et al 2011; Jentoft et al 2009). Advantages of co-management include: enhanced sense of ownership encouraging responsible fishing; greater sensitivity to local socioeconomic and ecological restraints; improved management through use of local knowledge; collective ownership by users in decision making; increased compliance with regulations through peer pressure; and better monitoring, control and surveillance by fishers (Berkes 2007; Pomeroy & Williams 1994). Co-management of fisheries is expected to result in greater security of access and cooperation leading to enhanced sustainability of the cooperation leading to enhanced sustainability of the resource, more equitable distribution of benefits, improved conflict resolution among fishers, enhancement of fishers' status in relation to other stakeholders, sharing of information between comanagers, and higher level of voluntary compliance (Pinkerton 1989).

Over the last two to three decades there has been a rapid growth in research interest in common property regimes and the extent that they can overcome the problems of open access to and overexploitation of common pool resources (Dietz et al 2003). One research focus has been identifying conditions under which community management institutions and common properties regimes can be sustainable (Agrawal 2001; Ostrom 1994). Some assessments have focussed on institutional factors such as tenure, leadership and compliance associated with the performance of community or co-management (Pagdee et al 2006; Pomeroy & Berkes 1997), while others have emphasized environmental factors (Agrawal & Chhatre 2006). Most of the studies that have analysed co-management efficacy in increasing fish catches, fish abundance, and fish diversity have been conducted in coastal ecosystems (Campbell et al 2012; Gelcich et al 2008; Hamilton et al 2011); relatively few studies have analysed tropical freshwater wetland ecosystems (Sultana & Thompson 2007).

Wetlands in Bangladesh encompass a wide variety of dynamic ecosystems including mangrove forests, natural lakes, man-made reservoirs (such as the Kaptai Lake in Chittagong Hill Tracts), freshwater marshes, baors (oxbow lakes), beels (big depressions where water remains yearlong), river, haors (bowl-shaped large tectonic depression and aggregation of many beels, inundated during the monsoon season creating vast sheets of water) and extensive floodplains that are seasonally inundated (Akter 2011). In particular, haors facilitate a level of natural fish production and biodiversity that is significant at local, national and regional levels. Among the haors, Hail haor of north-eastern Bangladesh (Sylhet Division) is one of the largest and most important one. The Hail haor is an ideal setting for implementing and testing alternative systems of fishing management and conservation, including co-management. The Hail haor has intense small-scale fisheries that have resulted in over fishing of some target fish (Castello et al 2011), but some fishing communities have engaged in co-management, regulating fishing efforts, and controlling access to outside fishers (Almeida et al 2009; Lopes et al 2011). Co-management in the Hail haor includes 'fishing agreements', which are basically government support of local initiatives by fishers (Castro & McGrath 2003), sustainable development reserves (Castello et al 2009) and extractive reserves (Begossi et al 1999), although the reserves sometimes do not constitute true co-management (Begossi 2010; Lopes et al 2011).

But in recent years, the Hail haor has been under serious threat because most of it has been encroached upon by the local people for expansion of agriculture by converting haor lands into agricultural field especially paddy fields, and there has been excessive harvesting of fish and other aquatic resources (DoF 2009). To conserve the wetland resources and restore its biodiversity, the government introduced a co-management system in 1998 under MACH (Management of Aquatic Ecosystems through Community Husbandry) project supported by USAID in three large wetlands: Hail Haor in

Sreemongal, Turag-Bangshi River and wetlands in Kaliakoir and the Kangsha-Malijhee basin in Sherpur, Bangladesh (MACH 2005). This project involved the entire system of resource users and stakeholders (poorer fishers, farmers, landless labourers, women, local elites and government officials), two groups in each region of the sites (Resource Management Organization (RMO) and Fisheries Resource Users Group (FRUG)), with separate Non-government organizations (NGOs) for each type of group, adequate alternate income generation activities (AIGAs) to reduce fishing pressure, human resources development, adaptive management and policy initiatives. MACH made linkages between the RMOs and local government - the elected Union Parishads and the officers of line agencies who form the Upazila administration to ensure synergies and to formalize the status of the RMOs. RMOs in Hail haor serve as a platform for bringing together community people and concerned stakeholders to work towards sustainable development of this haor.

Although some studies have addressed these co-management systems (Almeida et al 2009; Castello et al 2009; Silvano et al 2009), to the best of our knowledge, no survey has analysed the effectiveness of co-management system in Bangladesh. This study represents one of the most comprehensive analyses conducted on the actual and potential effects of co-management systems in the productivity of the Hail haor, one of the important freshwater wetlands in Bangladesh. In this study, we aim to evaluate the biodiversity status and also to reveal the impact and performance of existing co-management systems, especially in two RMOs, namely Borogangina and Dumuria RMO in the Hail haor, Bangladesh.

Material and Method

Study area. The study was conducted in Hail haor (24°25'3"N and 91°40'57"E) in Sreemongal and Moulavi Bazar Upazila under Moulavibazar District of Sylhet Division Bangladesh (Figure 1). The total area of Hail haor is around 18,000 ha: in wet season the area goes under water is approximately 14,000 ha, whereas in dry season the area is typically just over 4,000 ha on an average. This haor has 14 wetland sanctuaries including 130 beels. About 172,000 people live in 61 villages; all of them, more or less, are dependent on its resources for their livelihoods (Chakraborty et al 2005).

A total of eight RMOs, namely: Agari, Ramedia, Borogangina, Jethua, Kajura, Dumuria, Balla and Sananda were formulated for the management of Hail haor resources, involving 548 members where 426 members are general body members (Male 317, Female 109) and 122 are executive members (Male 92, Female 30). A total of 21 beels are managed under these RMOs. Among the eight RMOs only Borogangina and Dumuria RMOs were selected for the study. We selected these two RMOs based on advice from local leaders and fishing organizations, who indicated that these two RMOs manage major economically important fishing sites of the Hail haor (Majumder et al 2013).

Survey methods. A multi-stage random sampling technique was applied for the study. We interviewed 173 people, following a standard questionnaire with questions about education level, occupation, and fishing activities (Table 1). Additionally, six Focus Group Discussions (FGDs) were conducted; two FGDs from two RMOs and rest were with the local community, fisherman, FRUG members and government and NGOs officials who are not the members of RMOs; four Key Informant Interviews (KIIs) also conducted with the RMOs members. A semi-structured questionnaire and checklist (Pimbert & Pretty 1995) was used for the interview, KIIs and FGDs. Field survey was conducted over a period of three months from April to June 2013. The strengths, weaknesses, opportunities and threats (SWOT analysis) were conducted from questionnaire surveys and interview with the stakeholders.

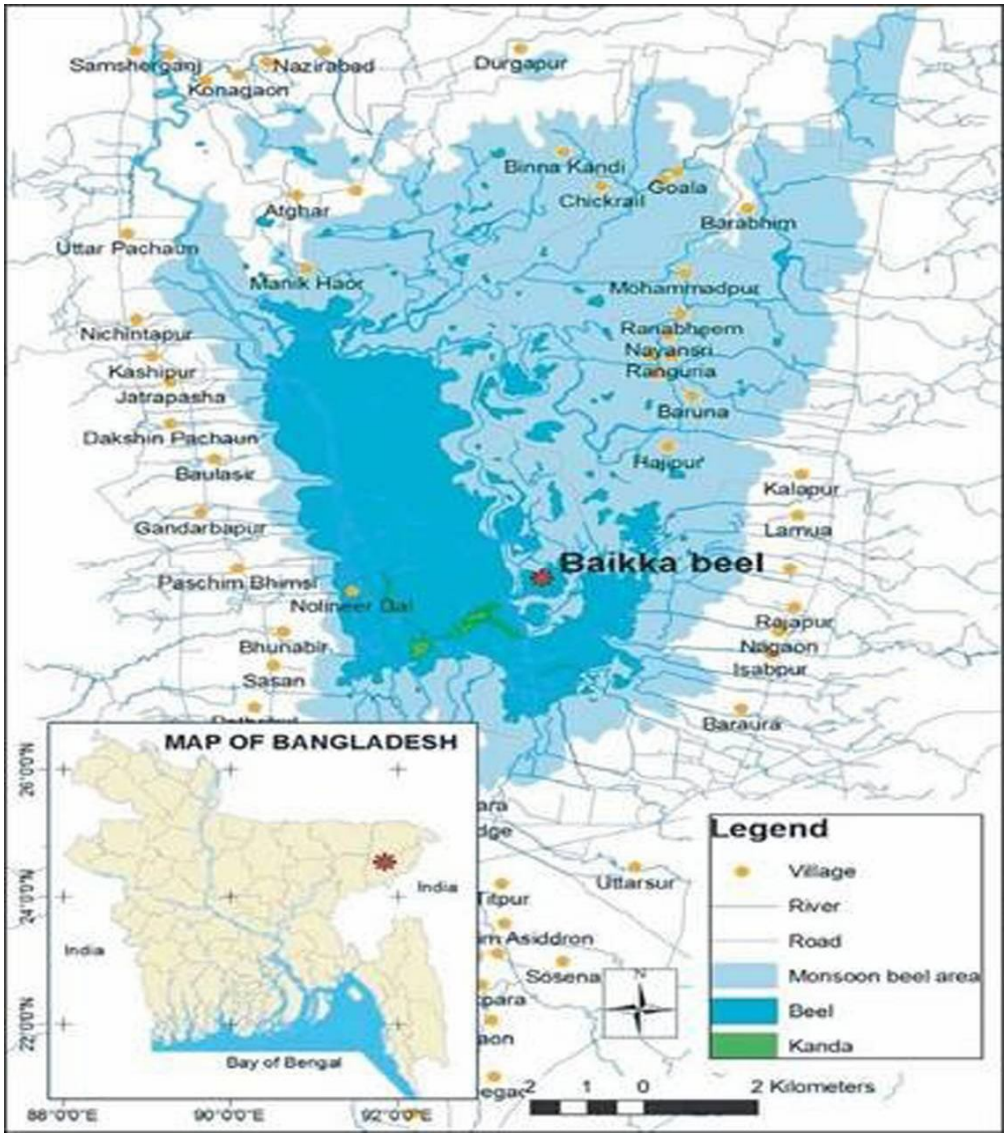

Figure 1. Maps indicating study areas. Star denotes sampling site: Hail haor (Source: Kabeer 2013).

Table 1

Respondents selection for getting information for the study

Respondent group	*Survey method*	*Respondents (%)*
Borogangina RMO	Interview, FGD	28 (16.19)
Dumuria RMO	Interview, FGD	20 (11.56)
Member of the FRUGs	Interview, FGD	48 (27.75)
Government and NGOs officials	Interview, FGD	5 (2.89)
Community people	Interview, FGD	12 (6.94)
Fisherman	Interview	60 (34.68)

RMO - Resource Management Organization; FRUG - Fisheries Resource User Group; NGO - Non-government organization; FGD - Focus Group Discussion.

Method of fish biodiversity study. In this study, a total of 60 fishermen were randomly selected from the villages surrounding the haor. Fishermen were categorized into five groups on the basis of fishing gears which were used by them (seine net, cast net, big cast net, gill net, and push net). Each group had 12 members operating the same gear. New members were selected in each group at every sampling day. For the study of biodiversity of Hail haor, sampling of catches and their assessment were carried out once a month. Data were collected from every group on each sampling day. The

representative sample was taken by hand without repetition of the same gear in each sampling day. The collected fishes were identified and sorted species-wise and the number of individuals for each species was counted and then percent composition was determined. The taxonomic guide by Rahman (1989) and Al-Mamun (2003) were used for the identification of fish species except for some larger and more common fish, which were identified on site. The Museum and Laboratory Specimen unit of the Faculty of Fisheries, SAU, Bangladesh were also used for this purpose. The collected data were analysed with the help of MS Excel and Origin™ version 9 software.

During collection of data, both primary and secondary sources were used. Primary data were collected from fishermen by the researcher himself. The secondary information was collected from fisheries office at Srimongol Upazila, the World Fish Center and other concerned government and NGOs that have been working extensively on fisheries resources on Hail haor.

Results and Discussion

Basic socio-demographic features of the respondents. The interviews indicated that most respondents did not complete secondary school. All the interviewees were full-time fishers who sell the fish caught mainly to middlemen or in the main city. Fishing was also the main activity of the fishers' fathers, and fishers (and their fathers) practiced agriculture as well (Table 2).

Table 2

General characteristics of respondents and fishing activities

Respondents	*Borogangina RMO*	*Dumuria RMO*	*Member of the FRUGs*	*Government and NGOs officials*	*Community people*	*Fisherman*
Education level						
Primary school incomplete	32	25	29	0	41	48
Secondary school incomplete	55	62	63	36	57	51
Secondary school complete	13	13	9	64	3	1
Economic activities						
Fishing	72	78	83	23	96	100
Agriculture	68	73	69	27	82	81
Retired	7	5	9	0	6	8
Carpentry	1	0	3	0	4	0
Commerce	4	7	3	15	5	0
Livestock	5	9	6	12	9	2
Economic activities (fathers)						
Fishing	59	68	69	21	82	89
Agriculture	52	61	52	19	72	73
Carpentry	3	5	7	9	6	8
Commerce	6	9	7	21	8	2
Livestock	8	12	9	16	12	7
Destination of fish caught						
Commerce	68	72	61	61	92	95
Do not sell	32	28	39	39	8	5
Where fish is sold						
Main city	12	18	9	6	5	2
Village	38	48	46	33	48	45
Middlemen	62	56	68	78	57	69

General characteristics of respondents and their fishing activities in the Baikka beel, Hail haor according to the fishers responses to interviews (n = 151 fishers interviewed). Numbers correspond to the percent of interviewed fishers who mentioned each information (number of fishers interviewed in each group is shown in the first row); the sum of percentages may be more than 100%, because some fishers mentioned more than one information.

Respondents were reported to be involved in a variety of haor-based livelihoods like fishing, pisciculture and related activities, rice production, duck and cattle rearing, non-timber forest products collection, and collection of aquatic plants for food, fodder, fuel and house building materials. Fishing is a major livelihood activity during the monsoon period (March to August). People also sometimes engaged in hunting and poaching of migratory birds during winter as well as cultivation of rice, oil seeds and pulses in the fringe areas.

Fish biodiversity status in Hail haor. Bangladesh has a globally important wetland ecosystem, boasting approximately 260 indigenous freshwater fish species (Rahman 1989). During the study period, a total of 54 fish species belonging to the 6 orders, 19 families and 39 genera were recoded in the catches of different gears used by the fishermen in the Hail haor (Table 3).

By comparison, 54 species of fish were recorded by Rahman & Hasan (1992) from the Kaptai lake which was same to the findings of present study. Nath et al (2010) found 47 species in Borulia haor, Bangladesh which was slightly lower than the present study. A somewhat similar number of fish species was noted by Haque et al (1999) who recorded 43, 58 and 60 fish species from different types of Oxbow Lake Project (OLP). A total of 40 species of fish including exotic species was observed in Salda beel, Bangladsh (Saha & Hossain 2002) which were relatively lower than that of Hail haor. Seventy five (75) species belonging to 23 families and 50 genera were recorded from different aquatic habitat (pond, lake, canal, river and paddy field) reported by Paik & Chakraborty (2003) which was comparatively higher in number than Hail haor. Comparatively more number of fish species was recorded in the beels of Sylhet-Mymensingh basin (Haroon et al 2002). Relatively fewer fish species than this investigation was recorded in Chenderon reservoir, India, illustrated in the report of Kah-Wai & Ali (2001). In Namada river, Maheshwari (2004) reported 57 fish species which was close to the findings of the present study. Huang et al (2001) reported that about 100 species are commonly found in Chinese reservoirs and Silvano & Begossi (2001) found 43 species for the Barra Bonita reservoir Brazil through landings.

Cypriniformes and Siluriformes (18 species each) were found to be the most dominant fish in the Hail haor. Among the families, the dominant families were Cyprinidae containing 16 species followed by Bagridae (7 species), Siluridae and Channidae (both 4 species), and Schilbeidae and Mastacembelidae (both 3 species) (Table 3 and Figure 2). Cyprinidae was found to be the most dominant family in view of species variety and Bagridae and Channidae occupied second position of abundance after Cyprinidae recorded in the Borulia haor, Bangladesh (Nath et al 2010). Paik & Chakraborty (2003) recorded 75 fish species belonging to 23 families dominated by Cyprinidae (28 species) followed by Bagridae, Centropomidae with five species each, and Channidae and Cobitidae contained four species each and Mastacembelidae and Siluridae contained three species each, and other families had two species from different Indian water bodies. Pipoppinyo et al (1998) noted 52 species belonging to 16 families, with 34 genera in pen Mae Sa watershed in Thailand. Cyprinidae represented a major contribution with large number of species in different open water bodies of Bangladesh (De et al 2011) and south west Sunderbans, India (Giri et al 2004; Mohan & Singh 2004) which almost support the findings of the present study.

Table 3

Species wise catch composition of fishes using different types of net used in Hail haor (by average number and percentage)

Sl. No.	Order	Family	Species	Average number of fish in each catch of different nets					Total catch of each sp. (no.)	Total catch of each sp. (wt. in kg)	Total catch in each common group (no.)	Total catch in each common group (wt.in kg)	% of total catch of each common group (no.)	% of total catch of each common group (wt. in kg)
				Seine net	Cast net	Big cast net	Gill net	Push net						
1	Cypriniformes	Cyprinidae	*Amblypharyngodon mola*	160	29	7	4	8	208	2.78	960	21.67	73.28	51.55
2			*Catla catla*	1	-	2	-	-	3	1.02				
3			*Cirrhinus cirrhosus*	2	-	1	-	-	3	1.08				
4			*Cyprinus carpio*	3	-	1	-	-	4	1.41				
5			*Esomus danricus*	82	15	14	1	3	115	1.29				
6			*Hypophthalmichthys molitrix*	1	-	1	1	-	3	1.67				
7			*Labeo bata*	4	1	1	1	0	7	0.34				
8			*Labeo calbasu*	2	-	-	-	-	2	0.41				
9			*Labeo gonius*	2	1	-	-	-	3	0.76				
10			*Labeo rohita*	2	1	1			4	2.02				
11			*Osteobrama cotio*	40	10	12	-	3	65	0.79				
12			*Pethia ticto*	37	14	13	3	4	71	1.35				
13			*Puntius sophore*	230	17	15	10	4	276	3.2				
14			*Salmophasia bacaila*	15	5	8	1	3	32	0.99				
15			*Salmophasia phulo*	30	2	6	2	5	45	0.75				
16			*Systomus sarana*	21	7	5	4	3	40	0.93				
17		Cobitidae	*Botia dario*	35	15	8	12	5	75	0.78				
18			*Lepidocephalichthys guntea*	-	2	2	-	-	4	0.1				
19	Siluriformes	Bagridae	*Mystus bleekeri*	6	1	3	1	2	13	0.28	95	5.54	7.25	13.18
20			*Mystus gulio*	5	2	2	3	0	12	0.36				
21			*Mystus tengara*	7	2	2	1	1	13	0.32				
22			*Mystus vittatus*	7	2	4	2	2	17	0.37				
23			*Rita rita*	2	1	0	-	-	3	0.71				
24			*Sperata aor*	3	-	1	-	-	4	1.09				
25			*Sperata seenghala*	5	1	1	0	0	7	0.16				
26		Siluridae	*Ompok pabo*	4	1	1	0	0	6	0.23				
27			*Ompok pabda*	5	1	2	-	-	8	0.31				
28			*Ompok bimaculatus*	5	2	1	0	0	8	0.32				
29			*Wallago attu*	1	-	1	-	-	2	1.09				
30		Schilbeidae	*Ailia coila*	3	-	-	1	-	4	0.1				
31			*Clupisoma garua*	1	0	0	0	0	1	0.1				
32			*Eutropiichthys vacha*	1	1	0	0	0	2	0.3				

33		Clariidae	*Clarias batrachus*	1	-	1	1	1	4	0.3				
34		Hetaropneustidae	*Heteropneustes fossilis*	-	2	2	-	-	4	0.21				
35		Pangasiidae	*Pangasius pangasius*	2	0	0	0	0	2	0.83				
36		Sisoridae	*Bagarius bagarius*	1	-	1	-	-	2	0.3				
37	Perciformes	Channidae	*Channa marulius*	4	-	1	1	-	6	1.98	161	12.81	12.29	30.47
38			*Channa orientalis*	7	2	2	1	1	13	1.88				
39			*Channa punctata*	15	5	2	-	1	23	1.71				
40			*Channa striata*	3	-	1	-	-	4	1.59				
41		Ambassidae	*Chanda nama*	7	2	4	2	2	17	0.17				
42			*Parambassis ranga*	6	2	2	1	1	12	0.1				
43		Mastacembelidae	*Macrognathus aculeatus*	2	3	1	1	2	9	0.3				
44			*Macrognathus pancalus*	2	4	2	-	2	10	0.58				
45			*Mastacembelus armatus*	2	3	3	-	1	9	0.56				
46		Anabantidae	*Anabas testudineus*	4	1	2	4	1	12	1.5				
47		Gobiidae	*Glossogobius giuris*	2	-	1	1	1	5	0.26				
48		Belontiidae	*Trichogaster fasciata*	10	4	5	3	2	24	0.34				
49	Osteoglos-siformes	Notopteridae	*Chitala chitala*	2	-	-	-	-	2	0.92	6	1.44	0.46	3.43
50			*Notopterus notopterus*	3	1	0	0	0	4	0.52				
51	Clupei-formes	Clupeidae	*Corica soborna*	35	20	12	8	4	79	0.25	84	0.45	6.41	1.07
52			*Gudusia chapra*	2	1	1	1	-	5	0.2				
53	Beloni-formes	Belonidae	*Xenentodon cancila*	1	-	1	-	-	2	0.07	4	0.13	0.31	0.31
54		Hemiramphidae	*Hyporhamphus limbatus*	1	0	1	0	0	2	0.06				

*% = percent

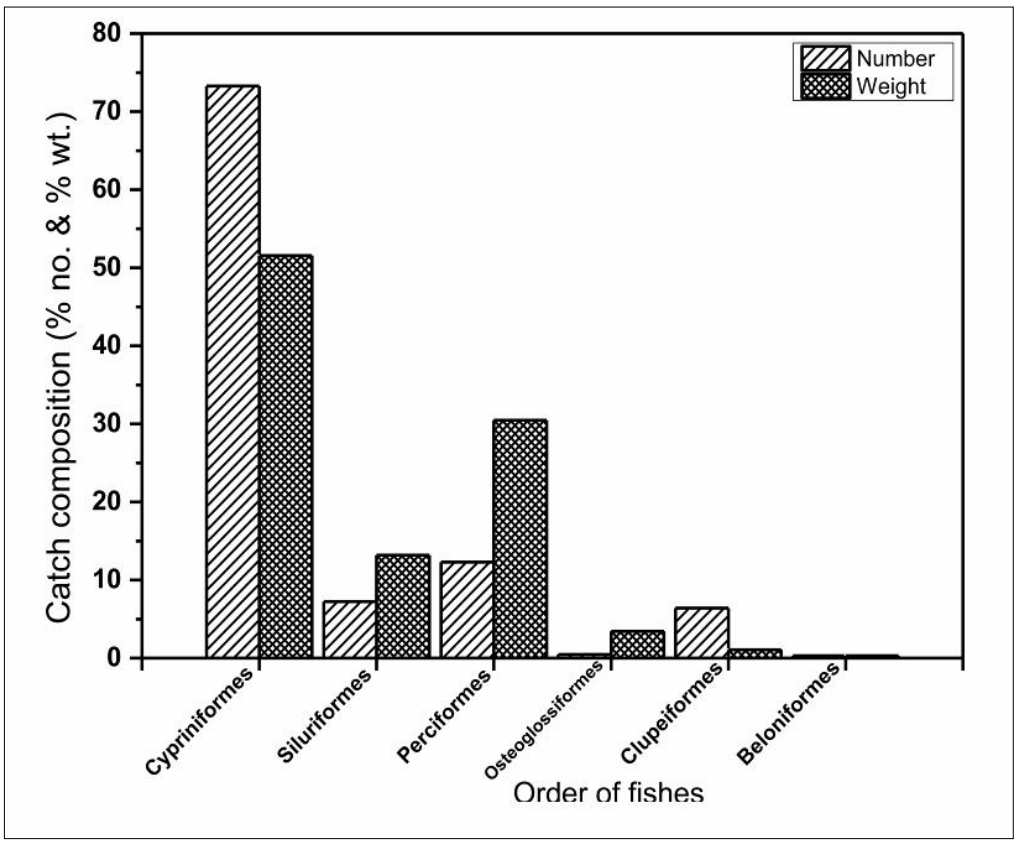

Figure 2. Catch composition assemblage by common group of related fish species in Hail haor during study period: April-June, 2013.

Hail haors is dominated by Cypriniformes (73.28% & 51.55%), followed by Synbranchiformes (12.29% & 30.47%) and Siluriformes (7.25% & 13.18%) in respect of numerical composition and weight (kg) respectively. *Puntius sophore* was found to be the most abundant species (21.10%) in Hail haor. In Boro beel, dominated by minnows (25.97%), considering weight and numerically *Puntius sophore* was found to be most abundant species (24.33%) (Saha 2007). The present study's observation also agreed with the findings of Haroon et al (2002) who reported Cypriniformes were the most abundant group and *Puntius* spp. were the most dominant genera in the Mymensingh-Sylhet basin of Bangladesh and it was also regarded as a numerous species in Dighali beel, India (Sugunan & Bhattacharjya 2000). Similarly, *Puntius* sp. was the most available fish species in Chanda, BSKB and Halti beels, Bangladsh (Hossain et al 2000).

Many valuable indigenous fish species that were once available in large volumes are currently under threat and severely depleted in the Hail haor area. This survey indicated that the following species could be threatened: *Labeo calbasu*, *Labeo gonius*, *Labeo bata*, *Systomus sarana*, *Osteobrama cotio*, *Rita rita*, *Sperata aor*, *Bagarius bagarius, Sperata seenghala, Clupisoma garua, Eutropiichthys vacha, Ompok bimaculatus, Ompok pabo*, *Pangasius pangasius*, *Chitala chitala*, *Channa marulius,* and *Channa orientalis* (IUCN 2000). Conversely, the exotic carps, including silver carp (*Hypophthalmichthys molitrix*), and common carp (*Cyprinus carpio*), commonly used in pond polyculture systems through Bangladesh were relatively common in the haor area. The respondents (95%) stated that the trend of fish production is decreasing by comparison to previous years. Their opinion was that indiscriminate use of different types of gears, overfishing, lake of awareness, and lack of alternative income generating sources are the main reasons behind this decline. But after the establishment of the co-management system and the establishment of the Baikka Beel fish sanctuary, the situation is now improving.

Co-management system in Hail haor. Hail haor is managed under co-management regimes known as resource management organisations (RMOs). The purpose of RMOs is to provide sustainable production and livelihoods by direct engagement by beneficiaries and resource-consuming peoples in an area in adopting various development-oriented programs. RMOs work closely with fisheries resources users' groups (FRUGs), and both organisations operate with the support of the Department of Fisheries (DoF). For example, the deputy commissioner at Moulvibazar manages Baikka Beel, with technical support from the DoF and active participation of local community RMOs, especially the Borogangina RMO. These organizations are managed by a written constitution approved by the government. The purpose, governance structure, nature and activities of the two selected RMOs are shown in Table 4.

Table 4

Structure and activities of the studied RMOs

Function	*Borogangina RMO*	*Dumuria RMO*
	General structure	
1. Executive committee (EC): there will be an EC containing 11 members elected by the general members of the organization through election for two years.	Following the constitution	Following the constitution
2. General committee (GC): GC containing 51 members.	Following the constitution	Following the constitution
	Functional activities	
1. Regular monitoring to protect from illegal fishing	Continuous monitoring	Irregular monitoring
2. Awareness raising activities for the conservation of wetland resources	Regular activities	Regular activities
3. Ensuring participation of poor fishermen to stipulate plan, implement and wetland conservation	60% of the GC members are poor fishermen	60% of the GC members are poor fishermen
4. Increasing water holding capacity through re-excavation of surrounding water bodies to improve the fish habitat with other aquatic flora and fauna	Re-excavation activities is done on regular basis	Re-excavation activities is done but not in regular basis
5. Establishing seasonal fish sanctuary to increase productivity of aquatic flora and fauna during dry season	Maintain as a permanent seasonal fish sanctuary	Have no seasonal fish sanctuary
6. Afforestation and reforestation within and surrounding the haor area	About 20-25 thousand Hijol (*Barringtonia acutangula*) trees were planted	Tree plantation and awareness raising activities is running
7. Proper utilization of water during lean season	Have no activity	Have no activity
8. Adopt and implement programmes regarding conservation and improvement of other resources of wetlands	Taken activities as awareness rising through meetings, posters, festoons, etc. Support people regarding alternative income generation activities, manage loan from NGOs, etc.	Taken activities as Borogangina RMOs but in a small scale. Support people regarding alternative income generation activities, manage loan from NGOs, etc.
9. Adopt and implement programmes for socio-economic improvement	Create awareness about sanitation, education, social responsibilities, etc.	Create awareness about sanitation, education, social responsibilities, etc.
10. Arrange various human resource development programmes	Have no activity	Have no activity

*Regular and continuous monitoring was done in every day whereas regular awareness raising activities were done on every month.

Table 5 reports respondents' perceptions of the effectiveness of the two RMO management systems (Borogangina and Dumuria) in developing the productivity of the concerned wetlands. Respondents were asked their opinions on a set of indicators related to soundness of the concerned institution and its activities, and they assigned values to each indicator based on their judgment. The average of their scores showed the status of the RMOs.

Table 5

Performance of two major RMOs, the existing co-management system in Hail haor

Indicator	*Score*	
	Borogangina RMO	*Dumuria RMO*
Resource management	8	6
Pro-poor	7.71	7.33
Women's role	6	6
Organizational status	9.28	7.33
Governance and leadership	9.43	6.33
Total score out of 50	40.43 (80.80%)	33 (66%)

*Score was calculated out of 10 at each parameter.

Five broad indicators, namely resource management, pro-poor, women's role, organizational status, and governance and leadership, were chosen to assess the co-management system of the two RMOs in Hail haor. As can be seen, Borogangina RMO scored 40.43 (80.80%) and Dumuria RMO scored 33.0 (66%) out of 50. So, comparatively Borogangina RMO is performing better than Dumuria RMO. The reason that Borogangina was performing better than Dumuria might be more active communication with the policy makers and also better organizing capability.

Table 6 showed the perception of the local community people towards co-management and wetland conservation.

Table 6

Local community perception regarding co-management and wetland conservation

Issue	*RMOs respondent (N = 48)*	*% RMOs respondent*
Increased livelihood status	35	72.92
Fish sanctuary development	46	95.83
Bird sanctuary development	34	70.83
Release of fish fingerlings in water bodies	38	79.17
Increased employment and income opportunity	33	68.75
Positive attitude of community regarding resource management	43	89.58
Conservation of fish and wetland biodiversity	36	75.00
Fishing restrictions during breeding period	45	93.75
Haor is protected from illegal fishing	39	81.25
Conflicts mitigation	25	52.08
Increasing the number of awareness and management related trainings	36	75.00
Increasing tourism opportunity	29	60.42
Provide incentives during natural calamities	20	41.67
Improvement of communication system	14	29.17
Restoration of fish habitat	33	68.75
Development of full time conservation guard for the protection of haor resources	10	20.83

*N = total number of respondents.

The majority (95.83%) of respondents reported that this area is developed as a fish sanctuary due to co-management implementation, followed by restrictions on fishing during breeding periods (93.75%). They also mentioned that community peoples changed their attitude to one of positive approval of resource management (89.58%), and as a result, the wetland is now more protected from illegal activities than previously

(81.25%) and there is increased awareness of the importance of release of captured fish fingerlings in water bodies (79.17%). They also reported that after the co-management initiative, community awareness increased, and management related training by the authority (75%) resulted in more positive attitudes towards conservation of fish and wetland biodiversity (75%) (Table 6).

The results reveal that the haor in the regions where fishers have been more involved in co-management have yielded fish of larger sizes, greater fish abundance, and greater fish biomass (considering either all fish or only commercial fish), as well as a higher proportion of reproducing fish in high-water season. We observed differences in the biomass and abundance of fish among the regions. Furthermore, in the studied areas engaged in co-management, the fishers caught more fish, indicating that the higher fish biomass in the haor near these villages may have increased fish catches. We did not conduct detailed interviews to investigate the social status and welfare of the fishers, as done in other studies (Sultana & Thompson 2007; Solomon et al 2012). However, knowing that the fishers in the studied region rely heavily on fish for food and income (Hallwass et al 2011; Silvano et al 2014), we considered that any improvement in fish catches would also improve their socioeconomic conditions and increase their food security (Sultana & Thompson 2007). Therefore, the higher abundance of this fish in the haor in the co-managed regions may serve as insurance against future fish shortages (Gelcich et al 2008; Silvano et al 2014).

Fishers in studied areas are more dependent on fishing as a commercial activity, which may be partially related to their commitment and interest to engage in co-management. Conversely, some fishers are also dedicated to small-scale agriculture and do not regularly commercialize the fish caught (Table 2), which may partially explain the previous failure of a co-management system established by these fishers that was dismissed due to difficulties of enforcement. It is noticeable that most of the fishers' fathers also practiced fishing as their main activity in the groups: such a tradition of fishing among generations may have influenced the stronger organization of fishers from the areas towards co-management of exploited haor (Silvano et al 2014).

Major problems and challenges of co-management system in Hail haor. Co-management organizations in the Hail haor face a number of problems and challenges in wetland management. The major problems and challenges faced are: (1). The co-management system started in 1998 under the Management of Aquatic Ecosystems through Community Husbandry (MACH) project. The agreement was to renew this system after every five years. Various relevant government agencies such as the Department of Land, Department of Fisheries and Department of Livestock were actively involved in the initiative. But after 2010, the government cancelled this agreement and did not renew the tenure of this lease especially for beels which were above 20 acres in size. These beels were handed over to the private sector for aquaculture. The RMOs eventually appealed to the High Court with a writ petition against this decision, and it is still in the process of review. As a result, the management system cannot function properly and faces conflict between community people and the lessee, and the haor is losing its biodiversity due to lack of proper management; (2). Most of the time, the lessees violated the terms and conditions of their leases by catching fish throughout the year and using destructive gear because of lack of proper monitoring by the authority; (3). Presently, the government does not provide any financial help to the RMOs, so it is difficult to manage the haor efficiently and monitor it properly (concerned government officials from fishery department do not monitor regularly although they are assigned to do so); (4). Members of both RMOs afford voluntarily, and (5). Lack of specific training and awareness raising programmes on increasing wetland productivity and wetland resources management.

A SWOT (Strength, Weakness, Opportunity and Threat) analysis of the co-management system in Hail haor area was done which is shown in Table 7. One limitation of our survey is that we could not apply the rigorous before-after-control-impact (BACI) sampling design, which is usually required for studies on the efficacy of management interventions, such as reserves or protected sites (Guidetti 2002; Silvano et al 2014). We

therefore cannot unambiguously associate the observed regional differences to co-management alone, due to the lack of this before-after comparison, even considering that we properly compared control-impact areas. For instance, we cannot guarantee that fish abundance increased in the haor because of co-management intervention. Indeed, notwithstanding its importance, the BACI experimental design has been rarely adopted, even in the much better studied marine and reef fisheries (Francini-Filho & Moura 2008): most of the knowledge base and recommendations about the benefits of marine protected areas and other management approaches have been based on studies that lack BACI sampling (Guidetti 2002).

Table 7

SWOT analysis of co-management and wetland conservation in Hail haor

Strength	*Weakness*	*Opportunity*	*Threat*
Active participation of the local community in resource management	Too few financial projects are running that support community people	Should be strong linkage between RMOs, FRUGs and other stakeholders in co-management activities	Small amount of budget for AIG support to the community and members of RMOs afford voluntarily
Resource user conflicts are significantly decreasing	Not proper monitoring of the wetland resources	Increase the monitoring programme to mitigate the existing conflicts	Have not enough employment scope to reduces community resource dependency
Co-management involves a greater share of management to empower local communities	Community organizations have over-complex structures	Transform and empower poor user groups to become resource managers	Hunting and water pollution reduces usable habitat for many species
Women are now involved in resource management planning	They have taken out credit or loans with too high interest	Small-scale business can reduce dependency on external loans	Most of the women are not involved in such activities
AIG activities reduces extreme poverty and resource dependency	Most of the time in a year, the young have no work and are unemployed	Create employment opportunity and develop enterprises based on value-added wetland products	High illiterate rate is a major problem
Government and NGOs are working together for improvement of the resources	Institutional arrangements for wetland management are too complex	More sufficient funds and coordination among organizations can increase the efficiency of these activities	Firewood collection and grazing hampers the natural regeneration of swamp forest trees

Our synthesis shows that co-management holds great promise for successful and sustainable fisheries as a whole. However, there is an urgent need to gather long-term ecological, economic and social data from a variety of fisheries in a multidisciplinary context in order to compare empirically different degrees of users' involvement in management decisions and to better understand and improve fisheries co-management (Gutiérrez et al 2011; Levin 2010).

Conclusions. The fishing benefits and livelihood improvement of the co-management initiatives in the Hail haor are encouraging and indicate that co-management could be a viable strategy for addressing the heterogeneity of fisheries in wetland management, and a viable alternative to protected areas. Co-management may also help to maintain the sustainability of fisheries in large tropical wetland basins including Bangladesh. However, although co-management may potentially contribute to local conservation and development efforts, systematic programme assessments will be essential to ensure long-term conservation and livelihood success. The present study suggests that the importance of Hail haor for the livelihoods of the community living in the immediate area and in that part of Bangladesh in general is immeasurable; that co-management activities should be further enhanced; and that all fishers surrounding the villages should

actively participate in co-management institutions and activities. Monitoring attitudes, behaviours and the health of the resource base are critical elements of resource sustainability. It is also imperative that strategies must be developed with input from scientists, resource managers, policymakers, government and non-government organizations and other relevant stakeholders, with the objectives of enhancing production, maintaining biodiversity in a sustainable manner and improving the livelihoods of the remaining, highly marginal fishermen in this region.

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