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Impact of community-based fisheries management practices on production and species diversity in Turag-Bangshi basin floodplains in Kaliakoir, Gazipur, Bangladesh

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Abstract
The study was conducted to investigate the communities perception and compliance to community-based fisheries management (CBFM) in Turag-Bangshi floodplains under Kaliakoir, Gazipur District. Measures such as ban on use of the harmful fishing gears, seasonal fishing closure, halt of fry fishing, halt of dewatering of beels and the impact of establishment of sanctuaries on fish production and species diversity were introduced by MACH project. Almost all members of the communities in Turag-Bangshi MACH (Management of Aquatic Ecosystem through Community Husbandry) site welcomed the introduction and complied with the implementation of all management measures which helped stopped use of harmful fishing gears, ensured survival and breeding of brood fish in the rainy season, protected and allowed fry to grow big, restored lost and degraded fisheries and organized communities for sustainable development of the fisheries. A total of 51 species of fishes were found in Makosh *beel* (natural depression). Among these, small indigenous species (SIS) under Cyprinidae family (*Puntius sophore*) was the most dominant. Many species available in the past recorded disappeared from the Makosh *beel* due to loss of habitat and industrial pollution that damaged spawning and nursery grounds of fish. Introduction of some selective native endangered species (*Nandus nandus*, *Notopterus notopterus*, *Ompok pabda* and *Labeo calbasu*) by MACH in the Turag-Bangshi water bodies increased diversity of species from 82 to 95. Over a period of five years during MACH intervention, the average production remained nearly 200% higher than the baseline production of 57 kg/ha to present 207 kg/ha due to maintaining sanctuaries and the closed fishing seasons. Per capita daily fish consumption of the surrounding communities also increased by 78% (from 27 to 48 g/person/day) which is much higher than the national average fish consumption in Bangladesh. The implementation of community-based MACH project management measures substantially improved fish habitat, production, consumption and socio-economic conditions of the surrounding communities. The model can be used to improve the floodplains of Bangladesh.

Key words: Community-based fisheries management, Sanctuary, Biodiversity

Introduction

The inland capture fisheries of Bangladesh has registered a gradual decline due to over-exploitation and degradation of wetland habitats resulting in the loss of suitable habitats for large number of riverine and floodplain endemic fish species (Craig *et al.* 2004). Human impacts on ecosystems such as water pollution, construction of embankments for flood controls, etc, contributed to many valuable indigenous fish species to be threatened or endangered. Over the last 15 years, the water flow into Bangladesh from upstream rivers has been reduced by 25% and the downward trend is expected to be continued (Hussain and Mazid 2001).

The floodplains in Bangladesh are the most suitable spawning and feeding grounds of many freshwater fish species (Rahman *et al.* 1999, Thakur and Das 1986a and b). The decrease of floodplains, the catch rates per unit areas affected by the FCDI projects reduced to as much as 75% according to fishermen (Nishat and Bhuiyan 1995). As a result, the rural poor and fishermen who were dependent on fishing in these water bodies for nutrition and livelihood for centuries lost their means for survival. Therefore, effective implementation of appropriate fisheries management measures such as regulation of fishing gear and catch efforts, over-exploitation and open access, establishment of sanctuaries, restoration of degraded wetlands is absolutely necessary to revive the lost floodplain, improve the livelihood of fishermen and fish production (Welcome 1985, Craig *et al.* 2004, Parvin and Faisal 2002, Nabi 1999, Hossain *et al.* 1999, Ahmed 1999, Ahmad *et al.* 1998). A new approach called community-based fisheries management seemed to be effective tools for sustainable fisheries management. Under such community-based management, several measures such as ban on the use of harmful fishing gears, fishing closure, halt on fry fishing, halt of dewatering of natural depression and establishment of sanctuaries were taken, which are not a easy task to do in a community. The present study was undertaken to study the impact of community-based fisheries management measures as introduced by the MACH project.

Materials and methods

MACH: MACH stands for Management of Aquatic Ecosystems through Community Husbandry. This is a joint GoB/USAID project implemented by the Department of Fisheries and sponsored by USAID. The present study conducted in Turag-Bangshi floodplain site.

Description of the study area: Lower Turag-Bangshi basin floodplains of the MACH project located about 40 km north from the capital city Dhaka. The site covers seven unions of Kailakoir Upazila under Gazipur District and one Union of Mirzapur Upazila of the Tangail District. The Turag-Bangshi River flows through the site with many *beels* (natural depression) on either side of the river. During rainy season, the floodwaters spill over the riverbanks through canals connecting the adjacent *beels* turning them into a large watershed. Through these canals fishes move from the rivers to the *beels*/floodplains for spawning and nursing. When water recedes after the monsoon the

fish either move into the deeper perennial portions of the *beel* or back into the river. The hydrology of the Turag-Bangshi Floodplain is determined principally by the monsoon occurring through May-October followed by a dry period in November-April. Of the 26 *beels* lying in the project area, Makosh *beel* was selected for the study during October-December 2006. The general information of the Makosh *beel* is given in Table 1.

Table 1. Demographic and environmental information of Makosh *beel*

Environmental information (Water resources)		
Annual rainfall	:	1400-1800 mm
Overall catchment	:	14,574 ha
Wet season area	:	4,374 ha
Dry season area	:	37 ha
Associated floodplain	:	23,230 ha
Rivers in the project	:	Turag, Bangshi, Goalia, Upper Turag
Beels in the project	:	26 Nos. (Perennial-10)
Demographic information		
Population	:	225,905
Family size	:	5.31
Literacy rate	:	48%
Landless families	:	89%
Full-time fishing	:	15%
Household fishing	:	85%

Source: MACH Turag-Bangshi site Technical Paper-1, May 2006

Data collection

Primary information on understanding and compliance to various fisheries management measures as introduced by the MACH project management and their impacts on production in general and sanctuary in particular were collected through interviewing the members of the Resource User Groups (RUG), Resource Management Committees (RMC) and the Resource Management Organizations (RMO) as constituted by the project. Data on project management matters and the benefits of introducing resource management measures were obtained from secondary sources such as MACH project publications and reports.

Community understanding and compliance to MACH management tools

A pre-designed questionnaire was used to get response in regards to understanding and compliance of the Resource Users Communities (fishers) to the introduction of 5 fisheries management tools which include: ban on the use of harmful fishing gears, seasonal fishing closure, halt of the fry fishing, halt of dewatering of *beels*, and establishment of sanctuaries. Participatory Rural Appraisal (PRA) and some semi

structured questions were also used for collection of qualitative data for supplemental stocking, fish production, economic benefits and water pollution. Information on fish diversity as affected by various factors like over-exploitation, water management, supplemental stocking and aquatic pollution were collected by using a pre- designed questionnaire and direct sampling of fish in Makosh *beel* of the Turag-Bangshi basin. Data on fish production from Makosh *beel* was obtained from the site office of MACH.

Results and discussion

Impacts and compliance to various MACH introduced fisheries management tools

To asses the impacts of various fisheries management tools applied by MACH, a total of 60 fishermen from adjacent Resource Users Groups (RUG) were interviewed at home/and/or *beel* area during the study period. The results of the interview focused on the impact of the various MACH introduced management tools are summarized in Table 2 and discussed below:

Table 2. The response of beneficiaries on conservation management tools

Management tools	Happily accepted (%)	Not happily accepted (%)
Ban on the use of harmful fishing gears	89	11
Seasonal closure	88	12
Halt on fry fishing	82	18
Halt of dewatering of *beels*	96	4
Establishment of fish sanctuaries	99	1

Ban on the use of harmful fishing gears

Various types of fishing gears were found to operate in the Makosh *beel* where most of the gears were traditional and few of them were exclusive. Some forms of gears are found to be used round the year. These are by nature non selective gears. On the other hand, selective gears are used for relatively shorter period mainly during floods because the target species can be caught by that particular gear during that season. Hence, smaller meshed gill nets are used during early monsoon (June-August) to catch monsoon breed younger fish. With the growth of fishes, large mesh size gill nets come into operation to catch larger fish, during September to December. Time of the day is also important in fishing. Some of the gears are operated intensively at night, others at dawn, dusk or at mid day. The fishing gears which were found to operate in the study area were broadly categorized on the basis of their degree of harmfulness and impacts on fish population and shown in Table 3.

Table 3. Categorization of fishing gears based on their impacts on floodplain fisheries

Impact levels	Name of the fishing gear (English/local)
Harmful	Seine net- Net jal, Veshal jal Cast net - Jhaki jal, Khepla jal Fish trap - Dughair/Koi dughair
Very harmful	Gill net - Current jal, Kauri jal
Fish friendly	Clap net - Bhuti/Bhuri jal Hand seine net - Duri jal Push net - Thela jal Gill net - Fash jal above 9 cm Lift net - Dharma jal Fish trap - Bhair, Charo, Biti, Tubo, Arinda, Polo Hooks and line - Long line, Chip borshi, Chin borshi Wounding gear - Koch, Juti, Achra, Teta

A total of 28 different kinds of traditional fishing gears were recorded from the study area. Besides, dewatering and handpicking were also practiced by fishermen. Some gears are recognized as highly harmful to fish namely current jal (monofilament nylon gill net) and kauri jal (fine mesh seine net). About 89% of the respondent welcomed introduction of the ban on use of current jal and kauri jal in MACH sites and they are well aware of its negative impact on fish production. DoF, RMOs and UP Chairmen are involved in motivation and monitoring activities for implementing the ban on the use of harmful gears in the MACH site.

Seasonal closure

Three categories of fishermen living in four villages around the Makosh *beel* were found to be engaged in fishing. They are professional fishermen fishing round the year, Seasonal fishermen fishing during a part of the year both for livelihood and subsistence fishermen fishing only for fish consumption. The highest number of fishermen were found to be fishing during the post-monsoon and the lowest in pre-monsoon season. The project introduced seasonal closure in Turag-Bangshi during the month of April-June each year. The beneficiaries welcomed introduction of closure being convinced that every brood fish will get chance for breeding and recruitment which will ultimately increase production for better harvest leading to increased harvest and income during the rainy season. However, the professional fishermen urged for alternate source of income during fishing closure seasonal.

Halt on fry fishing

The small indigenous cyprinid, catfish and snakeheads spawn in the early monsoon

and the fries move to the shallow areas of the *beels* for grazing and nursing. In order to protect the fry, the project imposed halt on fry fishing and arranged monitoring by RMOs. About 82% of the respondent welcomed the halt on fry fishing as they were fully convinced that these fry will grow up marketable size within few months with high market price and a portion of these will remain as brood fish for breeding in the next year.

Halt of dewatering of beels (natural depression)

The majority fish in the *beel* are resident species. They live permanently and complete entire life cycle in the *beel* and its associated floodplains. So, there is a need to preserve water in the dry season for them. However, full drying of *beel* and other aquatic habitats for the purpose of irrigation in crop field is a common practice in Bangladesh. This is highly detrimental which leaves no place for the fish to survive. To make matters worse for fish, the water that remains is sometime pumped out to the last drop for catching any remaining fish. Other aquatic animals and plants are also destroyed when all water is removed. As a result, no fish stock remains to breed in the next monsoon with subsequent decline in fish stocks. This also affects biodiversity. In order to present decline, MACH has implemented halt of dewatering of *beels* in the Turag-Bangshi site through local NGO support. About 87% of the resource users group gladly accepted the initiative to ensure enough fish to breed in the next rainy season.

Establishment of sanctuaries

One of the main management tools that the project adopted is establishment of aquatic sanctuaries in order to provide all time safe home for fish and to protect them from not being caught. Sanctuaries are established in a particular perennial portion of the water body where fishing is not done round the year. Different types of shelters and barricades are placed in and around the sanctuaries so that no one can fish within the sanctuaries. All resource users (99%) have been found to welcome establishment of sanctuaries and consciously refrain from fishing along with preventing others to fish.

Fish diversity

It is quite difficult to determine the actual biological diversity in an open water ecosystem within a short period of time. Nevertheless, attempts were made to measure fish biodiversity by direct sampling in different places in Makosh *beel* during the study period. The fish populations were studied by observing fish from markets and catches from different fishing sites. Previous fish production data were collected through interviews of the fishermen and local villagers living around the Makosh *beel*. Data on fishing gear and catch per unit effort (CPUE) was taken directly from the field by observing the gears used and catches there from as well as by interviewing the fishermen. The species of fish as recorded during the study in the Makosh *beel* caught by

different fishing gears are presented in Table 4.

Table 4. List of fish species recorded in Makosh *beel* in Turag-Bangshi MACH site

Sl. No.	Common/ English name	Family	Local Name	Scientific Name
1	Minnows	Cyprinidae	Rohu	*Labeo rohita*
2	& Carps		Mrigal	*Cirrhinus mrigala*
3			Kalbasu	*Labeo calbasu*
4			Gonia	*Labeo gonius*
5			Mola	*Amblypharyngodon mola*
6			Chep Chela	*Chela cachius*
7			Chela	*Salmostoma bacaila*
8			Dhela	*Rohtee cotio*
9			Batashi	*Paseudeutropius atherinoides*
10			Dankina	*Rasbora daniconius*
11			Gutum	*Lepidocephalus guntea*
12			Puiya	*Lepidocephalus irrorata*
13	Barb		Chala puti	*Puntius chola*
14			Tit puti	*Puntius ticto*
15			Jatt puti	*Puntius sophore*
16			Giliputi	*Putius gelius*
17	Loaches	Gobitidae	Rani	*Botia dario*
18	Clupeids	Sardines	Chapila	*Gudusia chapra*
19		Clupeidae	Kachki	*Corca soborna*
20	Catfish	Schilbeidae	Kajoli	*Ailia coila*
21		Siluridae	Pabda	*Ompok pabda*
22		Bagridae	Bajrai Tengra	*Mystus tengara*
23			Tengra	*Mystus vittatus*
24			Batashi	*Batasio batasio*
25			Gulsha	*Mystus bleekeri*
26			Ayre	*Aorichthys aor*
27			Guji Ayre	*Aorichthys seenghala*
28			Magur	*Clarias batrachus*
29		Heteropneustidae	Shingi	*Heteropneustes fossilis*
30	Featherbacks	Notopteridae	Foli	*Notopterus notopterus*
31	Snakehead	Channidae	Taki	*Channa punctatus*
32			Shol	*Channa striatus*
33			Cheng	*Channa orientalis*
34	Eel	Mastacembelidae	Tara baim	*Macrognathus aculeatus*
35			Guchi baim	*Macrognathus pancalus*
36			Boro baim	*Mastacembelus armatus*
37	Gouramies	Osphronemidae	Khalisha	*Colisa fasciatus*
38			Chuna Khalisha	*Colisa sota*
39			Vheda/Meni	*Nandus nandus*
40	Glassfish		Lamba chanda	*Chanda baculis*

41			Gol chanda	*Chanda nama*
42			Lal chanda	*Chanda ragna*
43	Puffers	Tetradontidae	Potka/Tepa	*Tetraodon cutcutia*
44	Gobies	Gobitidae	Baila	*Glossogobius giuris*
45			Gugri baila	*Brachygobius nunus*
46			Nadi baila	*Awaous stamineus*
47	Perches	Ambassidae	Koi	*Anabus testudineus*
48			Napit koi	*Badis badis*
49			Tinchokha	*Aplocheilus panchax*
50	Gars	Belonidae	Kakila	*Xenentodon cancila*
51	Prawn	Palaeomonidae	Gora Icha	*Macrobrachium styliferus*

A total of 51 species of fish have been identified in Makosh *beel*. Many of them live in the rivers during dry season. They migrate laterally onto the floodplain through canals for breeding, feeding and growing during early monsoon. Their larvae, young and adults migrate back to the river during late monsoon when water recedes. According to the villagers and the fishermen, many species available in the past disappeared now from the Makosh *beel* due to destruction of breeding and nursery ground by reduction of habitat destruction for agriculture and industrial pollution. Among the available 51 species, small indigenous species (SIS) under Cyprinidae family exist in highest number. According to the survey done by MACH, species diversity of fish in Turag-Bangshi site varied from 82 to 95 in different years (1999 to 2006) and dominated by weight by Jat puti (*Puntius sophore*), a typical open water barb in Bangladesh. Small shrimps were highest by percentage composition (10-19%) (MACH Technical report, 2006) at baseline as well as subsequent years is a matter of concern because a high proportion of shrimps in floodplain catches indicate a fishery that has severely been damaged due to lack of appropriate conditions for breeding and recruitment of larger *beel* resident fishes (de Graaf *et al.* 2001).

Reintroduction of threatened fish species by MACH

To enhance and maintain the biodiversity, a total of 312,700 individual fish belong to 11 endangered species were released to the floodplains by the MACH project. The reintroduction along with establishment of sanctuaries and improvement of habitat contributed to increase species diversity from 82 (baseline year 1999) to as many as 95. The RMOs also successfully re-established some key lost species such as *Nandus nandus*, *Notopterus notopterus*, *Ompok pabda* and *Labeo calbasu*. The reintroduced species in many cases have been reported to breed in the area and successfully maintaining a viable population. A list of such reintroduced species is shown in Table 5.

Table 5. List of threatened fish species reintroduced by MACH in Turag-Bangshi site

Sl. No.	Common Name	Local Name	Scientific Name
1	Carp	Rohu	*Labeo rohita*
2		Kalbasu	*Labeo calbasu*
3	Minor carp	Shar punti	*Puntius sarana*
4		Gonia	*Labeo gonius*
5	Catfish	Pabda	*Ompok pabda*
6		Boal	*Wallago attu*
7	Snakeheads	Shol	*Channa striatus*
8		Gojar	*Channa marulius*
9	Featherbacks	Chital	*Chitala chitala*
10		Foli	*Notopterus notopterus*
11	Guramies	Meni/Bheda	*Nandus nandus*

Source: MACH Turag-Bangshi site Technical Paper-1, May 2006

Impact of sanctuary on fish production

Since 1999, RMOs have established 23 fish sanctuaries in the Turag-Bangshi site covering nearly 10 hectares of water area. The Ministry of Land has also established three permanent sanctuaries in the Turag river under the co-management of RMOs and the local government organizations. Nine sanctuaries in Makosh *beel* and seven in Aowla *beel* floodplains have been established by the local communities in parts of areas where they have fishing rights. Each sanctuary has its own management committee constituted from the surrounding communities and the membership of the local committees makes up the general bodies of the four RMOs. The sanctuaries have been demarcated by flags placed on bamboo pools and have permanent signboards. With the aim of protecting fish in the dry season when water dwindles to about 7% of its monsoon extent, the river sanctuaries are positioned in scour holes, locally called Kum, and the *beel* sanctuaries likewise are located in the deepest points, locally known as Doho. Establishment of sanctuaries, restriction of fishing during early monsoon, and reduction in fishing effort by MACH supported resource users, fish catches in three large wetlands have increased markedly (Fig. 1). Over five years (2000-2005), the average catch has remained nearly 200% higher than baseline figures due to maintaining sanctuaries and closed seasons. The baseline catch in 1999 was 57 kg/ha whereas the average over the next five years was 207 kg/ha.

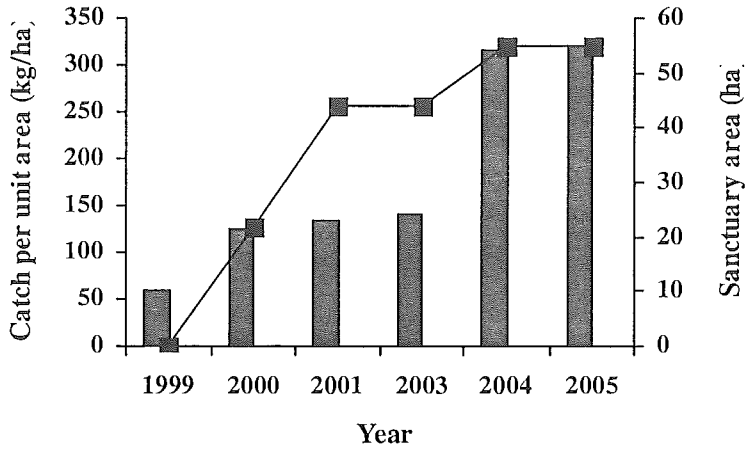

Fig 1. Showing the production of Sanctuaries under MACH sites
(Source: MACH Technical Paper-1, May 2006)

Overall fish production

The results of fishing effort, total estimated catch and fish consumption rates in Turag-Bangshi site are shown in Table 5. Fishing effort is considered as one attempt by any number of fishermen using one set of gear or as the means through which fish are caught. The intensity of the fishing effort depends on seasons of the year. Most of the areas of the *beel* remain dry during the dry season from January to March. With the onset of the monsoon rises in water levels, the use of all types of fishing gears also increases simultaneously. Due to the vastness of water bodies, gears are operated more frequently during the monsoon (July-September). When water level starts receding during the post- monsoon period (October-December), the number of gears decreases due to less abundance of fish. The catch per unit of effort (CPUE) in Turag-Bangshi site is calculated as catch in kilograms per person per day (kg/person/day) and catch per unit of area (CPUA) calculated as catch in kilograms per hectares of water body (kg/ha) and shown in Table 6.

Table 6. Changes in fish catches in relation to wetland management activities in MACH Turag-Bangshi sanctuaries

Year	Area of sanctuaries (ha)	Total estimated catch (ton)	Effort (person/ day/ha)	CPUE (kg/ person/ day)	CPUA (kg/ha)
1999-2000*	0	253	217.3	0.27	57.8
2000-2001	22.34	546	397.5	0.31	124.7
2001-2002	44.48	558	491.7	0.21	104.8
2002-2003	44.48	613	500.4	0.28	140.1
2003-2004	54.59	1,379	509.3	0.62	315.2
2004-2005	54.59	1,403	717.2	0.45	320.7

Source: MACH Technical Paper-1, May 2006 (* Baseline, no management intervention)

The findings reveal that CPUE of 0.27 kg/person/day was lowest in the baseline year (1999) and increased to 0.45 kg/person/day in 2005 after 6 years of MACH management interventions. Similarly, CPUA also increased from the baseline year (58 kg/ha) compared the year 2005 (321 kg/ha). A substantial increase in total fish catch and in catch per hectare was observed in the water bodies brought under MACH management practices. Total estimated catch increased by 2 to 6 times over the baseline catch of 243 tons in the year of 1999 to 1,403 tons in 2005 by when MACH also reestablished 11 threatened fish species. Gains in fish catches in the site are remarkable as the fishery was in a very poor condition before the restoration program. Per capita daily fish consumption among the surrounding communities increased by 78% (from 27 to 48 g/person/day) (MACH Technical Paper-1, May 2006) which is much higher than the national average fish consumption in Bangladesh. The communities now can catch more fish in the floodplain to feed their families as well.

Economic benefits

The total fish catch from the project command area has increased each year from baseline catch. To calculate the economic benefits of the Turag-Bangshi fishers' community yearly total catch was multiplied by the per kg price of fish (average price assumed at Tk 60 per kg) and the results were converted as million Taka and compared with the baseline value. From Figure 2, it is revealed that additional value of fish has increased with the increase in annual catch. This has generated more income and improved the socio-economic status of the fishers' community. In addition, increased catch provided opportunities to improve over 85% of households in the project area in fishing activities. The project also provided training and credit to those household groups who own less than 0.2 ha of land. Therefore, the poors have been benefited by various ways.

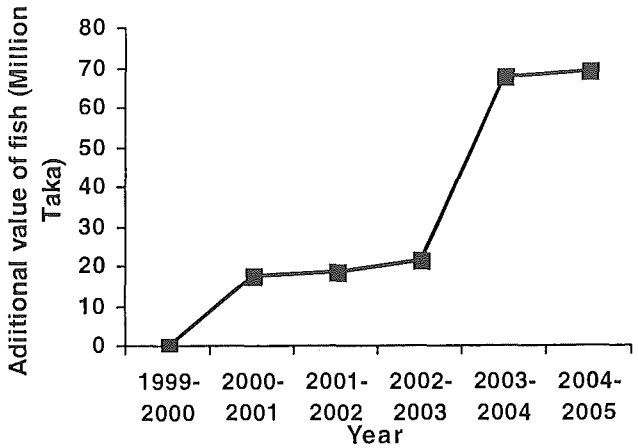

Fig. 2. Additional income from fish production in Turag-Bangshi site (Data constructed from Table 6)

Water pollution

An increasing aquatic pollution is noticed in the Turag-Bangshi site due to setting up of a large number of chemical and textile industries in the surrounding areas. This industrial pollution seriously damaging the aquatic ecosystem of the Makosh *beel* in Kaliakoir and also adversely affecting the people who rely on its water for bathing, agriculture and fisheries. According to the local communities, particularly during dry season when water volume decreased industrial effluents damage the water quality parameters to a level that cause sudden total mortality of fish in the *beel.* The sudden death of fish due to discharge of industrial toxicants is reported to be the major cause of decline of brood fish in Makosh *beel* as well as in other Turag-Bangshi sites. The local communities reported that fish from some parts of the *beel* now are not safe and edible and fish kills in the Turag River sanctuaries are also observed. Industrial pollution is one of the three major sources of inland waters of Bangladesh following agrochemicals and domestic wastes (Haque 1989). The Resource Management Organizations (RMO's) are campaigning for their right to cleaner water. Five teams now regularly monitor water quality in the *beel* and the river, and this activity is designed to sustain after MACH support ends. Adoption of best practices of toxic disposal and creation of awareness among the people of the extent of damage of pollution, the situation is expected to improve. Floodplain fisheries play an important role in providing nutrition and livelihoods for rural people of Bangladesh. The main purpose of the present study was to investigate the understanding and communities compliance to overall MACH introduced fisheries management measures and the impact of establishment of sanctuary on fish production in its Turag-Bangshi site in Kaliakoir under Gazipur District. The implementation of community-based MACH management measures have resulted in substantial improvement of fish habitat, fish production, fish consumption and economic conditions of the surrounding communities.

Conclusion

Establishment of sanctuaries and restocking of fish have significantly increased the capture fisheries production, species diversity and reestablishment of endangered and disappeared species. Although the five years during project intervention the average production remained nearly 200% higher than the baseline production of 57 kg/ha to 207 kg/ha due to maintaining sanctuaries and closed fishing seasons. Total fish catches increased by 2 to 6 times from 243 tons in 1999 to 1,403 tons in 2005. Per capita daily fish consumption of the surrounding communities increased by 78% (from 27 to 48 g/person/day) which is higher than the national average fish consumption in Bangladesh. The socio-economic status of the fishers community has substantially improved due to increase in fish production and income. The results obtained by MACH provide new insights into the management and improvement of floodplain fisheries resources. It is therefore, suggested that the Ministry of Fisheries and Livestock should replicate the new community-based floodplain management approach

as developed by the MACH project in other floodplain areas for gradual development of floodplain fisheries and the fishing communities of Bangladesh.

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