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Status of Fisheries Resource and Management Approach in the Open *Beels* of Bangladesh: A Comparative Case Study

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Abstract

A fish catch monitoring program was introduced in Ashura *beel*, Goakhola *beel* and Dikshi *beel* in 1997 through the Community Based Fisheries Management (CBFM) project. The project focused on developing community management approaches which would encourage participation of the fishers, beneficiaries and community in sustainable management of the fishery resources. The present study conducted in all three open *beels* indicated that the 2002 annual fish production increased by 359 and 222% compared to the base line survey in 1997 in Goakhola and Dikshi *beels*, respectively, but only 53% in Ashura *beel*. The catch per person per day increased by 50 and 123% in Goakhola and Dikshi, respectively, but decreased by 40.5% in Ashura *beel* as compared to the base line catch in 1997. Species diversity was higher in Ashura and Dikshi *beels* in 2002 than in 1997; however, Goakhola *beel* was more diverse in 1997. Estimated MSY for Ashura, Goakhola and Dikshi was 48.0, 23.0 and 78.0 tons, and corresponding fishing effort 16452, 7812 and 19984 gear days•year^{-1}, respectively. Analysis of effort data indicated that maximum fishing pressure has been reached or exceeded for all three floodplain *beels* and any further increase in catch effort should be restricted.

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Introduction

The inland fishery of Bangladesh covers about 4.5 million hectares and is considered the most important aquatic resource base of the country. Seasonally inundated flood lands and *beels* (low lying depression) contribute 36.4% of the total inland open water fish catch (DoF 2003). At the macro level, fish constitutes 5 to 6% of the gross domestic product and more than 4.8% of the country's export earnings (DoF 2003). Economically, more than 90% of the rural community depends on fisheries for their livelihood. Small-scale aquatic resources or water bodies with associated physical and biological attributes constitute a lifeline to these subsistence communities (Silvius et al. 2000).

There are more than 300 species of fish and prawns living in and around the wetlands of Bangladesh (Rahman 1989). The various native fish species are a source of nutrition and income to the rural population (Rainboth 1990). Small fishes are the accessible and preferred food of poor people and are a good source of micro-nutrients (Thilsted et al. 1997). Minkin et al. (1997) observed that a rural household consumes more than 50 species of fish or prawn during the course of a year. Besides fish, in the *beels* there are several indigenous aquatic plants, including water hyacinth and lotus, which are used as livestock feeds; some aquatic vegetation is also consumed by humans. The *beel* fishery also serves as a main economic resource for communities of landless fishers.

Generally there are no restrictions to local people fishing in the *beels*. During winter the semi-dry areas are used to cultivate rice, locally known as *boro*. The basic mechanism for managing the *beels* has been based on the allocation of fishery and cultivation rights through periodic leasing. The district administration usually leases the *beel* water-body to the fishers, mostly represented by community based organizations, through an auction. Similarly, they issue a short term lease to farmers for cultivation. Inland fisheries under competitive leasing have intermediary managers in the form of 'Leaseholders'- local elites who include fisher leaders, money lenders, landowners, politicians and professional *jalmohal* managers (Thompson 2004). In most cases the *beel* water area and the cultivation area overlap, causing conflicts between farmers and fishers.

A Community Based Fisheries Management (CBFM) project is being implemented through a partnership with the WorldFish Center, the Department of Fisheries (DoF), and several partner NGOs, to test and

access alternative local fishery management arrangements that might achieve greater efficiency, equity and sustainability. This paper focuses on the *beel* fishery resources management of three open *beels*, the Ashura *beel*, Goakhola *beel* and Dikshi *beel* studied under the project during 1997 to 2002 to assess the status of resources and effectiveness of management intervention in the *beels*.

Management approach and status

Partner NGOs helped the fishers to organize *Beel* Management Committees (BMCs) for fishery resources management. Beel Management Committees were formed in all three water bodies through election of members by stakeholders and have their own resource management plans and rules. The number of BMC members was 50, 31 and 30 for Ashura, Dikshi and Goakhola, respectively. Committees generally adopted simple conservation-based measures (Table 1).

Table 1. Management interventions under Community Based Fisheries Management

Name of water body	Closed season	Management status				
		Closed area	Gear/fishing restriction	Habitat restoration	Sanctuary	Approaches
Ashura *Beel*	May-July	Fishing restriction around fish sanctuary	Mono-filament gill net	Withdrawal of 33 fish aggregating devices	Sanctuary of 8 ha estab-lished in 1997 to protect biodiversity	Fishers Managed Fishery
Goakhola *Beel*	May-July	Fishing restriction around fish sanctuary	Gear restriction during dry season	Partially excavated	1.22 ha fish sanctuary from Nov 2002	Women Managed Fishery (fishers & farmers)
Dikshi *Beel*	May-July	Fishing restriction during dry season	Gear placement restricted to protect breeding stocks	Excavated area in *beel* with *khata**	Sanctuary of 0.4 ha established in Nov 2002	Fishers Managed Fishery

***** Fish aggregating device

Materials and Methods

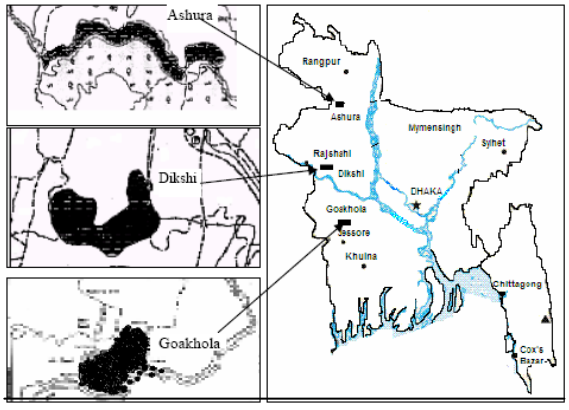
Ashura *beel* is located in Nawabganj Upazilla 70 km southeast from Dinajpur district, with 29 villages around the *beel*, where a diverse community includes immigrants and ethnic minorities spread across all

villages. Total area of *beel* is 252 ha, including seven depressions. The ecosystem of this *beel* supports many wild fish species. The *beel* fishery is also a key economic resource for landless fishers. During the wet-season it forms as a water body with multiple uses that can be accessed by the community. During winter when the monsoon flood water recedes, the underlying land becomes available for the cultivation of rice on privately held plots. Of the 604 beneficiaries, 77 were female. Caritas, one of the partner NGOs, started working around this water body with the fishers in early 1996.

Goakhola *beel* is located 17 km from Narail District in southwest Bangladesh. The *beel* consists of a large private floodplain area and this seasonal *beel* is connected by Goakhola canal to Afra canal, which connects to Bhairab River. The whole area is a privately owned farmland except for a small connecting canal. The depth of the *beel* area is 1.2 to 1.8 meters during the monsoon season, which lasts for five to six months. The water level in the *beel* and adjoining *beels* is now controlled by a sluice gate located at the mouth of Goakhola canal. During the monsoon season the *beel* fishery extends over 250 ha. All 60 beneficiaries are female. Banche Shekha, a local NGO has been working with the women beneficiaries around this *beel* since 1997.

Dikshi *beel* is a floodplain water body located in Chatmohor Thanas of Pabna District. The *beel*, a physically open floodplain is officially only 10.5 ha. During the monsoon season, the coverage extends over several hundred ha of private land. Most parts of the *beel* are cultivated during winter. One canal connecting the *beel* and river is blocked by a sluice gate. All 344 beneficiaries are male. Caritas has been working with the beneficiaries around the *beel* since 1997.

The three *beels* were selected as they vary in characteristics (Map 1), being open or privately owned lots. All three *beels* share a similar characteristic as being the main livelihood provider to many residents in the adjacent rural communities.



Map 1. Location of the three beels in Bangladesh

Catch monitoring and gear surveys

Fishing activity was observed for four to eight days per month, per site, continuously for 72 months. Gear surveys involved a regular spot survey for a sample of gear in operation, and the total catch from each gear type. Gear census covered the number and types of gear operating in the study sites. Species-wise catch statistics for each gear type was recorded.

The average number of gear units per day was used to estimate total gear-wise fishing effort for that month as well as for the whole year. Mean gear-wise catch rate was used to estimate total catch for that month, as well as for the whole year.

Gear wise overall species distributions were calculated from annual catch statistics data. Year wise as well as overall species distributions were calculated from catch statistics data.

Khata (fish aggregation device) and kua (ditches) census

A census of all *khata* and *kua* in the study sites was undertaken from 1997 to 2002. Data including information on species composition and abundance were collected from fishers during the harvest season. Annual catches of *khata* were based on the total seasonal harvest and expressed as catch per ha of *khata* per year.

Shannon-Wiener diversity index

The Shannon-Wiener Index (H′) is one of the several indices used to measure biodiversity. The function is defined as:

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

where $_S$ = number of species and p_i = the proportion of individuals from the i^{th} species in the sample.

Regression analysis between dependent variables (gear days and person days) and catch rates was determined. The surplus production model of Schaefer (1954) was used here to estimate Maximum Sustainable Yield (MSY) and the corresponding fishing effort (f_{msy}).

Results

Pattern of gear changes and diversity

The fishing population in Ashura *beel* comprises 63% of full time fishers, 11% part time fishers and 26% subsistence fishers (who only catch fish for food). Since the 1997 base line survey, subsistence fishing days have increased by 28%, and were highest in 2002. With the exception of 2001, there was a steady increase in the number of fishing days in the *beel* from 1997 to 2002. Changes in gear usage among three categories of fishers showed that the full time fishers used mostly seine nets, bag nets, large lift nets and gill nets. Part time fishers generally used cast nets and hook and line. Subsistence fishers mostly used push nets. The number of gear days in this *beel* fluctuated. However compared to the baseline survey in 1997, the number of gill net, cast net, push net, trap unit, seine net and lift net days had increased by 86, 62, 495, 643, 10 and 93%, respectively, by 2002.

In Goakhola *beel*, the pattern of changes among the three categories of fishers revealed that the participation of full time fishers increased abruptly in 2002. The participation of subsistence fishers was low in 1997 but increased gradually from 2000 to 2002.

Gill net, trap, cast net, hook and line, lift net and spear are among the most prominent gear types used in Goakhola *beel*.

In Dikshi *beel*, the number of full time fishing days and subsistence fishing days increased significantly from 1999. There was a slight decline in the number of fishing days during 2002 due to the reduction of fishing pressure which is a part of the fishery resources management under the project. Gill nets, trap units and hooks and lines are among the main gear types extensively used in Dikshi *beel*. Cast nets, long-lines, lift and push nets are less common.

Main species and gear efficiency in Ashura, Goakhola and Dikshi beel

While, the fishing gears widely used in the *beels* have harvested almost all abundant species, some selective gears captured a limited number of species. The most abundant species, which in total contributed more than or around 90% of the catch for each gear type in each *beel*, are summarized in table 2.

Table 2. Gear efficiency and species composition by weight (main species) in Ashura, Goakhola and Dikshi *beels*

Gear types	Ashura Name of species	%	Goakhola Name of species	%	Dikshi Name of species	%
Gill net	*Wallago attu*	36.9	*Puntius sophore*	32.0	*Puntius sophore*	39.3
	Mystus tengara	22.3	*Anabus testudi-*	17.7	*Channa puncta-*	12.7
	Puntius sophore	15.2	*neus*		*tus*	
	Mastacembelus	6.25	*Channa punctatus*	10.9	*Colisa fasciatus*	10.2
	pancalus		*Macrognathus*	8.23	*Nematopalaemon*	3.62
	Cyprinus carpio	4.84	*aculeatus*		spp.	
	Mystus bleekeri	3.14	*Heteropneustes*	7.44	*Channa striatus*	3.46
	Channa punc-	2.76	*fossilis*		*Mystus tengara*	3.26
	tatus		*Glossogobius*	5.22	*Mastacembelus*	2.97
	Hatetoneuptes	2.34	*giuris*		*pancalus*	
	fossilis		*Nandus nandus*	4.96	*Heteropneustes*	2.89
			Channa striatus	3.21	*fossilis*	
Large lift net	*Puntius sophore*	30.6	*Puntius sophore*	32.2	*Puntius sophore*	18.8
	Nematopalae-	13.9	*Channa striatus*	10.5	*Channa punc-*	12.4
	mon spp.		*Mastacembelus*	8.14	*tatus*	
	Chanda sp.	11.3	*pancalus*		*Xenentodon.*	11.4
	Salmostoma	11.3	*Channa punctatus*	7.81	*cancila*	
	bacaila		*Labeo rohita*	7.69	*Hypophtalmich-*	7.20
	Amblypharyngo-	8.42	*Xenentodon*	6.90	*thys molitrix*	
	don mola		*cancila*		*Nematopalaemon*	5.89
	Mastacembelus	4.95	*Colisa fasciatus*	4.97	spp.	
	pancalus		*Macrognathus*	2.91	*Catla catla*	5.38
	Mystus tengara	4.84	*aculeatus*		*Colisa fasciatus*	4.91
	Gudusias sp.	3.64			*Chanda ranga*	4.57
Cast net	*Mystus tengara*	36.7	*Puntius sophore*	37.6	*Puntius sophore*	44.8
	Puntius sophore	26.2	*Channa punctatus*	17.4	*Channa punc-*	15.6
	Channa puncta-	10.5	*Channa striatus*	10.3	*tatus*	
	tus		*Mastacembelus*	5.36	*Colisa fasciatus*	13.4
	Mastacembelus	9.08	*pancalus*		*Channa striatus*	6.68
	pancalus		*Mystus tengara*	5.02	*Xenentodon*	3.78
	Nematopalae-	8.11	*Nandus nandus*	4.74	*cancila*	
	mon spp.		*Macrognathus*	3.82	*Mystus tengara*	2.54
	Heteropneustes	2.96	*aculeatus*		*Nematopalaemon*	2.45
	fossilis		*Colisa fasciatus*	3.39	spp.	
	Glossogobius	2.20			*Labeo rohita*	2.11
	giuris					
	Puntius concho-	1.29				
	nius					
Push net	*Nematopalae-*	44.6	*Puntius sophore*	40.0	*Nematopalaemon*	77.4
	mon spp.		*Channa punctatus*	27.5	spp.	
	Puntius sophore	29.1	*Colisa sota*	10.0	*Colisa fasciatus*	7.15
	Chanda spp.	9.20	*Heteropneustes*	9.85	*Channa punc-*	4.76
	Glossogobius	4.73	*fossilis*		*tatus*	

Table 2. Gear efficiency and species composition by weight (main species) in Ashura, Goakhola and Dikshi *beels* (continued)

Gear types	Ashura		Goakhola		Dikshi	
	Name of species	%	Name of species	%	Name of species	%
	Giuris		*Mastacembelus*	7.55	*Puntius sophore*	4.28
	Channa punc-	3.41	*pancalus*		*Mastacembelus*	2.49
	tatus		*Nemacheilus* sp.	5.05	*pancalus*	
	Esomus danricus	1.88			*Glossogobius*	1.27
	Mastacembelus	1.18			*giuris*	
	pancalus				*Macrobrachium*	0.68
	Mystus tengara	0.99			*birmanicum*	
Hook & line	*Wallago attu*	39.0	*Puntius sophore*	37.0	*Channa punc-*	60.9
	Mystus tengara	20.7	*Channa punctatus*	21.8	*tatus*	
	Channa puncta-	17.3	*Anabus testudi-*	20.6	*Channa striatus*	9.17
	tus		*neus*		*Channa marulius*	6.49
	Mastacembelus	9.21	*Mystus tengara*	7.96	*Puntius ticto*	2.31
	pancalus		*Channa striatus*	5.48	*Wallago attu*	1.69
	Heteropneustes	5.76	*Heteropneustes*	3.12	*Puntius sophore*	1.67
	fossilis		*fossilis*		*Labeo rohita*	1.54
	Mastacembelus	1.55	*L.abeo rohita*	3.05	*Xenentodon*	1.44
	armatus		*Glossogobius*	0.27	*cancila*	
	Glossogobius	1.05	*giuris*			
	giuris					
	Anabus testudi-	0.50				
	neus					
Trap units	*Nematopalae-*	56.7	*Puntius sophore*	19.0	*Nematopalaemon*	34.3
	mon spp.		*Mastacembelus*	15.9	spp.	
	Puntius sophore	28.0	*pancalus*		*Channa punc-*	14.6
	Wallago attu	2.89	*Nematopalaemon*	13.9	*tatus*	
	Chanda sp.	2.71	spp.		*Mastacembelus*	7.21
	Nemacheilus sp.	2.23	*Channa striatus*	10.4	*pancalus*	
	Puntius concho-	1.65	*Channa punctatus*	8.83	*Puntius sophore*	6.68
	nius		*Glossogobius*	4.91	*Colisa fasciatus*	6.56
	Colisa fasciatus	1.54	*giuris*		*Chana striatus*	4.96
	Mastacembelus	0.91	*Colisa sota*	4.48	*Puntius ticto*	4.38
	pancalus		*Nandus nandus*	2.63	*Colisa lalius*	3.15
Seine net	*Puntius sophore*	27.6				
	Nematopalae-	12.6				
	mon spp.					
	Chanda spp.	10.2				
	Mastacembelus	9.80				
	pancalus					
	Salmostoma	9.20				
	bacaila					
	Mystus tengara	5.75				
	Amblypharyn-	5.56				
	godon mola					
	Wallago attu	5.22				

Comparative analysis of Ashura, Dikshi and Goakhola beels

Gear proportions

Comparison of the fishing gears used in the three *beels* (Table 3) revealed that fishing diversity is higher in Goakhola and Dikshi *beels*. Fishers targeted mostly carnivorous species in Goakhola and Dikshi *beels*, while in Ashura *beel*, fishers generally targeted herbivores species. Ashura is a perennial water body and self-recruiting barbs and carps are the major contributor species and fishers usually targeted the herbivores species. However, Goakhola and Diskhi are seasonal water bodies where migratory fish from rivers are major contributor species which could be the reason to harvest the carnivorous species. In Ashura, gear used comprised 22.85% gill nets, 22.67% cast nets, 22.67% push nets, 17.36% trap units, and the remaining 14.45% included seine net, lift net, hook and line, and long line. In Goakhola and Dikshi *beel*, trap units are the most dominant gears used.

Table 3. Proportions of different gears (%) use in the three *beels*

Types of gears	Composition of gears (% by number)		
	Ashura	Goakhola	Dikshi
1. Gill nets	22.85	22.44	21.82
2. Seine nets	5.48	0.11	0.25
3. Lift nets	3.39	2.64	5.08
4. Push nets	22.67	1.00	5.57
5. Trap units	17.36	34.84	36.07
6. Hook & line	3.17	21.29	8.62
7. Cast net	22.67	13.20	7.68
8. Long line	2.42	0.08	6.36
9. Spear	-	2.45	3.17
10. Set bag	-	0.33	-
11. Pen/other	-	0.33	0.46
12. Hand	-	2.00	4.93

Species diversity

Ashura *beel* has the largest permanent water area among the three *beels*. In 2002, this *beel* recorded the highest number of species caught.

The species diversity in Ashura and Dikshi *beels* was higher in 2002 compared to the base line survey in 1997. However, species diversity in Goakhola was slightly lower in 2002 compared to baseline survey in 1997 (Figure 1). Goakhola is a seasonal *beel* and water remains only in small narrow strips in the dry season which might be the reason for the minor decline in the number of species.

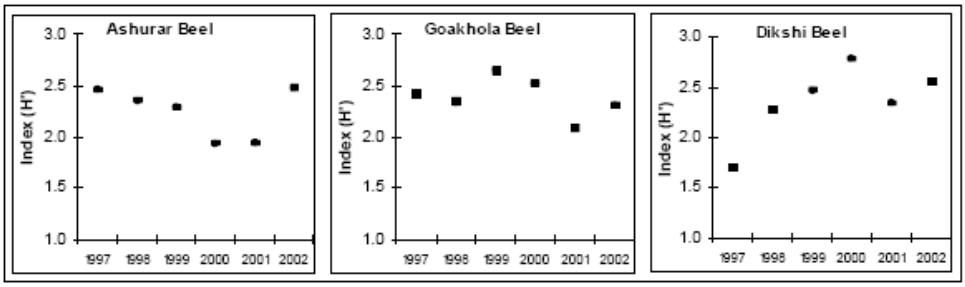


Figure 1. Estimates of mean H' with 95% confidence limits plotted as function of time with six years of observation

Status of main species and total annual catch

In Ashura *beel* the total catch increased from 1998 to 1999 and declined in 2000 to 2001. The annual catch in Goakhola increased significantly by 225% in 2002 compared to 2001. The annual catch in Dikshi *beel* reached its peaks during 2000 to 2002. The total catch trend, with the top four most species caught, including using the *khata* method and fishing in the *kua,* in the three open *beels* are given in table 4.

Table 4. Catch trends (tons) in the three *beels* and contributions of main species

Name of water body	Study years	Total catch (gears)	Total catch (*khata*/ *kua*)	Annual open catch (tons)				
				Puntius sophore	*Mastacembelus pancalus*	*Channa punctatus*	Small prawn	Other fish
Ashura *beel*	1997	30.6	0	7.60	1.94	1.25	4.84	14.98
	1998	49.9	0	12.67	5.01	1.00	7.90	23.31
	1999	58.1	0	20.18	4.51	0.59	10.45	22.36
	2000	45.3	2.9*	15.91	1.78	0.16	11.42	16.01
	2001	32.0	0	6.51	1.38	0.25	9.45	14.37
	2002	46.8	0	5.38	2.64	3.64	6.59	28.53
Goakhola *beel*	1997	6.3	4.4	1.77	0.59	1.02	0.48	2.48
	1998	11.1	3.4	2.96	0.93	2.16	0.30	4.71
	1999	9.1	3.5	2.22	0.85	1.07	0.50	4.43
	2000	12.8	6.0	3.51	0.46	1.30	0.21	7.32
	2001	36.8	5.5	13.45	1.97	4.35	0.23	16.83
	2002	43.0	6.1	11.26	1.37	6.26	1.17	22.95
Dikshi *beel*	1997	17.3	5.0	1.84	0.81	4.52	7.40	2.53
	1998	16.6	5.0	1.64	0.49	5.16	3.48	5.89
	1999	39.1	0	7.32	0.54	7.14	1.65	22.40
	2000	90.6	0	12.82	8.95	12.12	10.75	45.68
	2001	113.2	0	28.07	11.38	17.00	21.29	35.52
	2002	70.9	1.0	13.23	3.53	10.85	11.57	31.77

* *Khata*

Annual catch trends

Income derived from fishing activities is influenced by several factors, such as catch rates of different species, ownership of gear, family participation in the work process, number of active fishing days and fish price. Annual variations of average catches (kg) per gear per day, catch per person per day and catch per person per hour in the three open *beels* are presented in table 5.

Table 5. Average catch rates (kg) per gear per day, number of gear days, number of person days, catch per person per day and catch per person per hour during 1997-2002

Name of water body	Study years	Average catch rates (kg)	No. of gear days	No. of person days	Daily catch (kg•person^{-1}•day^{-1})	Hourly catch (kg•person^{-1}•hr^{-1})
Ashura *beel*	1997	3.86	7927	11822	2.59	0.60
	1998	4.69	10634	16518	3.02	0.69
	1999	4.17	13940	21916	2.65	0.61
	2000	2.79	16227	23728	1.91	0.44
	2001	1.79	17840	20496	1.56	0.36
	2002	2.01	23232	30411	1.54	0.35
Goakhola *beel*	1997	2.36	2700	3040	2.1	0.48
	1998	3.88	2851	3302	3.4	0.78
	1999	2.43	3743	4249	2.1	0.48
	2000	2.75	4669	5169	2.5	0.57
	2001	5.90	6099	7391	4.9	1.13
	2002	5.95	7171	9121	4.7	1.08
Dikshi *beel*	1997	2.64	6501	6626	2.6	0.60
	1998	2.25	7407	7495	2.2	0.51
	1999	3.88	10065	14216	2.8	0.64
	2000	4.39	18874	30336	2.9	0.67
	2001	5.29	19312	31630	3.6	0.83
	2002	4.96	13899	18369	3.9	0.90

Maximum Sustainable Yield (MSY)

Estimated MSY for Ashura, Goakhola and Dikshi were 48.0, 23.0 and 78.0 tons, and corresponding fishing effort was 16452, 7812 and 19984 gear days•year^{-1}, respectively. In Ashura *beel* fishing effort was high in 1999. The total fish catch at nearly 49 tons was close to the MSY level, indicating slight over exploitation of the fishery resources in the *beel*. In Dikshi *beel* higher overall catch was recorded in 2001, hence indicating over exploitation of the fishery resources. However, Dikshi *beel* is well connected with the river and species diversity and catch per unit area (CPUA) is also higher compared to the two other *beels*. The total fish catch in Dikshi and Goakhola *beels* was close to the MSY level, but the resources are highly overexploited in Ashura *beel* compared to the two other *beels*. Estimation of optimum fishing effort in each *beel* to ensure the production at MSY level of fisheries stocks is shown in figure 2.

Sustainable management

The CPUA and CPUE (catch per unit effort) were used to estimate the maximum level of fisher density per unit area (ha). Regression of CPUA versus fisher densities showed that in Ashura *beel*, fisher density increased in 1999 when compared to 1997 and 1998 (Figure 3). It should be further noted that at the start of CBFM interventions, the Ashura *beel* was under-exploited. This changed rapidly from 1999 onwards, when the fishing moved rapidly to over exploitation. As a result CPUA decreased in 2000, 2001 and 2002 as fisher density increased to its highest level in 2002. This primary analysis indicates that prior to over exploitation Ashura *beel* could have supported a fisher density not exceeding 52•ha^{-1}• year^{-1}.

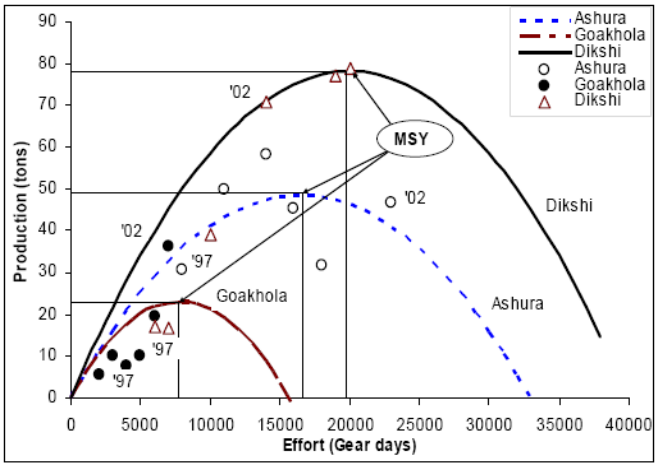


Figure 2. Maximum Sustainable Yield (MSY) and corresponding fishing effort (f_{msy}• year^{-1}) for Ashura, Goakhola and Dikshi *beels*

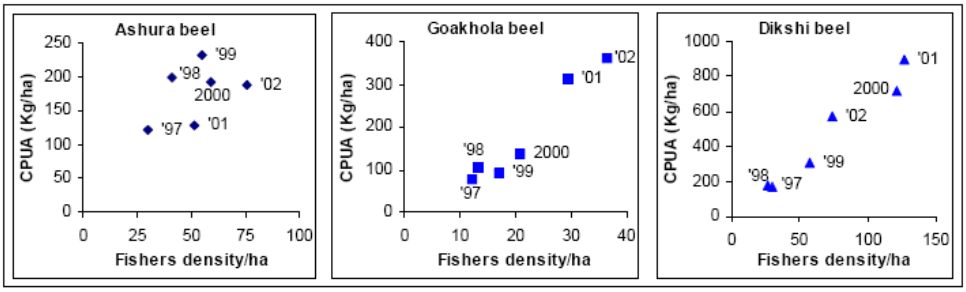


Figure 3. Annual plot of CPUA versus fisher density in Ashura, Goakhola and Dikshi *beels* from 1997 to 2002

In Goakhola fisher density showed an increasing trend (Figure 3). The annual CPUA also increased over the years, reaching its highest in 2002. In Dikshi *beel*, fisher density increased in 2001, as did CPUA which may be close to over exploitation of this fishery. However, fisher density significantly decreased in 2002, reducing the CPUA. Overall, the fisher density fluctuated annually and peaked during 2000 and 2001.

Annual CPUE versus fisher densities were plotted for Ashura, Goakhola and Dikshi *beels* (Figure 4). In Ashura *beel* the CPUE increased in 1998 with corresponding fisher density of around 40•ha^{-1}•year^{-1}. However, fisher density increased in 2000, decreased in 2001 and dramatically increased in 2002. As a result CPUE decreased in 2002. The results indicated overexploitation of the fishery resources in Ashura *beel* and suggested to reduce fisher density below 50•ha^{-1}• year^{-1} as one step towards sustainable fishing effort. In Goakhola *beel*, fisher density showed an increasing trend and reached the maximum level in 2002. Despite the substantial increase in fisher density between 2001 and 2002, CPUE remained largely unchanged. A possible explanation is that exploitation rates are very close to MSY. As a result, it is suggested that the fisher density in Goakhola *beel* be constrained to a maximum of 20•ha^{-1}• year^{-1}. In Dikshi *beel*, fisher density increased in 2001, with a corresponding rise in CPUE. In 2002 fisher density decreased dramatically. As CPUE also decreased, we suspect that the fishery resources are very close to the maximum exploitation level. Clearly, maximum fisher density has been reached, and the surplus production model suggests overexploitation during 2001 and 2002. Therefore, a reduction in fisher density to about 70•ha^{-1}• year^{-1} is suggested.

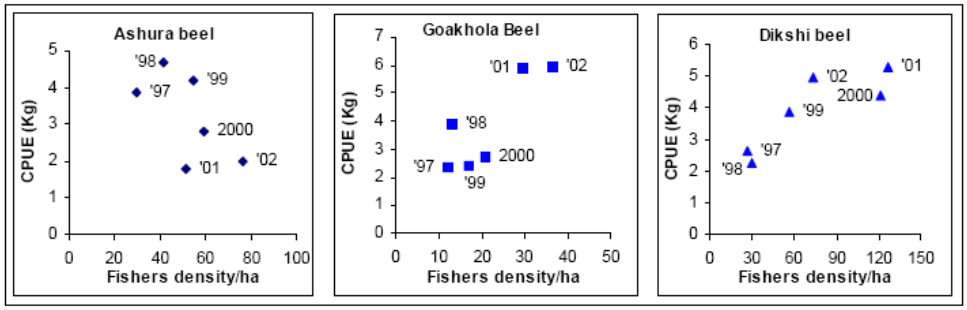


Figure 4. Annual plot of CPUE versus fisher density in Ashura, Goakhola and Dikshi *beels* during 1997 to 2002

Discussion

The Community Based Fisheries Management approach has been able to improve the management of resources. Success of CBFM-provides a mechanism for the implementation of management measure including closed seasons, gear restrictions, habitat restoration and fish sanctuaries. However, the study clearly indicates that without appropriate mechanism in place to limit total fishing effort, the effectiveness of CBFM is limited.

Effective management of fishing effort has to be implemented in the water bodies to protect principal species and ensure the sustainability of the available resources. Over the years the number of traps or gill nets per fisher has increased which directly impacts the effort level. The study proposes to reduce the number of fishing effort (gear days) operating in the *beels* and adopt the system of allocating fishing rights to fishers based on seasons or areas, as well as alternative income generating activities which can reduce the pressure on the resources.

It was noted that despite being linked with the river during the monsoon season, there is a lack of juvenile fish in Ashura, Dikshi and Goakhola *beels*. This is due to the operation of the sluice gate and water regulation (Goakhola *beel*) which hinders the movement of juvenile fish from the river into the *beel*. Hence, species diversity mainly depends on the production cycle of the current species inhabiting these water bodies, which are being heavily harvested.

For effective fish sanctuaries, at least 10% of dry season area has to be established in Dikshi and Goakhola *beels* and stocking of native juvenile carps in the deeper water of Ashura *beel* is strongly recommended.

Baut is a kind of traditional and festive mode of destructive group fishing where thousands of people of all ages head towards a *beel* with a variety of gears to fish. *Baut* in Dikshi *beel* has to be prevented.

In this regard, the best management option would be to convince all stakeholders that the maximum fisher density has been reached and the entry of new fishers can be detrimental to the existing fragile fishery resources.

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