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FISHERIES MANAGEMENT IN CLOSED WATERBODIES; EXPERIENCE OF CBFM

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INTRODUCTION

Community Based Fisheries Management Phase 2 is a technical assistant project started in September 2001 and implemented by a partnership of the Department of Fisheries, WorldFish Center and eleven partners NGO's and supported by the Department for International Development (DFID). Project is developing and testing a range of CBFM approaches and models in the open water fisheries in Bangladesh. The goal of the project is to improve the livelihoods of poor people dependant on aquatic natural resources through the adoption of improved inland fisheries management policies resulting in more sustainable, equitable and participatory management of these resources. The project covered a total of 116 water bodies that include 38 river sections, 14 closed water bodies, 28 open water bodies, 28 floodplains and 8 small water bodies.

Stocking is considered as a means of enhancing fish production in closed, semi-closed and floodplain water bodies. In CBFM project it is only done in relatively small water bodies with few outlets and where the fishers organized under the project, pay the *jalmahal* (state owned fishery) lease and can prevent escape of fish and control fishing effort**.** In most cases these water bodies were stocked before the CBFM project by the previous lease holders, so the idea and technology is not new to the waterbody although the fishers were not usually involved before in decisions making process and control over the water bodies. Present study covered 14 closed water bodies where stocking is considered as a means of enhancing fish production.

Although floodplain stocking programmes through past projects have been credited by the government with increasing fish production and fishers' income, at the same time serious concerns have been raised about the ecological and social equity implications, as well as the cost-effectiveness and sustainability of stocking programmes. Escape of fish is a problem as noted earlier, but the areas affected by stocking are limited.

Methodology:

The project water bodies under stocking can be divided into three categories:

a) Water bodies stocked under CBFM-1 (i.e. stocked by the respective community since about 1996 or 1997) which are continuing with stocking under CBFM-2,
b) Newly stocked water bodies – where the fisher's community started stocking under CBFM-2 in late 2002 or 2003 and,
c) Newly stocked water bodies – where the fisher's community started partial stocking under CBFM-2 in 2003.

For comparison with the project sites, CBFM-2 is also monitoring and studying non-project water bodies which receive no project support. Out of these, three control sites are being stocked by the leaseholders. Most of these control water bodies also have a previous history of stocking which is why they were selected for comparison. Most of the stocked water bodies are supported by two NGO partners (BRAC and Caritas). In addition to closed water body stocking, the community of Chargram in Daudkandi (Comilla district) has stocked carps in the converted semi-closed water bodies, and is supported by SHISUK one of the project partner. It is to be noted here that the low-lying crop land area in Daudkandi is converted into semi-closed seasonal water bodies. Besides the fisher community of Dopi-Beel in Mithamoin (Kishorganj District) has stocked common carp in an open beel, and is supported by Proshika (CBFM-2 partner). Most of these stocked beels are situated in Rangpur district, with others in Mymemsingh, Kishoregonj, Netrokona, and Tangail districts. The water bodies are listed in Table 1.

Table-1. List of stocked waterbody under CBFM-2.

Sl. No.	Name of waterbody	Upazila	District	NGO	Remarks
CBFM-1 project sites, stocked in 2002 and before from 1996 or 1997					
1	Hamil Beel	Kalihati	Tangail	Caritas	Deeper depressions
2	Rajdhola Beel	Purbodhola	Netrokona	Caritas	Deeper depressions
3	Dhumnodi Beel	Kawnia	Rangpur	BRAC	Dead river/oxbow lake
4	Ruhia Baisa Beel	Ranpur sadar	Rangpur	BRAC	Bonded off from floodplain
CBFM-2 project sites, stocked in 2002 and 2003 onwards					
1	Kafri Khal	Mithapukur	Rangpur	Caritas	Dead river
2	Tulshidanga Beel	Mithapukur	Rangpur	Caritas	
3	Chapandaha Beel	Pirgonj	Rangpur	BRAC	
4	Kalian Nodi	Phulpur	Mymensingh	Caritas	Pen culture
5	Betaldoba Beel*	Kotiadi	Kishoregonj	BRAC	
Partial stocked sites					
1	Saralar Beel	Mithapukur	Rangpur	BRAC	
2	Dopi Beel	Mithamoin	Kishoregonj	Proshika	Open beel stocking
Floodplain stocking sites					
1	Chargram	Daukdandi	Comilla	SHISUK	Floodplain stocking
Control Sites					
1	Shampur Baor	Phulpur	Mymensing	Private	Stocked by lessee
2	Doriar Beel	Pirganj	Rangpur	Private	Stocked by lessee
3	Laohajong Khal	Sonatola	Bogra	Private	Stocked by lessee

* Data gap: Water body drop out in 2004 and again included in 2005.

Management of stocked beels

All the water bodies with annual stocking of carps are Government *jalmahals* excluding Chargram where revenue is paid for the lease (under CBFM-2 the administrative responsibility has been handed over to DoF). A beel management committee (BMC) is formed representing groups of fishers organized by the NGO/UFO, and this BMC pays the yearly lease value using its revolving fund set up and initiated by the project. The communities in all stocked water bodies have their own resource management rules. They have closed seasons, harmful gear ban etc. The BMC of each water body with supervision from the NGO maintains records of costs and returns of stocking and harvesting including the quantities of fish stocked and harvested. In most water bodies fishing takes place in an organized way through the participation of fisher groups who form the general members of the community based organization (CBO) with the BMC its elected/representative decision making body. As is common with other culture-based fisheries in ponds and ox-bow lakes, the water bodies of CBFM-2 are stocked with carps (both native and exotic carp) each year - usually during May-August. These carps, with the exception of common carp *Carpio carpio*, do not breed in the water bodies. Following the stocking, fishing remains closed (banned) by the fishing community until the time when the BMC decides to harvest. After stocking, the participants follow a roster duty to prevent poaching.

Harvesting usually starts in October and continues up to December-January and even to February-March. Time of harvesting is also determined by water level and fish growth. During organized fishing, all the participants are active by roster, working in teams to operate jointly owned seine net (*ber jals*). In some beels there is additional organized fishing targeting particular natural fish (such as *Gudusia chapra*). Except for organized fishing, some BMCs sometimes hire other professional fishers when the participants do not own gear. In such cases, fish are caught on a share basis and about 25-30% of the wild fish goes to the professional fishers group but no share of carps are given to the hired fishers.

Fish after harvest, are either sold by the BMC on the spot though auction or carried to the nearest market to get a better price. The records of stocking and harvesting maintained by the BMCs have provided the basis for analysis for the different water bodies reported here.

Catch monitoring and gear survey

Catch monitoring is an observational process on fishing effort. Gear survey involves a regular spot survey for a sample of gears in operation and the total catch from the gear. In addition with organized fishing the observation of fishing activity was done for duration of four to eight days per month per site. Survey sampling covered gear census and catch monitoring (subsistence fishing). Gear census covered the number and types of gear operating in the study sites. Catch monitoring recorded species wise catch statistics of each gear type.

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.

The monthly catch monitoring data was further pooled to analyzed yearly percentage distribution over species. Gear wise overall species distributions were calculated from annual catch statistics data.

Overall production was estimated by summing estimated total production for all gear types in each year (subsistence catch and organized production from BMC record).

Shannon-Wiener diversity index:

The Shannon-Wiener Index (H') is one of 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.

Key Issue 1: Fishers Community Involvement

Numbers of water bodies, distribution pattern and management aspect of CBFM-1 sites are given in table 2 below:

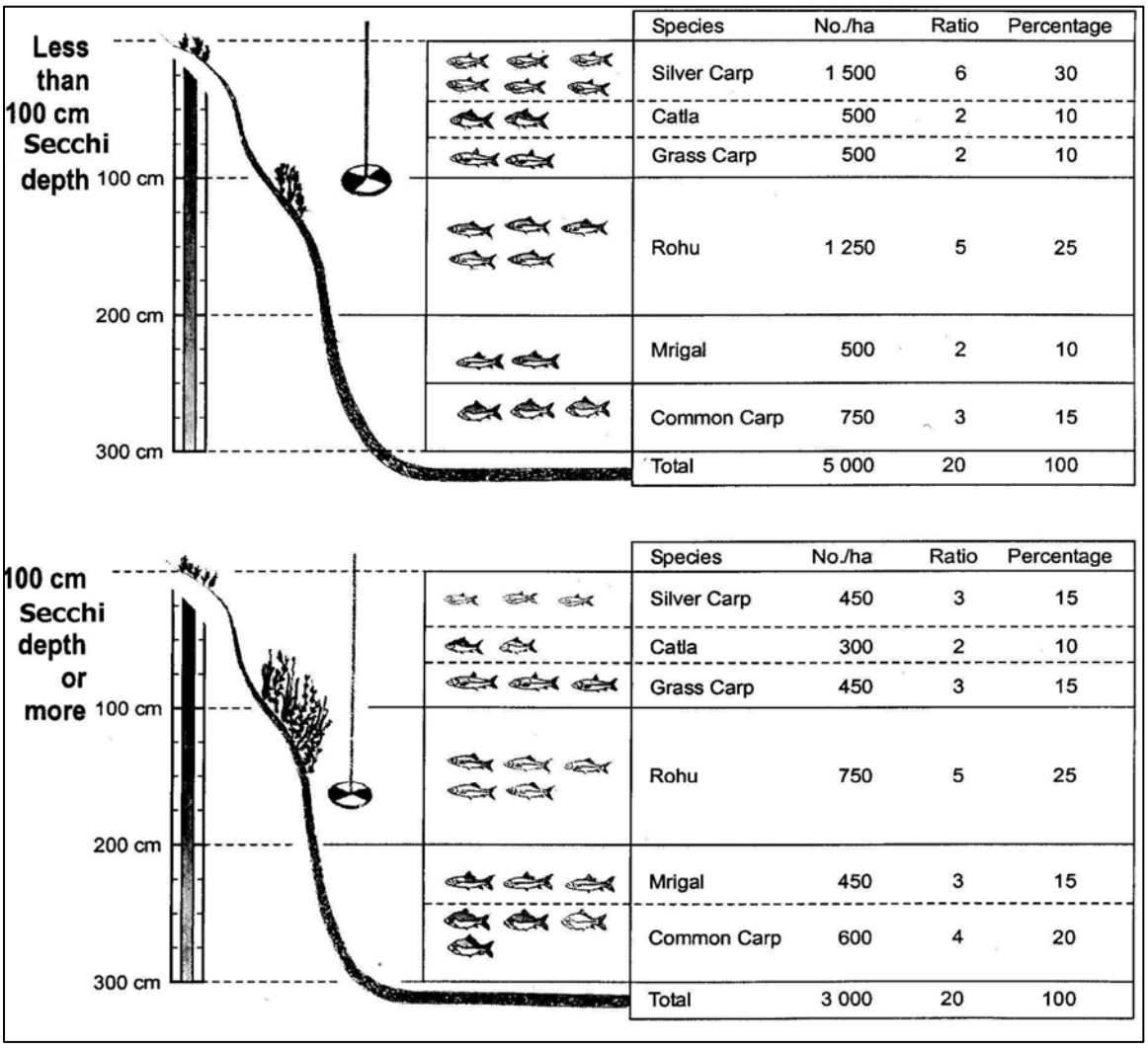
Table - 2. Distribution pattern of water bodies and beneficiary status

Name of WB	Lease value (Taka)	Area (ha) min-max	Registration status	BMC/RMC Members	Total beneficiary
Project sites:					
Hamil Beel	55208	16-20	Registered (Cooperative)	6 all male	♂=138, ♀= 37
Rajdhola Beel	366025	40-53	Registered (Cooperative)	16(♂=14,♀=2)	♂=83, ♀= 37
Dhumnodi Beel	108272	46-58	Registered (Social)	10 all male	♂=121, ♀= 0
Ruhia-Baisa Beel	34327	12-45	Registered (Social)	6 all male	♂=64, ♀= 0
Chapandaha	83458	2-90	Registered (Cooperative)	9 all male	♂=49, ♀= 0
Saralar beel	42500	6-50	Registered (Cooperative)	11 all male	♂=61, ♀= 33
Kafri khal	87916	15-70	Applied (Cooperative)	9 all male	♂=171, ♀= 18
Tulshidanga	26146	0.41-30	Applied (Cooperative)	9 (♂=7, ♀=2)	♂=77, ♀= 39
Kalian nodi	50303	26-40	Registered (Cooperative)	22 all male	♂=181, ♀= 19
Chargram		93-102	Registered, Joint Stock Co	17 Board member	♂=459, ♀= 154
Control sites:					
Doriar beel		37-80			
Louhajong beel		16-61			
Shampur		30-45			

Key Issue 2: Static Management Plan and Easy to Manage

A beel management committee (BMC) is formed representing groups of fishers organized by the NGO/UFO/SUFO, and this BMC pays the yearly lease value using its revolving fund set up and initiated by the project. The BMC of each water body with supervision from the NGO maintains records of costs and returns of stocking and harvesting including the quantities of fish stocked and harvested. In most water bodies fishing takes place in an organized way through the participation of fisher groups, who form the general members of the Community Based Organization (CBO), with the BMC, the elected/representative and decision making body. As is common with other culture-based fisheries in ponds and ox-bow lakes, the water bodies of CBFM-1 are stocked with carps (both native and exotic carp) each year - usually during May-August. Stocking density and harvesting related training conducted to the NGOs and DoF staff for all CBFM-2 sites and manual provided to follow up these at all stocking sites. According beneficiaries learned about stocking density (Figure 1). Following the stocking, fishing remains closed (banned) by the fishing community until the time when the BMC decides to harvest. Harvesting usually starts in October and continues up to December-January and even to February-March. Time of harvesting is also determined by water level and fish growth. During organized fishing, all the participants are active by rota, working in

teams to operate jointly owned seine net (*ber jals*). In some beels there is additional organized fishing targeting particularly natural fish (such as *Gudusia chapra*). Except for organized fishing, some BMCs sometimes hire other professional fishers when the participants do not own gear. In such cases, fish are caught on a share basis and about 25-30% of the wild fish goes to the professional fishers group but no share of carps are given to the hired fishers. Fish after harvest, are either sold by the BMC on the spot though auction or carried to the nearest market to get a better price. The records of stocking and harvesting maintained by the BMCs have provided the basis for analysis for the different water bodies reported here.



Species	No./ha	Ratio	Percentage
Silver Carp	1 500	6	30
Catla	500	2	10
Grass Carp	500	2	10
Rohu	1 250	5	25
Mrigal	500	2	10
Common Carp	750	3	15
Total	5 000	20	100

Species	No./ha	Ratio	Percentage
Silver Carp	450	3	15
Catla	300	2	10
Grass Carp	450	3	15
Rohu	750	5	25
Mrigal	450	3	15
Common Carp	600	4	20
Total	3 000	20	100

Figure 1. Secchi depth and proposed stocking density (no/ha) of different carps under CBFM-2 project water bodies (Source: Hasan and Middendrop 1998).

Results and discussion:

Key Issue 3: Production Sustainable

A Comparative analysis of stocking and harvesting performance

The production of stocked water bodies is related to a number of factors like timely stocking, size of fingerlings, rate, level of compliance of the local people and effectiveness of controlling measures for escaping of fish. Analysis of the result of the stocked water bodies under CBFM-2 shows that the production varies greatly between the old stocked and newly stocked water bodies. In case of old stocked water bodies the idea and knowledge for stocking are well known to the participants so the stocking performances are higher than the new stocked water bodies. But there are some new stocked water bodies as Chapundaha where stocking performances are good though it is a new stocked waterbody. It is to be noted here that in some water bodies such as Saralar-Beel, there is very minimal return in 2003 as compared to the previous year. The main reason for such low production is related to non-cooperation of the participants and local people. Except that outsiders cut the fence two times and also illegally caught stocked fish in 2003. In case of this waterbody it is also to be noted that in 2002 a good number of carps entered the waterbody from spill over ponds surrounding the water bodies during flash flood of 2002 which naturally increased the production and rate of survival. The same situation is found in case of Dopi-Beel in 2002 where recovery rate is exceptionally high. Stocking and harvesting performance for stocked water bodies from 2002 to 2005 are shown in Table 3, 4, 5 and 6.

Table- 3. Stocking and harvesting status of different water bodies in 2002.

Waterbody	Av. area (ha)	Stocking rate (no/ha)	Stocking wt. (Kg/ha)	Stocking Cost (Tk/ha)	Stocked fish Catch (kg/ha)	Natural fish catch (kg/ha)	Total catch (kg/ha)	Gross return (Tk/ha)
Rajdhola Beel	46.5	2367	52	2861	95	46	141	7983
Dhumnodi	52	7362	104	6090	436	78	514	38748
Ruhia-Baisa	11	7465	69	5339	677	241	918	31207
Hamil Beel	16	3262	35	3339	1021	174	1205	44372
Chapandaha	14	2498	76	3201	40	2	42	1658
Saralar Beel	16	2185	67	2801	462	141	603	22594
Kafri Khal	29	0	0	0	0	0	0	0
Tulshidanga	20	1044	38	1123	50	14	64	2714
Kalian nodi	29	0	0	0	0	0	0	0
Doriar Beel	59	1152	56	2441	35	3	38	1508
Lauhajong	38	0	53	3684	130	16	146	5842
Shampur	38	18421	0	4579	1227	0	1227	22646

Table- 4. Stocking and harvesting status of different water bodies in 2003.

Waterbody	Av. area (ha)	Stocking rate (no/ha)	Stocking wt. (Kg/ha)	Stocking Cost (Tk/ha)	Stocked fish Catch (kg/ha)	Catch natural fish (kg/ha)	Total catch (kg/ha)	Gross return (Tk/ha)
Rajdhola Beel	46.5	5324	87.3	8232	135	42	177	10501
Dhumnodi	52	2812	36.1	3781	361	78	439	33266
Ruhia-Baisa	11	7866	89.2	6766	989	474	1463	51559
Hamil Beel	16	4488	45.2	4006	955	160	1115	43917
Chapandaha	14	3752	82.6	5773	1218	63	1281	51963
Saralar Beel	16	1544	47.7	3114	124	219	343	17125
Kafri Khal	29	1128	37.9	2496	81	6	87	4367
Tulshidanga	20	1041	15.9	590	82	11	93	3938
Kalian nodi	29	5952	134.6	6968	309	35	345	17233
Doriar Beel	59	535	23.1	1015	92	42	134	6696
Lauhajong	38	23283	33.4	2658	64	4	68	3421
Shampur	38	28770	114.6	9262	752	16	768	38412

Table- 5. Stocking and harvesting status of different water bodies in 2004.

Waterbody	Av. area (ha)	Stocking rate (no/ha)	Stocking wt. (Kg/ha)	Stocking Cost (Tk/ha)	Stocked fish Catch (kg/ha)	Catch natural fish (kg/ha)	Total catch (kg/ha)	Gross return (Tk/ha)
Rajdhola Beel	46.5	2588	44	3510	373	335	708	22989
Dhumnodi	52	1721	45	2585	324	205	530	41003
Ruhia-Baisa	11	807	17	1636	983	2561	3544	118927
Hamil Beel	16	4167	0	3542	702	486	1188	57241
Chapandaha	14	968	27	2973	1003	397	1400	65116
Saralar Beel	16	2171	55	4204	97	565	662	36904
Kafri Khal	29	471	15	939	181	165	347	17281
Tulshidanga	20	250	3	121	135	184	319	11785
Kalian nodi	29	0	0	0	0	0	0	0
Chargram (SHISUK)	103	7077	0	12137	889	921	1810	33650
Doriar Beel	59	0	0	0	0	0	0	0
Lauhajong	38	2889	111	5045	52	1076	1128	39909
Shampur	38	0	0	0	0	0	0	0

Table- 6. Stocking and harvesting status of different water bodies in 2005.

Waterbody	Av. area (ha)	Stocking rate (no/ha)	Stocking wt. (Kg/ha)	Stocking Cost (Tk/ha)	Stocked fish Catch (kg/ha)	Catch natural fish (kg/ha)	Total catch (kg/ha)	Gross return (Tk/ha)
Rajdhola Beel	46.5	5090	114	7939	387	209	596	39194
Dhumnodi	52	1792	34	1892	348	322	670	43014
Ruhia-Baisa	11	4235	130	7184	521	1626	2147	83656
Hamil Beel	16	5524	104	6913	1080	700	1780	73403
Chapandaha	14	2321	115	4714	1082	112	1193	50796
Saralar Beel	16	568	13	234	50	313	363	13834
Kafri Khal	29	740	19	1281	142	197	339	17045
Tulshidanga	20	1109	10	634	149	120	269	11530
Kalian nodi	29	790	9	686	337	34	371	15375
Chargram (SHISUK)	98	6238	0	8447	1343	196	1539	67643
Doriar Beel	59	7005	21	1847	713	47	761	27009
Lauhajong	38	5533	70	3910	109	92	200	8518
Shampur	38	10864	54	3243	388	0	388	14359

3. Stocking and harvesting performance:

Analysis of the result of the stocked water bodies under CBFM-2 shows that the production varies greatly between the old stocked and newly stocked water bodies. In case of old stocked water bodies the idea and technology for stocking are well known to the participants so the stocking performances are higher than the newly stocked water bodies. Total production as a function of stocking density in 2002 (baseline year) and 2005 for project water bodies are shown in fig. 2. Natural fish production plotted as a function of stocking density in 2002 (baseline year) and 2005 for project water bodies are shown in figure 3. Total production plotted as a function of stocking density in 2002 (baseline year) and 2005 for control water bodies are shown in figure 4. The most successful example of Community Managed fisheries has been accomplished for Hamil-beel (from 1996 under CBFM) the oldest stocked water body in Tangail district, production trend analysis for 16 years data showed mean production during pre-CBFM (1989-1995) was 227 Kg/ha and that significantly increased to 848 Kg/ha during CBFM (1996-2004).

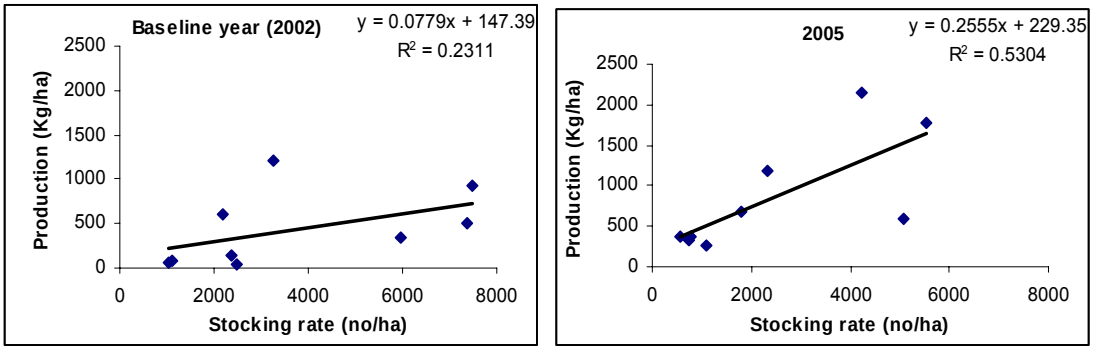


Fig. 2. Total production per ha plotted as a function of stocking density in 2002 (baseline year) and 2005 for project water bodies.

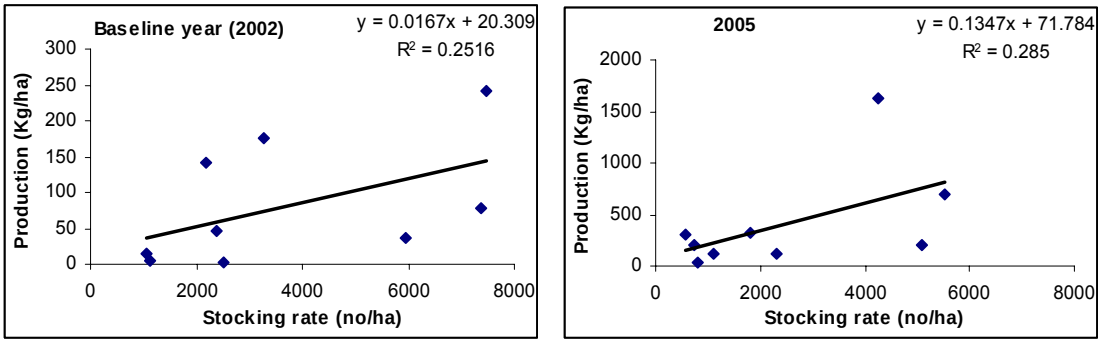


Fig. 3. Natural fish production per ha plotted as a function of stocking density in 2002 (baseline year) and 2005 for project water bodies.

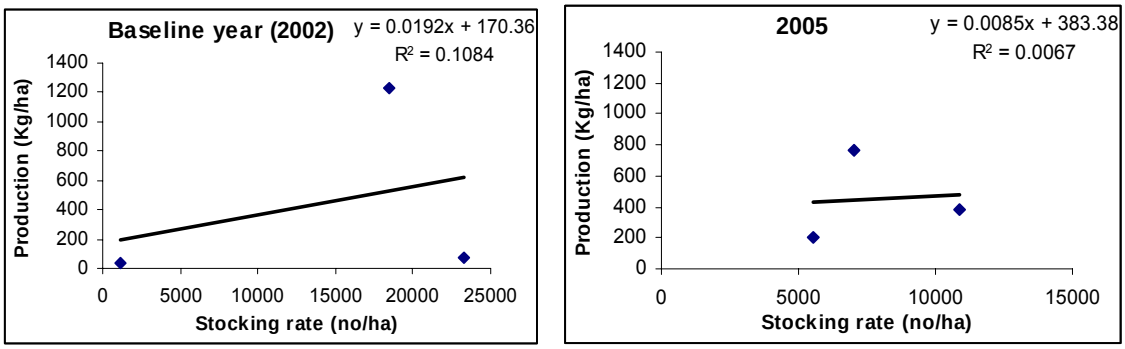


Fig. 4. Total production per ha plotted as a function of stocking density in 2002 (baseline year) and 2005 for control water bodies.

Production trend under CBFM-2:

The study reveals that natural fish production trend increased from an annual average of 87 kg ha-1 in 2002 to 383 kg ha-1 by 2005. The total harvests form the stocked water bodies have increased significantly from an annual average of 436 kg ha^{-1} in 2002 to 927 kg ha^{-1} by 2005 (Figure-5). Production trend have increased for both natural and cultured species under CBFM-2 project. The annual variations of stocking cost during 2002-05 were found steady or minor change. Whilst annual gross return from fishing shows significantly increasing trend between 2002 and 2005 (Figure 6). Production is highly correlated with stocking number as well as stocking size. Annual average stocking density was found 3273 fingerlings per hectare in 2002 and decreased to 2841 in 2005 (Figure 7). Water body wise (project and control) overall production and catch value (kg per hectare) trends are shows in figures 8 and 9 respectively.

The CBFM project funded one partner NGO, SHISUK has developed a floodplain aquaculture system which encloses a floodplain area using earthen embankments connected to the floodplain by sluice gates and one of the most successful example of floodplain culture. In this system they stocked variety of species including exotic species. Survival proportion of different stocked species showed consistency with stocking rate and species type. Species composition during stocking and harvesting periods are presented in figure 10.

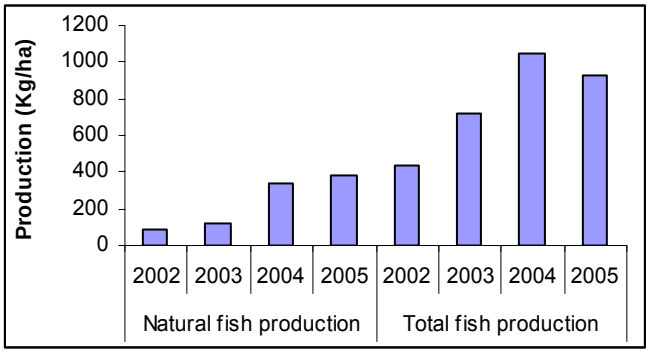


Fig. 5. Annual production trends of natural and total fish production between 2002 and 2005.

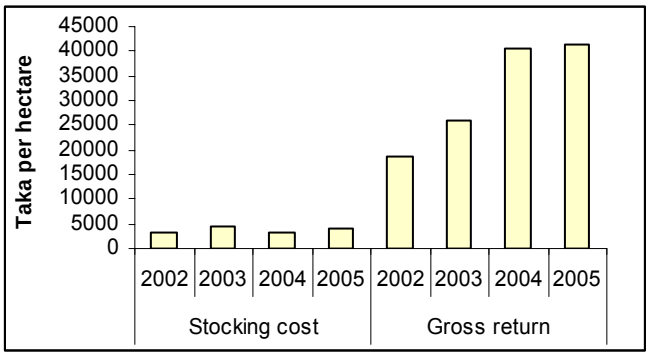


Fig.6. Stocking cost and gross return from 2002 to 2005.

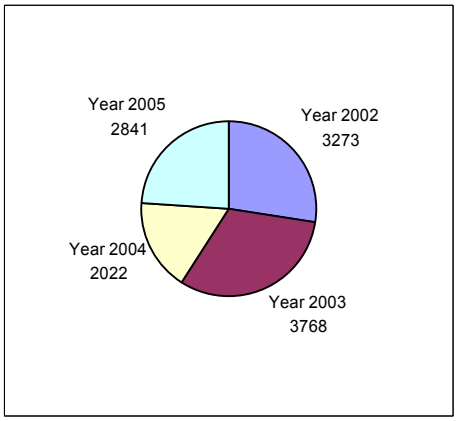


Fig. 7. Stocking number per hectare between 2002 and 2005

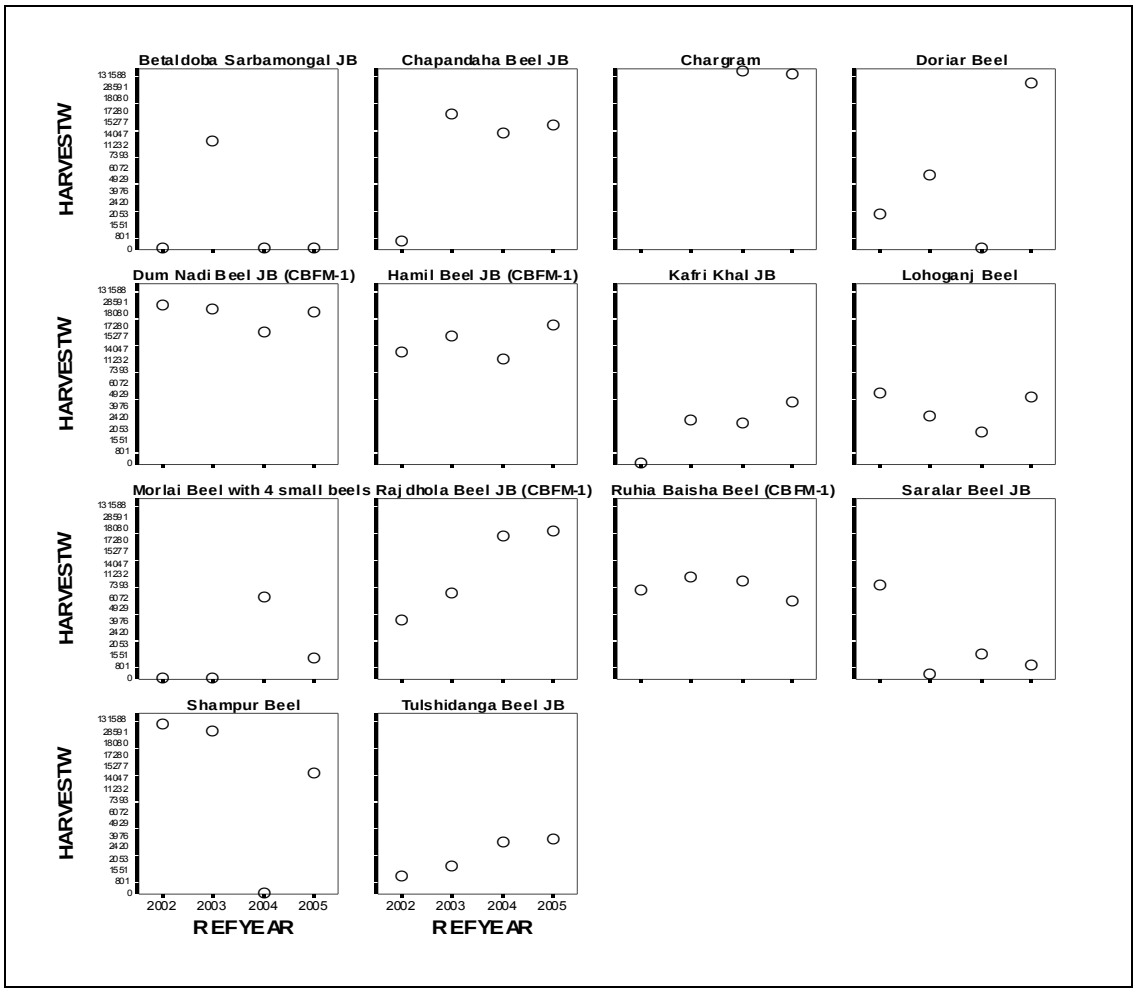


Fig. 8. Production trends of different stocked water bodies between 2002 and 2005.

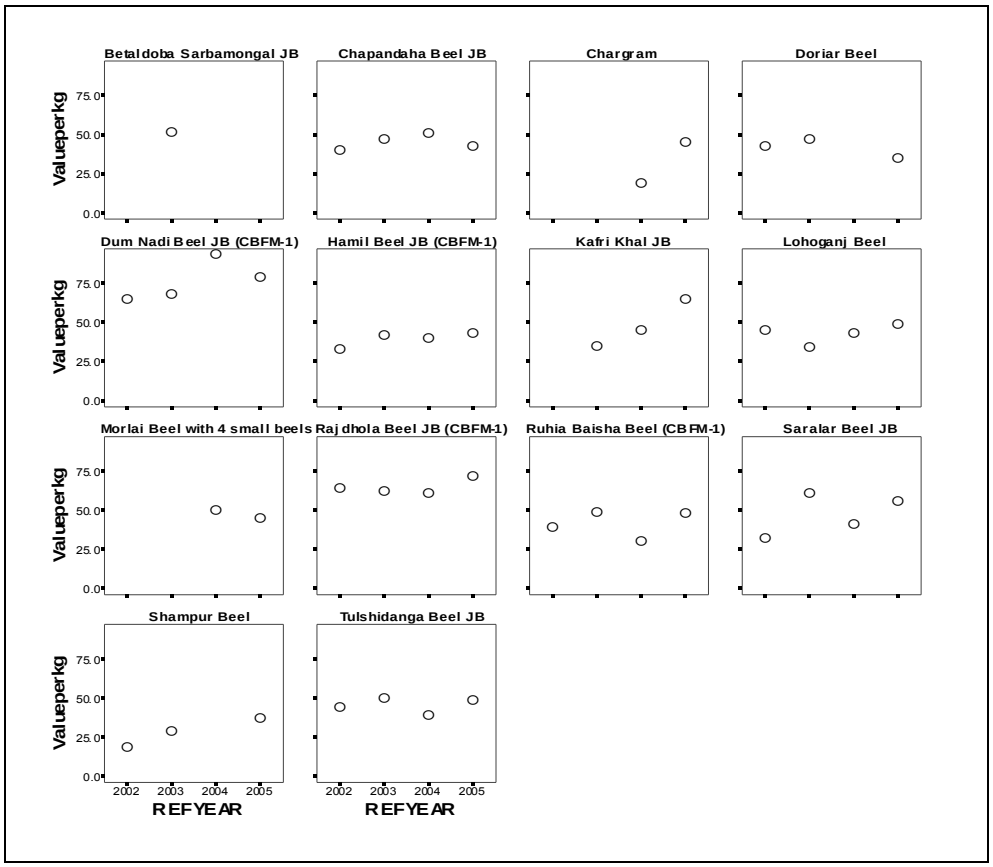


Fig. 9. Trends in fish value (Tk. per kg) between 2002 and 2005.

Species wise stocking and harvesting performance at Chargram:

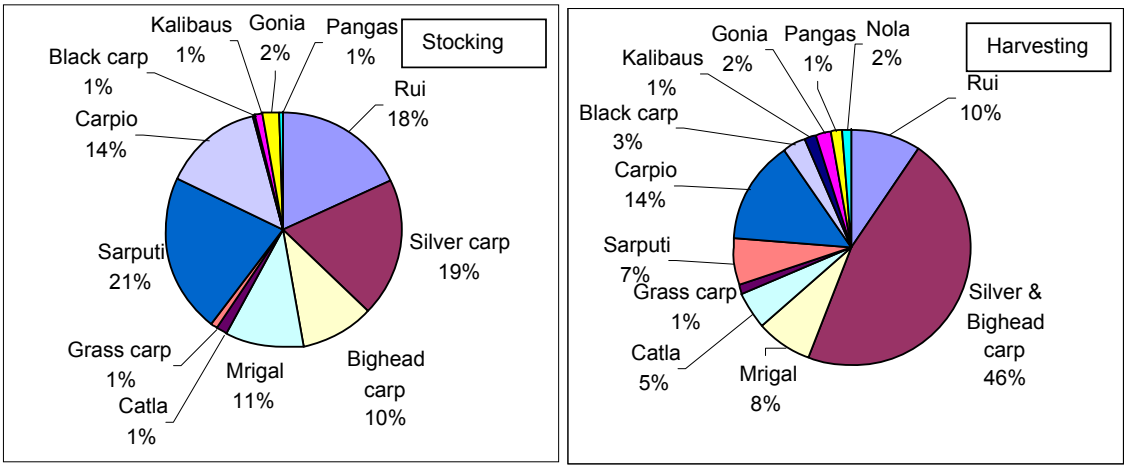


Fig. 10. Species composition during stocking and harvesting at Chargram sites in 2004.

Closely monitoring and Long term impact to production:

Over a period of 4 years of improving community management fish productions have been improving. The study reveals that harvests form the 8 stocked water bodies with data consistency have increased significantly from an annual average of 380 kg ha^{-1} in 2002 to 921 kg ha^{-1} by 2005 (Figure-11).

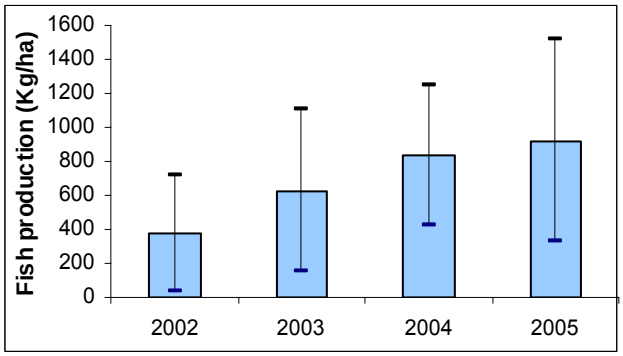


Fig. 11. Fish production trend in stocked water bodies under CBFM-2 during 2002 to 2005.

The key successful example of fish production (Kg/ha) trend for four stocked water bodies during pre CBFM, CBFM-1, Interim and CBFM-2 periods reveals that production increased significantly during CBFM-2 periods. Mean production was 251 kg/ha during pre-CBFM (1989-95) which significantly ($P<0.05$) increased to 559 kg/ha during CBFM-1 (1996-99) and to 776 kg/ha during CBFM-2 (2002-05) (Figure 12).

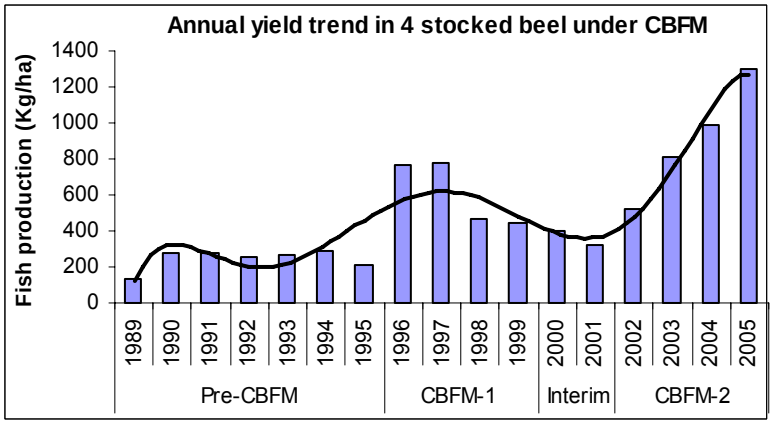


Fig. 12. Annual production trends in 4 stocked beel during pre CBFM and CBFM periods.

Annual trends in CPUE, CPUA and H':

Annual trends of catch per unit effort (CPUE), catch per unit area (CPUA) and biodiversity index (H') are show in table 7. Correlation between stocking density and harvesting performance (kg/ha) reveals optimum stocking density around 4500 per hectare are presented in figure 13.

Table-7: Annual trends of CPUE, Production and Biodiversity index

Waterbody	CPUE (Kg)				Production (Kg/ha)				Biodiversity Index (H')			
	'02	'03	'04	'05	'02	'03	'04	'05	'02	'03	'04	'05
Rajdhola Beel	2.89	6.59	11.41	1.58	141	177	708	596		3.075	2.633	
Dhumnodi	7.98	10.48	9.02	9.57	514	439	530	670	1.968	2.521	2.015	2.43
Ruhia-Baisa	2.49	4.42	3.87	3.33	918	1463	3544	2147	3.051	3.418	2.942	3.433
Hamil Beel	1.43	2.74	0.92	0.45	1205	1115	1188	1780	2.001	2.141	2.851	2.01
Chapandaha	7.92	23.33	14.85	34.33	42	1281	1400	1193	0.984	2.906	2.725	2.526
Saralar Beel	3.44	7.89	2.35	1.19	603	343	662	363	2.653	2.611	2.747	3.102
Kafri Khal	1.08	2.08	6.89	2.33	-	87	347	339	2.585	2.326	2.489	2.67
Tulshidanga	8.81	2.71	4.51	8.56	64	93	319	269	2.457	2.629	2.099	1.743
Kalian nodi	0.66			11.21	-	345	-	371				
Chargram							1806	1533				
Doriar Beel	-	30.70	13.95	148.3	38	134	-	761			1.809	0.448
Lauhajong	1.53	16.09	11.49	17.36	146	68	1128	200	1.778	2.381	2.225	1.986
Shampur	-	-	-	-	1227	768	-	388				

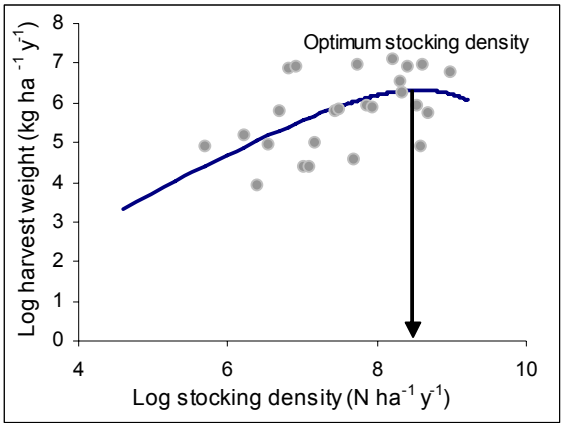
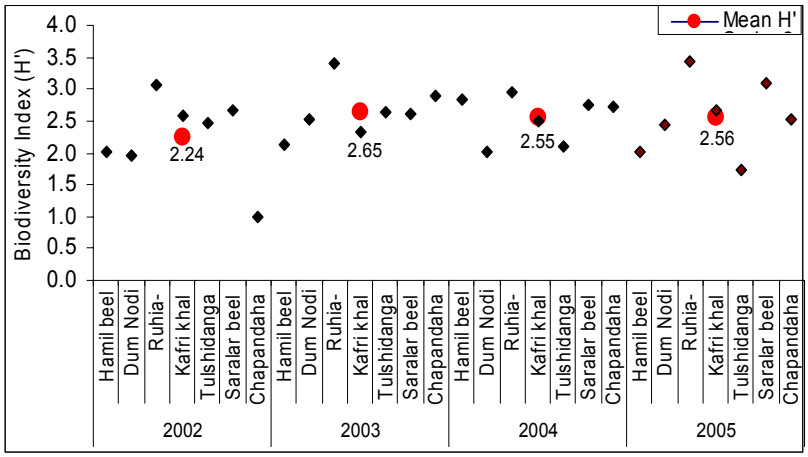


Figure 13: Proposed optimum stocking density per hectare.

Key Issue 4: Fish Biodiversity

4. Impact to natural species in stocked water bodies and Environmental Friendly

A comparison of annual mean diversity index (H') for seven stocked sites based on natural species proportions during 2002-2005. Average biodiversity index was 2.24 in 2002 which significantly (P<0.05) increased to 2.65 in 2003 and to 2.55 in 2004 to 2.56 in 2005 (Figure-14).



Twelve small indigenous species in average contributed 90% of the natural fish production in 2004 (Table-1). This contribution indicates healthy environment with lower stocking rate that significantly contributed in livelihoods of poor beneficiaries. Sustainability of natural indigenous species through proper stocking density is also vital for poor community. Dendogram in figure 15 showed the relationships of small indigenous species based on 53 numbers of species in the studies stocked water bodies.

Table 1

Scientific name	Percentage Contribution	Cumulative (%)
Jat Puti (*P. sophore*)	21.92	21.92
Taki (*C. punctatus*)	13.16	35.07
Baim (*M. pancalus*)	12.89	47.97
Baila (*G. giuris*)	11.68	59.65
Guraicha (*N.tenuipes*)	9.99	69.65
Tengra (*M. tengara*)	7.47	77.12
Shing (*H. fossilis*)	2.78	79.89
Kholisha (*C.fasciatus*)	2.77	82.67
Chanda (*C. lala*)	2.51	85.17
Kaikla (*X. cancila*)	2.29	87.45
Gutum (*L. guntea*)	1.43	88.88
G.chapra	1.28	90.17

The Jatputi (*Puntius sophore*), highest livelihood contributor fish in 2004, and represented by 22% in stocked waterbodies.

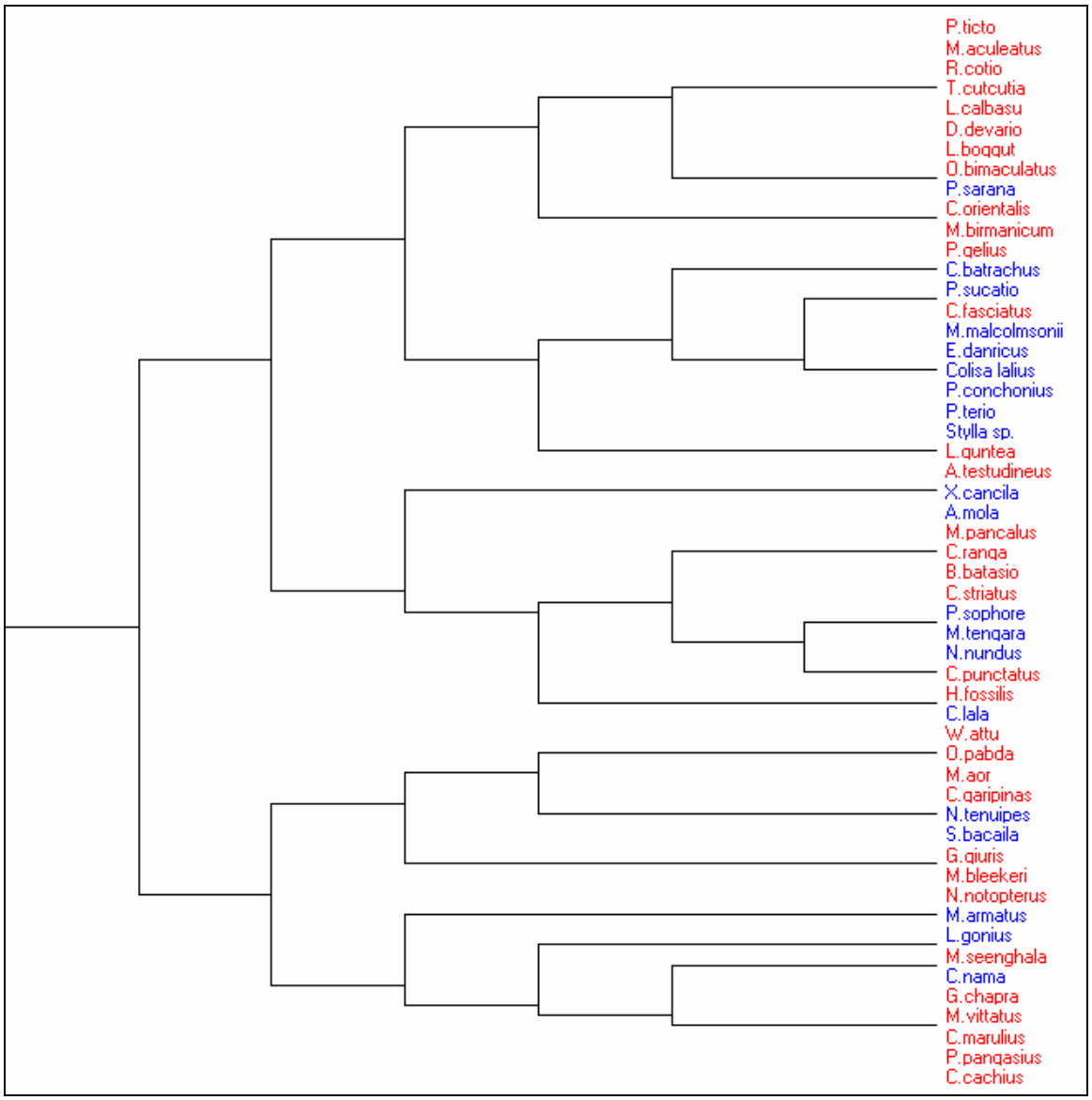


Fig.15. The dendrogram of the cluster analysis of natural species (53) produced by TWINSPAN under stocking program.

Key Issue 5: Acceptable and low cost involvement

A portion of net benefit from each stocked waterbody is equally distributed among all participant beneficiaries of each stocked water bodies in each year.

Key Issue 6: Does CBFM works

Major issues and constraints in stocked water bodies

The introduction of exotic species and alien species to the natural closed/semi-closed water bodies has resulted in competition for food and space and ultimately in the decline of indigenous species. In Dopi-Beel, which is well known as one of the biodiversity hotspots of Mithamoin, Netrokona district, exotic species such as *Cyprinus carpio* have already established breeding populations and contribute more than 50% of the exploited stock. Alien species such as Catla (*Catla catla*), Ruhu (*Laboe rohita*) and Mrigal (*Cyrrhinus mrigala*) have been cultured in most of the stock water bodies under CBFM-2 and consequently a gradual reduction of the endemic population in these water bodies. The following issues emerge from the assessments of stocking during 2002 -2005 in CBFM-2 water bodies:

- Fishers do not follow stocking principles (rate, size, species composition).
- Sometimes records are not properly mentioned in respect of cost and returns, and data are insufficient for proper analysis.
- Fishers are interested to stock small sized fish (sometimes only 2-3 cm long) as the number per kg is high but they are not aware about low survival rate of small sized fish in large water bodies.
- Fish disease (EUS) cannot be controlled as some of the water bodies are too large for any control measures.
- Water abstraction has not been stopped (a major threat to dry season fish refuges).
- Lack of adequate fingerlings and timely supply of fingerlings in local markets.
- Funds for stocking are still controlled by NGOs in some water bodies although the project arrangement as agreed in the MOAs between each NGO, WorldFish Center and DOF is for the NGOs to set up bank accounts for the BMCs to be jointly operated by the BMC and NGO and to deposit there a revolving fund to cover annual costs (lease and stocking), delays in release of funds by NGOs hampered timely stocking in some sites.
- Lack of nursery ponds as a nearby source of fingerlings.
- Sometimes the BMC members themselves are suppliers of fingerlings (e.g. Dhumnodi Beel) and set inflated prices or over-record numbers of fingerlings to get more profit.
- Sometimes the participants are involved in poaching.
- Measures to prevent fish escape are not adequate.
- Stocking results in profits and large carps, this attracts attention and thereby poaching and pressure from local influential.

Recent development of the stocked water bodies of CBFM-2

Some improvements in management has been established and the development of capacity for stocking management is a gradual process:

- Account keeping has been maintained in all the water bodies.
- BMCs have been advised to stock larger fingerlings (12-15 cm).
- Fishers of three water bodies (Hamil, Chapundaha and Dhumnodi) have made their own nursery ponds and the fishers of Kalian-Nodi have hired nursery ponds.
- In some water bodies the fishers have made *katha* (brush shelter) as fish sanctuaries – they form dry season refuges for both stocked and natural fish.
- Planning has to be improved and should ensure more timely stocking and the appropriate amount of fingerlings.
- A guideline in local language (Bengali) that focuses on simple principles of stocking has been prepared and distributed to the concerned NGOs and BMCs.

Conclusions:

In the case of the four water bodies that have been stocked from CBFM-1, the fishers now have set suitable stocking densities and they have developed over time (about 10 years) knowledge of stocking and harvesting management. In general their overall production per ha is higher than that in the new stocked water bodies under CBFM-2.

There is a concern that the introduction of large scale stocking of carps in open waters might imbalance the ecosystem and biodiversity leading to an adverse impact on non-stocked indigenous fish. Although floodplain stocking programmes through past projects have been credited by the government with increasing fish production and fishers' income, at the same time serious concerns have been raised about the ecological and social equity implications, as well as the cost-effectiveness and sustainability of stocking programmes. However, the fishers in CBFM do not stock large open floodplains, all of the water bodies reported here are of limited size and have few outlets that the fishers can fence. Escape of fish is a problem as noted earlier, but the areas affected by stocking are limited. Reviewing the results from various investigations in floodplains and in beel and baor stocking, it was found that single-stocking of carps each year with a density of 4,000–5,000 fingerlings/ha/year with an appropriate species composition ratio does not affect yield of indigenous fish when compared with no carp stocking. On the other hand, where there is multiple stocking with a density of 2,000-3,000 carp fingerlings in each stocking with an annual stocking frequency of 4 to 5 times, indigenous species are highly affected.

Given this evidence, for CBFM-2 water bodies a moderate stocking density of 4,000–5,000 fingerlings/ha/year through a single stocking is suggested to enhance production and maintain biodiversity.

KEY LESSONS SUMMARY

1. There is a concern that the introduction of large scale stocking of carps in open waters might imbalance the ecosystem and biodiversity leading to an adverse impact on non-stocked indigenous fish.
2. Although floodplain stocking programmes through past projects have been credited by the government with increasing fish production and fishers' income, at the same time serious concerns have been raised about the ecological and

social equity implications, as well as the cost-effectiveness and sustainability of stocking programmes.

3. However, the fishers in CBFM do not stock large open floodplains; all of the water bodies reported here are of limited size and have few outlets that the fishers can fence. Escape of fish is a problem as noted earlier, but the areas affected by stocking are limited.
4. Reviewing the results from various investigations in floodplains and in beel- deeper depressions and baor- are oxbow lakes stocking, it was found that single-stocking of carps each year with a density of 4,000–5,000 fingerlings/ha/year with an appropriate species composition ratio does not affect yield of indigenous fish when compared with no carp stocking.
5. On the other hand, where there is multiple stocking with a density of 2,000-3,000 carp fingerlings in each stocking with an annual stocking frequency of 4 to 5 times, indigenous species are highly affected.
6. Given this evidence, for CBFM-2 water bodies a moderate stocking density of 4,000–5,000 fingerlings/ha/year through a single stocking is suggested to enhance production.

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