STOCKING OF OXBOW LAKES IN SOUTHWEST BANGLADESH AND ITS IMPACT ON BIODIVERSITY AND ENVIRONMENT

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It is generally agreed that any significant increase in yield from inland capture fisheries can possibly be achieved from fisheries enhancement activities. Fisheries enhancement through stocking often synonymously used as "culture-based fisheries" is one of the most commonly practiced management interventions in lakes, reservoirs and floodplains in different parts of the world to augment fish production. In culture-based fisheries, the young fish are regularly stocked in open or semi-closed waters and recaptured at a larger size without aiming to establish a self-recruiting population. The stocking size of fish will generally vary depending on the type of water bodies to be stocked and the fish species being raised while the harvest size will greatly be influenced by the market demand and the consumption pattern of fish in the locality/region.

Bangladesh has the rich and diversified history of fisheries enhancement through stocking, dating back to early sixties when the Bangladesh Fisheries Development Corporation (BFDC) initiated the stocking programme in Kaptai Lake (largest man-made reservoir in Bangladesh). Further, over the last two decades or more (1978-2004), the government's Department of Fisheries (DoF) implemented a number of development projects dealing with floodplain stock enhancement and culture-based fisheries management with variable success.

Culture-based Fisheries Management in Oxbow Lakes

Oxbow lakes (local name: baors) are semi-closed water bodies, which occupy the dead channels of the rivers in the moribund delta of the Ganges. An oxbow lake normally is still part of the floodplain of the river, to which it is connected by inlets and outlets. During dry season, most of the oxbow lakes become converted to fully closed water bodies. There are approximately 600 oxbow lakes in southwest Bangladesh with an estimated combined water area of 5488 ha. Most of the oxbow lakes are located in five districts of southwest Bangladesh (Khulna division: Jessore, Jhinaidah, Chuadanga and Kushtia districts and Dhaka division: Faridpur district). It is generally estimated that around 14 000 fishers (2.5 fishers/ha water body) are directly involved and nearly 70 000 rural people are the direct beneficiaries of this fishery (Hasan, 2003).

Fish culture in oxbow lakes is a practice by which an open water fisheries is converted, by screening the inlets and outlets, into a culture-based fisheries. This culture-based fishery as practiced in Bangladesh essentially includes fingerling stocking, fish harvesting and regular deweeding. The fisheries management of oxbow lakes can, therefore, be summarized as stock management, species management, fishing effort management, and organizational/infrastructural support. Three species of Indian major carps (*rohu Labeo rohita*, *catla Catla catla* and *mrigal Cirrhinus cirrhosus*,) and three Chinese carps (silver carp *Hypophthalmichthys molitrix*, grass carp *Ctenopharyngodon idella* and common carp *Cyprinus carpio carpio)* are regularly stocked and harvested.

Six oxbow lakes were brought under culture-based fisheries management (CBFM) during Phase I of the Oxbow Lakes Development Project (OLP I, 1978-1985) and further twenty lakes were brought through Phase II of the Oxbow Lakes Small-Scale Fishermen Project (OLP II, 1988-97) (Hasan, 2001). Six oxbow lakes brought under CBFM are presently

A schematic drawing of an oxbow lake to show the screening of its inlets and outlets (after OLP II, 1997b)

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A young girl and a woman collecting water chestnut from a floodplain, Rangpur, Bangladesh

managed under direct supervision of the DoF with a reported average yield of 403 kg/ha during 1995-96 (Sattar and Khan, 1997). During OLP II, the average yield of stocked carps of 20 oxbow lakes under culture-based fisheries management increased from 121 kg/ha/year in 1991-92 to 700 kg/ha/year in 1996-97 (Hasan and Middendorp, 1998).

Traditionally, oxbow lakes and other similar water bodies have been used as common property resources, allowing unrestricted access to members of the surrounding communities. Although open access to water bodies is not conductive to sustainable management, mass participation can still be achieved through participatory management. The OLP II successfully transferred and institutionalized the fisheries management to the fishers themselves by ensuring their participation in the management process, through guaranteeing long-tern security of tenure and by developing appropriate institutions for implementation of the biological and social tools (Middendorp *et al*., 1996; Apu *et al.,* 1999; Hasan *et al.,* 1999a). Stocking process initiated through the OLP-II intervention has continued to be implemented in most lakes until now by the fishers/ groups controlling the lakes; sustainability of co-management of oxbow lakes fisheries remains to be evaluated in many cases after the project support was withdrawn in 1997. There has been an indication that in many of the oxbow lakes, brought under culture-based fisheries during OLP-II, institutional management (e.g., leadership rotation, share of the cost and benefits among the fishers) are not effectively working as envisaged.

The biological sustainability of stocking of culture-based fisheries in oxbow lakes has been demonstrated from a recent investigation carried out in 15 lakes by Hasan & Talukder (2004). Mean data of 15 oxbow lakes for two years (2001-02 and 2002-03) showed that stocking density ranged from 1 672 to 9 621 fingerlings/ha and the yield ranged from 91 to 1 465 kg/ha. Average carp yield was 663 and 762 kg/ha in 2001-02 and 2002-03, respectively, which compares favourably to that achieved during the OLP-II intervention period (Hasan & Middendorp, 1998; Hasan *et al*., 1999b; OLP II, 1997a; Hasan & Talukder, 2004a).

Impact of Stocking on Biodiversity and Environment

Oxbow lakes are the natural habitat and breeding ground of different indigenous fishes, which are naturally occurring fish species other than major carps. Non-stocked indigenous fishes available in oxbow lakes consist mainly of clupeids, catfishes, goby, perches, minor carps, minnows, snakeheads, mullets, pipe fishes, loaches, eels, freshwater prawns and other naturally occurring group of fishes (Haque

et al., 1999a; Hasan & Talukder, 2004a, b). These fish are generally harvested freely by the rural poor living around these water bodies and provides an important part of the protein in their diet.

Although biological sustainability and cost-effectiveness of stocking programme in oxbow lakes has proven to be sustainable, concern has often been raised about the ecological and social equity implications (Minkin & Boyce, 1994; Naqui *et al*., 1994; Rahman *et al*., 1999; Hasan, 2001). There is apprehension that the introduction of large-scale stocking of carps in the oxbow lakes might have imbalanced the lake ecosystem and lake biodiversity leading to an adverse impact on non-stocked indigenous fish (Ali, 1997). Eventhough the importance of environmental and biodiversity issues has been recognized for the eventual sustainable management of culture-based fisheries, the overriding concern of all stakeholders towards increasing the fish yields and sharing the benefits in a socially equitable manner often obscured the necessity for environmental protection. Middendorp & Bala (1999) listed three major types of environmental degradation of oxbow lakes. These are: (a) non-reversible environmental degradation caused by agricultural encroachment in the shallow fringe land of oxbow lakes, construction of embankments around the oxbow lakes to prevent stocked carps from escaping and unplanned construction of fish ponds in the fringe lands of lakes for fingerling raising; (b) environmental impacts of agricultural intensification caused by the increased use of pesticides in the paddy fields around the oxbow lakes; and (c) impacts of culture-based fisheries management resulting from large-scale deweeding and fingerling stocking.

So far only few studies report the impact of the stocking and related management measures on the environment and biodiversity of oxbow lakes and floodplains (FRI, 1996; Haque *et al*., 1999a, b; Hossain *et al*., 1999). Hossain *et al* (1999) reported a limited impact study of carp stocking on fish species diversity in three selected floodplains stocked under the Third Fisheries Project (TFP) and noted that Shannon-Weaver biodiversity indices calculated for three floodplains did not indicate any loss of fish biodiversity in terms of richness and evenness due to stocking. However, the stocking density used by TFP ranged between 14.4 and 24.3 kg/ha (Islam, 1999) which is apparently lower than the minimum stocking density normally used in most of the oxbow lakes.

Haque *et al*. (1999a, b) conducted a preliminary investigation on the impact of carp stocking on the biodiversity, yield and recruitment of non-stocked indigenous fish species (NIFS) and their contribution to the total fish production in oxbow lakes under culture-based fisheries management. The investigation showed that the oxbow lakes with stocking density ranging from 2 500–3 000 fingerlings/ha/year apparently did not affect yield of NIFS when compared with oxbow lakes with no carp stocking. The above preliminary findings thus indicated that subsistence fishing might not have been affected in case of lakes with low-density carp stocking. In contrast, the yield of NIFS was adversely affected when some of the oxbow lakes were multi-stocked with a stocking density of 2 000-3 000 carp fingerlings during each stocking period, the annual stocking

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A fisher with his catch of non-stocked indigenous fish using box trap from a oxbow lake, Jessore, Bangladesh

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An oxbox lake with partially broken metallic screen in the outlet, Jessore, Bangladesh

M. Kamal, (Mymensingh, Bangladesh)

Fishing in oxbow lake using purse-seine net, Jhenaidah, Bangladesh

frequency being 4 to 5. Haque *et al*. (1999b) further reported 43 species in two OLP lakes with high stocking density, 58 species of fish in two OLP lakes with low stocking density and 60 species in two control lakes (no carp stocking) in 1997-1998.

Based on the findings of studies carried out by Haque *et al*. (1999a, b), a further detailed study on the impact of level and periodicity of carp stocking on yield and species diversity of non-stocked indigenous fish species (NIFS) was carried out in nine selected oxbow lakes with different stocking and harvesting regimes (Hasan & Talukder, 2004a). These management regimes include high, moderate & low stocking, multiple, continuous & single stocking, continuous and periodic harvesting.

The lakes have been categorized as high, medium and low stocking regime based on the history of their stocking density over the past seven years (1994-2003) (Table 1). Stocking data for 1999-2000 and 2000-2001 were not available and therefore were not included for analysis of stocking history.

As presented in Table 1, Nasti, Porapara and Marufdia lakes were considered to be high stocking density lakes where the average stocking density over the past seven years ranged between 4 560 and 5 982 fingerlings/ha; Saster, Benipur and Kaliganga have been categorized as medium density lakes where stocking density ranged between 2 796 and 3 961 fingerlings/ha while low density lakes Bukbhara, Khatura and Bahadurpur had the average stocking density which ranged between 1 856 and 2 133 fingerlings/ha. Species diversity (no. of species) and estimated yield (kg/ha) of these studied lakes during the study period (August 2002 – July 2003) are given in Table 1. For comparison of species richness between high, medium and low density lakes, data were further analyzed to show the species assemblage by common groups of related fish and prawn species (Figs. 1, 2 and 3). The results and observations as summarized by Hasan & Talukder (2004a,b) are as follows:

- Yield of non-stocked indigenous fish in the nine selected lakes varied between 65 kg/ha (Sastar) and 407 kg/ha (Bukbhara).

Table 1. Seven years (1994-2003) stocking density of stocked fish and NIFS yield and species diversity in nine oxbow lakes during study period (August 2002 to July 2003)

Sl. No.	Lakes	SWA (ha)	NIFS (kg/ha)	Diversity (no. of species)	Stocking density (nos./ha)							Av. SD*
					1994-95	1995-96	1996-97	1997-98	1998-99	2001-02	2002-03	1994-2003
1	Nasti	54	98	21	1,504	5,496	9,018	8,607	3,270	5,993	2,119	5,144
2	Sastar	140	65	24	844	1,732	4,639	3,616	2,475	3,514	2,756	2,797
3	Porapara	88	66	23	1,782	3,743	4,008	7,210	5,637	6,977	2,565	4,560
4	Benipur	45	217	37	1,345	4,806	3,795	3,136	4,029	4,636	5,979	3,961
5	Marufdia	25	181	18	2,677	7,263	4,994	8,082	6,210	4,893	7,754	5,982
6	Bukbhara	138	407	39	2,601	2,049	1,193	1,355	2,045	2,804	1,377	1,918
7	Khatura	69	100	38	35	3,054	6	2,816	3,740	2,992	352	1,856
8	Bahadurpur	110	257	43	751	4,691	2,710	178	1,992	1,803	2,808	2,133
9	Kaliganga	15	142	22	2,088	1,870	1,837	2,968	2,765	4,142	3,905	2,796

**Average stocking density; the recommended fingerling stocking size varies between 10 and15 cm (weighing about 30-40 g) depending on the fish species stocked.*

- Except for Kaliganga Lake in Kushtia, the single dominant species was Indian River shad (local name: chapila), *Gudusia chapra*, accounting for 10.75 to 72.37 percent of total NIFS catch. The other dominant species harvested by different gears were giant river catfish (*Arichthys seenghala*), a variety of prawn species (Macrobrachium spp.), tank goby (*Glossogobius giurus*), glassy perchlet (*Parambassis spp*.), barb (*Puntius spp*.), snakehead (*Channa spp*.), catfish (*Mystus spp*.), freshwater eel (*Mastacembelus* and *Macrognathus spp*.), mola carplet (*Amblypharyngodon mola*) and Gangetic leaffish (*Nandus nandus*).

- The species diversity varied between lakes and the maximum of 43 species was recorded in Bahadurpur Lake and 18 species in Marufdia Lake.

- In lakes where high stocking densities (≥5000 fingerlings/ha) have been used over the last 7 years, the number of NIFS recorded during the study period were between 18 and 23 (Marufdia, Nasti and Porapara Lakes), and where the average stocking densities were ≤2000 fingerlings/ha, species diversity varied between 38 and 43 (Khatura, Bukbhara and Bahadurpur Lakes).

- Higher yield and biodiversity of NIFS were associated with lakes rich in submerged aquatic vegetation.

- Intensively managed (with high density stocking) culture-based fisheries in oxbow lakes led to the restriction of community access for subsistence fishing.

Although the trend is not very conclusive, the study indicates that high density (≥5000 fingerlings/ha) multiple stocking and continuous harvesting practised for longer duration (≥7 years) in some of the lakes have apparently led to the reduction of yield and biodiversity of non-stocked indigenous fish.

Figure 1. Species assemblage by common groups of related fish and prawn species in three lakes with high stocking density maintained during last 7 years. Data collected from August 2002 to July 2003

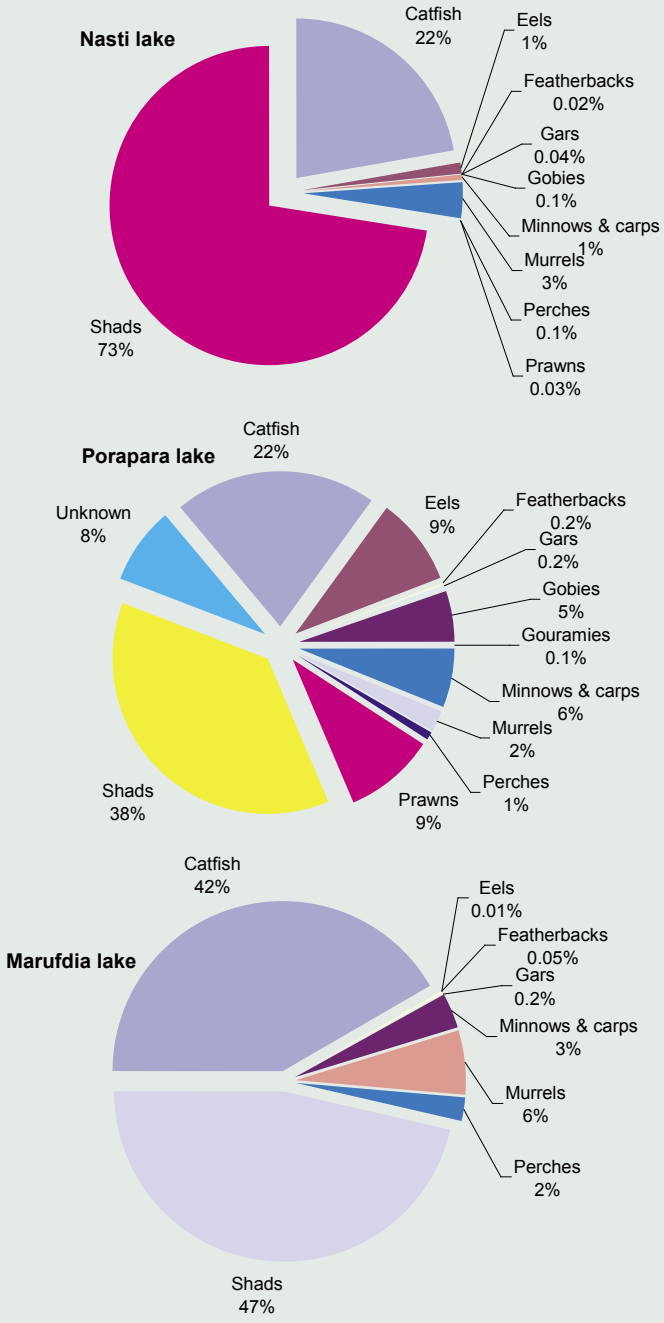


Figure 2. Species assemblage by common groups of related fish and prawn species in three lakes with medium stocking density maintained during last 7 years. Data collected from August 2002 to July 2003

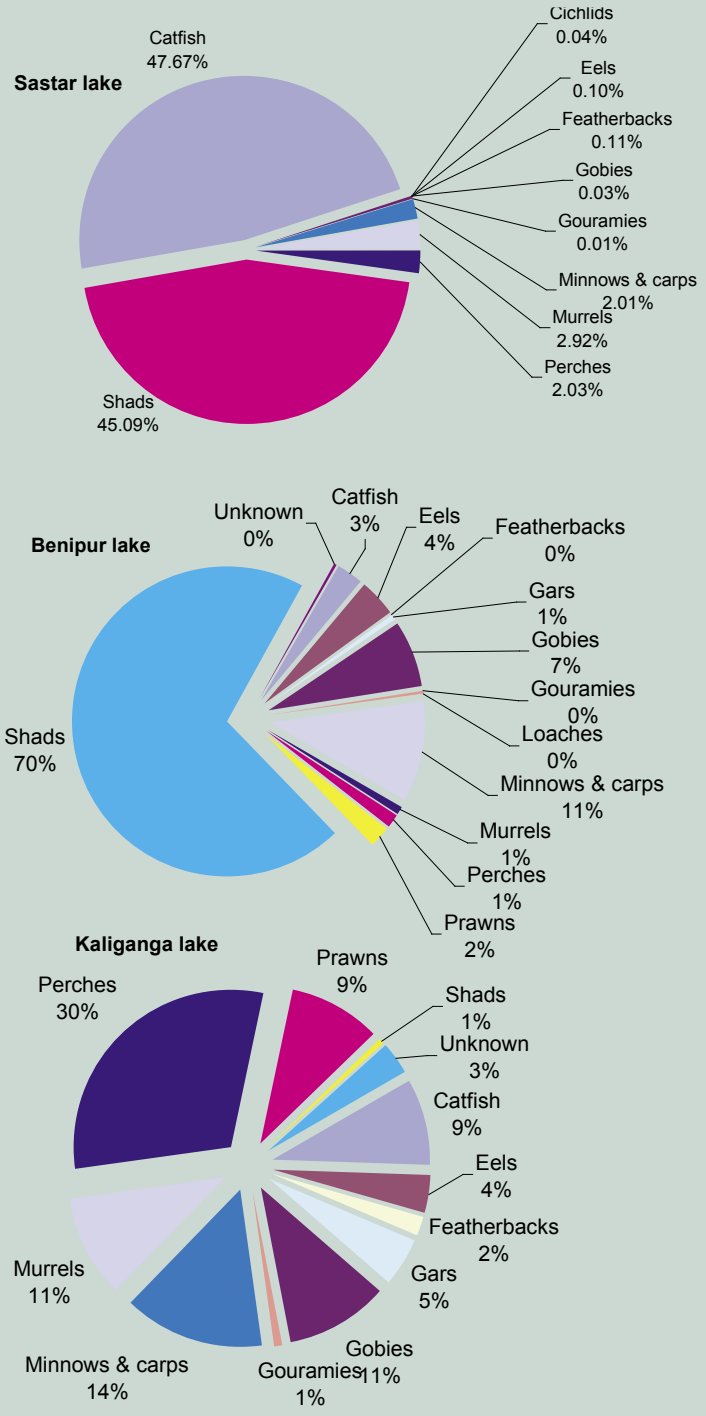
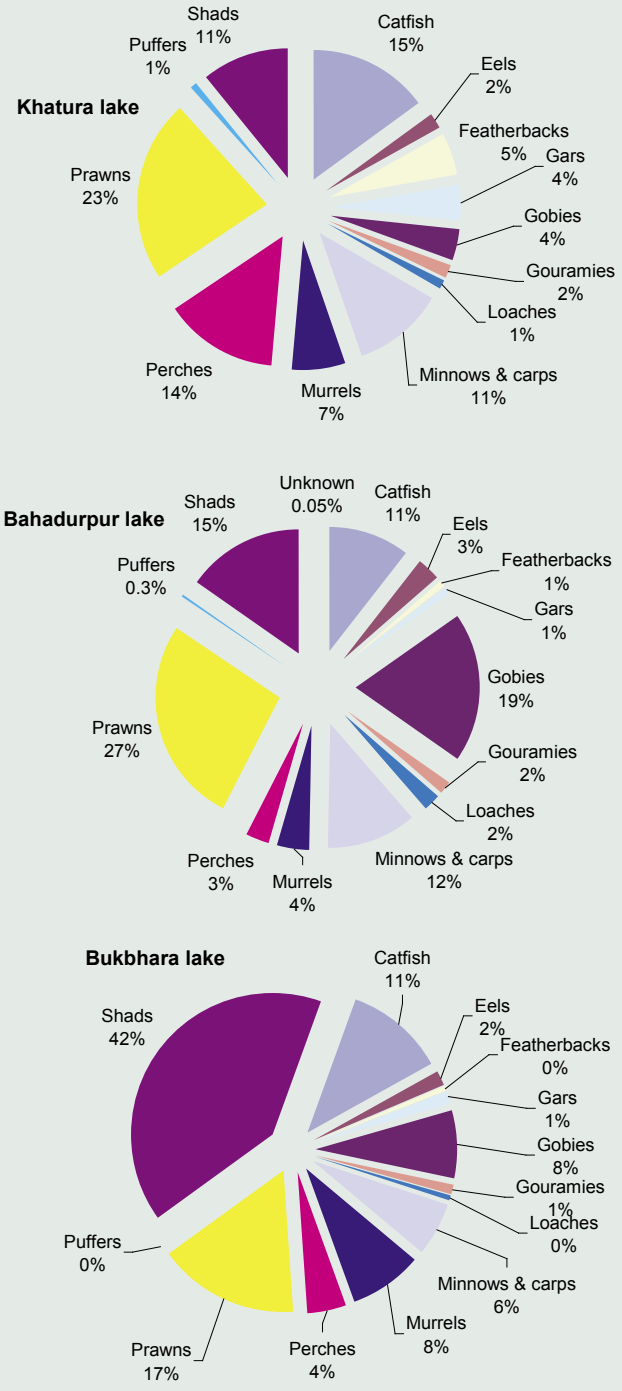


Figure 3. Species assemblage by common groups of related fish and prawn species in three lakes with low stocking density maintained during last 7 years. Data collected from August 2002 to July 2003



Conclusion

The major concerns for culture-based fisheries in oxbow lakes, semi-closed beels (=natural depressions in floodplain) and similar other waster bodies are listed below:

a. Restriction on the community access once the water bodies are leased to a group of fishers/society for culture-based fisheries management (CBFM). This eventually deprives the community from subsistence fishing thus depriving them from probably the only source of protein they have been getting for generations.

b. With apparent profitability as demonstrated through stocking, there has been a general tendency for government agencies to declare "an open access fishery (e.g., beels, oxbow lakes, dead rivers)" to "closed or semi-closed fishery" for the sole purpose of leasing to the influentials/elites, the ultimate objectives were to generate revenue and other associated benefits. Leasing of these open access fishery thus prevents the poorer section of the community from subsistence fishing.

c. Once closed and semi-closed water bodies are brought under CBFM, water bodies are cleared of aquatic vegetation thus depriving the poorer section of the community from their share of aquatic plants they have been using as food, fuel, fodder, etc.

d. Except for lakes managed with very high stocking density, stocking itself may not be main reason for the loss of biodiversity as has been reported (Haque *et al*. 1999a, 1999b, Hossain *et al*. 1999; Hasan & Talukder 2004a, b), but the practices associated with stocking may lead to such loss. For example, cleaning of aquatic vegetation leads to a general reduction in abundance and diversity of plant species, followed by habitat loss for certain small indigenous fish. This may lead to loss in biodiversity and/or changes in the species composition. Further drying of aquatic habitats for complete harvest of the stocked fish before new stocking, may also lead to the loss in biodiversity. Oftentimes, these water bodies are leased to the groups or the individuals for a particular time period and it is a general practice for the lease holders to harvest the water body completely by any means before it is leased to someone else.

Based on the foregoing discussion and observations, the following two recommendations are made:

a. There should be clear policy guidelines so that water bodies brought under culture-based fisheries management (CBFM) through stocking do not restrict community access to subsistence fishing of non-stocked indigenous fish.

b. Stocking programmes should consider as essential the rational balance between increasing fish yield and maintaining environmental integrity of the water body brought under CBFM. This is to ensure that high stocking density and associated management practices does not lead to loss of biodiversity and decrease the yield and abundance of non-stocked indigenous fish.

Nevertheless, with all its perceived negative impacts on social equitability and biodiversity, stocking and such interventions has positive impacts in addition to the increased production. If a wetland does not provide a measurable economic benefit, wide adoption of crop production in the wetland area is likely to take place, which may eventually lead to the destruction of aquatic habitats. Over the last few decades a major change has occurred in the quality of floodplain environments, as many typical wetland areas as well as grazing pasture lands have been converted into rice fields (Nuruzzaman, 1998). Therefore, rational management of oxbow lakes, semi-closed beels and similar water bodies through stocking and other interventions (e.g., sanctuaries, habitat restoration) may be encouraged within the broader framework of aquatic resource management.

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A fisher with his catch of small prawn, Jessore, Bangladesh


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An oxbow lake partly covered with water hyacinth, Jessore, Bangladesh

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