Net Benefits:
The Ecological Restoration of Inland Fisheries in Bangladesh

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Beginning in 1992, the Center for Natural Resources Studies (CNRS) has implemented community-based environmental restoration projects in Bangladesh that seek to protect and renew floodplain ecosystems. These efforts grew out of a situation where the country's aquatic resources were under assault by massive flood control projects. The CNRS strategy was inspired by research showing that the rural poor in Bangladesh rely a rich diversity of fish species for their diets and livelihoods. Most of these fish species depend on the annual inundation of floodwaters for their reproduction and growth. Yet these crucial social and biological realities were either unseen or ignored by the leading development agencies concerned with water management, flood control, and fisheries in Bangladesh. The CNRS projects have shown that an alternative strategy, based on investment in ecological restoration, can benefit both fish and people.

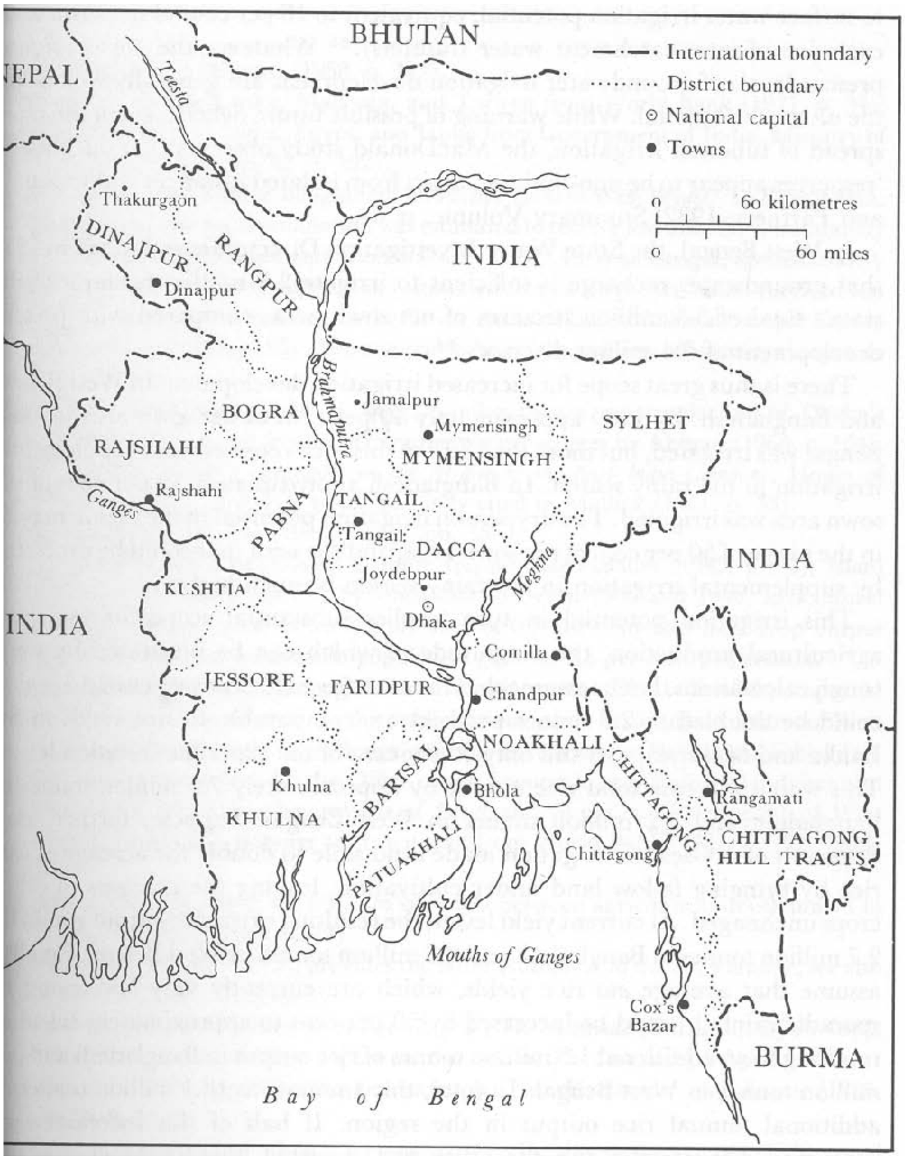
Inland Fisheries in Bangladesh

In his classic book, *Fish, Water and People: Reflections on Inland Openwater Fisheries Resources of Bangladesh,* the late Dr. M. Youssouf Ali described the link between fisheries and rural livelihoods in the Bengal delta:

> Bangladesh has the reputation of being very rich in inland openwater capture fisheries production. A large number of fish and prawns could be captured by men, women, and children at their doorsteps during the monsoon season, when all the low-lying areas of the country remained under floodwater. As a result of the plentiful availability of inland-water fish production, fish constituted the second most important component of the Bengali's diet next to rice. Bengali people have been known to be made up of 'rice and fish' (Ali 1997).

For centuries, the people living in the region that is now Bangladesh have depended on wild aquatic resources for their diets and economic security. Lying in the floodplain delta of the Ganges, Brahmaputra, and Meghna rivers (see Figure 1), the country has rich and diverse inland aquatic environments that support more than 300 inland species of fish and prawns (Rahman 1989; Rainboth 1990). Seasonally inundated floodlands and **beels** ***(perennial water bodies) account for roughly three-quarters of the inland open-water fish catch, with rivers accounting for the remainder. In the 1980s, it was estimated that 75% of rural families practiced seasonal consumption fishing, and that about two million Bangladeshis were engaged in commercial fishing and associated activities. Fish accounted for roughly three percent of the gross domestic product, and more than eleven percent of the country's export earnings (World Bank 1991, 1-3). Rural families consume fish an average of 3.5 days per week (Minkin,*** **et al.** ***1997), and more than 70 percent of animal protein in the diet comes from fish (Institute of Nutrition and Food Science 1983).***

Figure 1: Map



Source: Boyce 1987, 15.

The words ‘nutrition’ and ‘biodiversity’ are seldom linked, yet fish species diversity is an critical component of the nutritional profile of the Bangladeshi people. Poor people, in particular, traditionally have relied on a wide variety of species to meet their nutritional needs. A yearlong study conducted in 1992 found that poor families consumed between 50 and 75 species of fish annually. Most of these species migrate between rivers, where they find shelter during the dry winter seasons, and floodplains, where they spawn and feed during the summer monsoon. Fish are the principal source not only of animal protein but also of fatty acids in the diet, and they contribute important vitamins and minerals to the diets of children, pregnant women, and nursing mothers (Minkin, *et al.* 1997). These ‘vulnerable groups’ suffer the most from nutritional losses caused by impeded fish migration.

Prior to the 1992 study, the dietary contribution of the diverse fish species eaten in Bangladesh was largely ignored. Official documents lumped hundreds of edible species together under the headings 'miscellaneous' or 'other' fish (Department of Fisheries, 1988; World Bank 1991, 144). Fisheries 'experts' dismissed the small fish that play such an important role in the diet of the poor as 'junk fish.' Policy guidelines produced by the government's Flood Plan Coordination Organization referred only to a handful of 'economic species' – larger fish sold in urban markets – implicitly assigning no value to most of the fish produced and consumed in Bangladesh (FPCO 1992).

In the 1970s, Bangladesh was described by the Food and Agriculture Organization of the United Nations as 'possibly the richest country in the world as far as inland fishery resources are concerned'(FAO 1973, 31). By the 1980s, however, the central component of those resources – open-water capture fisheries – increasingly was under attack from large-scale flood control projects whose embankments blocked natural routes for fish migration. The 1990s saw a dramatic shift in fisheries production in Bangladesh, with a marked decline in open-water capture fisheries and a vast increase in closed-water pond aquaculture.

Although opportunities are shrinking, substantial numbers of people in Bangladesh still engage in subsistence fishing. In effect, this is a hidden economy. Families interviewed in the study of fish biodiversity and nutrition often initially described members who were engaged in subsistence fishing as 'unemployed'. Each year, large numbers of so-called unemployed individuals, numbering in the millions, enter a wageless labor system and obtain food for their families by catching fish. Inexpensive or free fish effectively subsidize grain production in Bangladesh by allowing laboring families to consume essential nutrients despite low wages and intermittent employment. The loss of subsistence fisheries today is an important but largely unrecognized factor compelling landless laborers and small farmers to leave rural areas in search of work in the cities.

Bangladesh's freshwater fish populations are heavily dependent on seasonal variations in rivers and floodplain ecosystems. During the summer monsoon season, the inundation of the countryside allows fish to migrate from the river to critical floodplain habitats. In the last two decades, however, millions of hectares of open-water resources in Bangladesh have been impacted by flood control projects and road embankments. These structures have blocked fish migration routes and destroyed the natural spawning and feeding grounds of many fish species. As a consequence, some fish species are no longer seen in the floodplains, and many others are at risk.

The importance of species diversity for both floodplain fisheries production and social equity has been largely overlooked in official fisheries development plans. Instead, fisheries management policies have focused on increasing the production of a limited number of commercially valuable species (Minkin and Boyce 1994). In particular, development strategies have promoted large-scale stocking of carp fingerlings, including 'exotic' species introduced from other countries. These costly programs have altered the country's aquatic ecosystem, favoring a narrow band of species at the expense of biodiversity. The stocked carps, particularly the exotics, compete with local species for food and space, reducing diversity in open waters. The major benefits of the stocking program go to leaseholders and large farmers, who seek to enclose the aquatic commons in order to profit from the sale of carp to urban markets (Toufique 1997). This misguided strategy runs directly contrary to the interests of the poor people, for whom easy access to a variety of fish species is of utmost importance.

Community-Based Ecological Restoration

The Center for Natural Resources Studies (CNRS), based in Bangladesh's capital, Dhaka, seeks to address issues of poverty, malnutrition, and underemployment by improving the environmental management of aquatic resources. Initially, CNRS aimed to demonstrate the feasibility of community-based ecological restoration as a means of benefiting poor people. A pilot project in Tangail district revitalized a degraded wetland ecosystem by reconnecting the floodplain to local rivers via canals. This project tested both a biological paradigm concerning the response of fish species to potential migration channels and a social paradigm resting on community support and involvement.

The project was built on the observations that fishing in Bangladesh is highly dependent on species diversity; that inland fisheries require movement of water between rivers and floodplains to remain robust and abundant; and that reductions in species diversity and fish movements hurt poor families disproportionately. Based on this diagnosis, the CNRS advanced the following propositions:

- The solution to fisheries problems in Bangladesh depends on management of the movement of water between rivers and floodplains.
- The rehabilitation of blocked and silted canals linking rivers and floodplain can substantially increase both fish production and species diversity.
- Water management programs to enhance fisheries can also provide agricultural benefits, by allowing effective drainage and increasing the availability of water for irrigation.
- Fish sanctuaries – refuges where fish are protected during the dry season – can enhance the benefits of water management.
- Community-designed interventions and management can ensure sustainable production and use of natural resources in the floodplains.

In sum, the conservation and enhancement of inland fisheries requires wise stewardship, so as to maintain the integrity of aquatic ecosystems of which humans are an integral part.

Site Selection

Intervention began with the selection of low-lying areas with permanent water bodies, known as *beels*, that had the following characteristics:

- The bed of the major link canal had been raised due to siltation, delaying the entry of water and reducing fish migration.
- There were perennial and seasonal wetlands in the area, and fishing was a major economic activity much of the year.
- Poor people enjoyed access rights for fishing in the wetlands as a common property resource.

- Local people believed that the opening of the canal would be beneficial for fish and crops, and the local government (union council) favored de-siltation.
- Poor people who fished in the *beel* and floodplain were organized.

Several initial project sites were selected. Here we present data from the first site, Sigharagi *beel*, a crescent-shaped wetland covering about seven hectares in the dry season. We then briefly report on experiences at a second site, Bejurnala *beel*.

Participatory Management

A project implementation committee (PIC) was formed for each site. It consisted of around 30 members – 10 to 15 percent of whom were women – representing villages located around the *beel*, and included various social strata and CNRS field staff. A respected local person was selected as PIC chairman, and the local union council chairman acted the PIC's adviser. The services of PIC members were voluntary.

Restoration Activities

The reopened canal not only facilitated fish migration, but also allowed more river water into the floodplain. Thus, habitat for fish in the Sigharagi wetland was expanded both spatially and temporally. In addition to re-opening canals, CNRS undertakes measures to enhance wetland habitats to make them more favorable for fisheries and other forms of aquatic life. These include the reintroduction of locally threatened species, the restoration of swamp forest and reed lands, and the placing of brush pilings into the water to provide shelter and safe habitats for fish.

The restoration of 'fish sanctuaries' – the deeper parts of the floodplains and river channels where fish survive during the dry season, and where they grow and attain maturity for spawning in the next monsoon season – is particularly important. Where perennial wetlands have been transformed to seasonal wetlands due to poor land use management, excavation, de-siltation and reforestation can help to restore sanctuaries. The complete draining of seasonal water bodies to catch fish is a common practice, but this is detrimental to fish populations, as it leaves no parent stock in the floodplain for the next year's reproduction. CNRS staff discussed the necessity of fish sanctuaries in seasonal wetlands with fishermen and owners of *pagars* (small ponds and ditches in which fish are trapped at the end of the monsoon season). In March 1995, a *pagar* located in the middle of the Sigharagi floodplain was leased as a demonstration plot, with the aim of raising public awareness about the need to conserve parent brood fish, and kept as mini-sanctuary for *beel* resident species. The villagers volunteered to protect the *pagar* sanctuary. At the onset of early monsoon rains, these fish dispersed on the floodplain and released millions of eggs even before the entry of river water through canals. During the catch survey in the following year, the fishers reported an abundance of species that they attributed to conservation in the *pagar* sanctuary. Based on this experience, the PIC decided to continue the practice of keeping a *pagar* as sanctuary to conserve the parent stock of fish.

Impact Monitoring

Careful data collection and research are standard features of CNRS projects. Data are collected on social parameters including consumption of fish species by different economic groups and involvement in fishing activities, and on biological parameters such as the fish harvest, fishing methods and intensity, and fish migration. In the Sigharagi *beel* project, 56 households were randomly selected for monitoring. Five village women with basic literacy and numeracy skills were trained in the use of structured monitoring formats and simple weighing instruments. The resident monitors visit the sample households for five consecutive days each month and collect data through interviews, direct observation, and measurement.

Project Benefits

Beels, *chawks* and *pagars* are three distinct types of fishing grounds in the Sigharagi floodplains. *Beels* are perennially inundated areas; *chawks* are seasonally inundated lands which are usually cultivated in the dry season; and *pagars* are temporary ponds and ditches dug within the chawks in order to trap fish. Both *beels* and *chawks* are generally open-access fishing areas for residents of the surrounding villages for at least part of the year. In the pagars fishing is restricted to the landowners or leaseholders, and their designated users. Poor households customarily have been allowed to catch residual fish, however, after the *pagars* have been fished by their owners and leaseholders, a practice akin to gleaning. They are also allowed to fish in low productivity *pagars* where the owners do not even bother to fish. P and landless households therefore have had some access even to privately held fishing grounds.

Yield and Diversity of Beel and Chawk Catch

Comparison of pre- and post-intervention data from the Sigharagi project site shows roughly a five-fold increase in the catch from the *beel* and the *chawk* in the first year (see Table 1). This dramatic rise indicates an underlying increase in wetland productivity. In the project's second year, production fell by about 30%, but it remained more than three times higher than the baseline figure. The decrease in the second year was due to relatively low river flooding, leading to lower ingress of water and a shorter inundation period. Moreover, spawn fishing in the project-rehabilitated canal had a negative impact on the overall productivity of the *beel* and floodplain. In light of this experience, the PIC launched an awareness campaign to discourage future spawn fishing in canals during the ingress of river water.

Table 1: Yield and Species Composition of *Beel* & Floodplain Catch

Species Group	Baseline (Dec'94-June'95)			Year One (Dec'95-June'96)			Year Two (Dec'96-June'97)		
	Weight (kg)	Percent of Total Weight	Number of Species	Weight (kg)	Percent of Total Weight	Number of Species	Weight (kg)	Percent of Total Weight	Number of Species
Small fish	830	33.5	25	4548	37.2	33	2160	24.8	29
Prawns	709	28.5	1	4052	33.1	2	1495	17.2	3
Snake heads	305	12.3	3	1626	13.3	2	2588	29.8	3
Eels	417	16.8	4	657	5.4	4	181	2	3
Small catfish	143	5.8	7	434	3.6	7	198	2.3	10
Major carps	4	0.2	1	375	3.1	3	1239	14.3	4
Large catfish	1	0	2	345	2.8	3	191	2.2	4
Exotic species	42	1.7	2	135	1.1	2	422	4.9	3
Knife fish	29	1.2	1	34	0.3	1	59	0.7	2
Minor carps	-	-	-	16	0.1	2	160	1.8	2
Total	**2,480**	**100**	**46**	**12,222**	**100**	**59**	**8,693**	**100**	**63**

The data also show an enhancement of fish species diversity, with the number of species caught increasing from 46 before the project, to 59 in year one, and 63 in year two. This reflects the positive impacts of habitat improvement and other conservation measures like the establishment of sanctuaries and restrictions on the use of harmful fishing equipment in the floodplain. Small fish, small prawns, snakeheads, and eels continued to make up the bulk of the catch. The share of carps and catfish rose following the canal rehabilitation, however, indicating successful recruitment of these riverine species into the floodplain.

Yield and Diversity of Pagar Catch

Total yield from nineteen *pagars* in the Sigharagi *chawk* area that were monitored before and after intervention more than tripled in the first year of the project. The production of fish from these *pagars* fell in the following year due to low flooding, but remained 70% higher than the baseline production. Major changes also were observed in the species composition of the *pagar* catch. Prior to intervention, commercially valuable major carp species represented less than 2% of catch and ranked only seventh in terms of contribution to yield. After intervention, in year one, major carps made up almost 24% of catch and ranked first, while in the second year major carps constituted 15% of the catch and ranked fourth. Similarly, large catfish, which were absent from the *pagars* in the baseline year, made up about 8% and 6% of the catch in the next two years, respectively. Exotic species, which include other carps and tilapia, also increased in absolute and relative terms. At the same time, the small fish group also showed impressive yield gains, ranking first and contributing over 24% of the catch in the second year.

Table 2: Yield and Species Composition of *Pagar* Catch

Species Group	Baseline (1995)			Year One (1996)			Year Two (1997)		
	Rank	Weight (kg)	Percent of Total Weight	Rank	Weight (kg)	Percent of Total Weight	Rank	Weight (kg)	Percent of Total Weight
Snake heads	1	597	41%	4	569	11%	2	497	20%
Small catfish	2	393	27%	5	509	10%	3	463	19%
Small fish	3	177	12%	2	1120	22%	1	593	24%
Knife fish	4	113	8%	9	77	1%	9	16	1%
Eels	5	86	6%	7	256	5%	7	76	3%
Exotic species	6	31	2%	3	744	14%	5	231	9%
Major carps	7	29	2%	1	1222	24%	4	363	15%
Prawns	8	25	2%	8	254	5%	8	33	1%
Large catfish	9	-	-	6	431	8%	6	167	7%
Minor carps	10	-	-	10	<1	0%	10	<1	0%
Total		**1451**	**100%**		**5182**	**100%**		**2439**	**100%**

Human Benefits

Fishing Participation

Men, women, and children fish in the Sigharagi wetland, although participation and end-use of the catch vary by age group and gender. Roughly 40% are subsistence fishers, about 35% are part-time professional fishers, and 25% are full-time professionals. Survey data show that females make up 7.4% of the fishers, most of whom are children below 15 years of age fishing for home consumption. Overall, children comprise 28% of all fishers, most of whom fish mainly for subsistence. In contrast, two-thirds of adult fishers sell at least some of their catch.

Participation in fishing varies from season to season, being highest during monsoon and post-monsoon months (July-December). In 1995, before the project intervention, fishers altogether spent 690 person-days fishing, with landless households accounting for the greatest fishing effort (see Table 3). Fishing effort increased substantially following intervention in response to greater fish availability and the extended spatial and temporal extent of wetland area. Total fishing effort almost doubled to 1,302 fishing days in 1996, with the greatest increase occurring among small farmer households, who spent four times as many days fishing after intervention. In 1997, the second year of the project, the total fishing days fell to 858, less than in the project's first year but still higher than the baseline situation despite the drought.

Table 3: Fishing Days by Household Type

Household Type	**Fishing Person Days**					
	Baseline (Feb-June '95)		**Year One (Feb-June '96)**		**Year Two (Feb-June '97)**	
	Days	*Percent*	*Days*	*Percent*	*Days*	*Percent*
Landless	434	63%	624	48%	402	47%
Small Farmer	118	17%	450	35%	300	35%
Medium & Large Farmer	138	20%	228	18%	156	18%
Total	**690**	**100%**	**1302**	**100%**	**858**	**100%**

Fishing by landless households fell below the pre-project level in year two. This was due not only to the low flooding, but also to a conflict that arose over access to the *beel*. Previously, the *beel* had been leased to a third party residing outside the project area, who controlled commercial fishing there through a local agent. Subsistence fishers had free access often after the major fish harvest. With project support, the PIC got the lease, but the local agent illegally sought to retain control over access to the *beel*, impeding fishing by villagers, particularly by the landless subsistence fishers. After he relinquished control, however, the villagers regained open access to the *beel.*

In addition, survey data showed that following the intervention landless households had reduced access to 'gleaning' in the private *pagar* fisheries, as these became even more productive. However, a share of the income from *pagars'* enhanced production does go to poor local fishermen who buy the fish from the *pagar* owners in advance at a relatively low price and, after protecting the *pagars* for two to three months, harvest the fish for a profit.

Fish Consumption

Per capita fish consumption for all types of households increased markedly in the year following project intervention. Average daily consumption rose from 24 grams before the project to 30 grams in the first year (see Table 4). In year two, per capita fish consumption slipped back to 25 grams, due to lower fish production resulting from low river flooding, exacerbated by the dispute over leasing arrangements in the *beel.*

Table 4: Fish Consumption by Household Type (in grams)

Household Type	Per Capita Fish Consumption (gm/head/day)		
	Baseline (Feb-June '95)	Year One (Feb-June '96)	Year Two (Feb-June '97)
Landless	18	22	19
Small farmers	26	42	26
Medium & Large farmers	40	43	36
All Types	**24**	**30**	**25**

The sample households consumed more than 60 different species of fish. Small fish species were eaten more than any other group. Before the project, purchased fish accounted for 73% of household consumption; their own catch represented only 27% (see Table 5). The project led to a marked increase in the proportion of self-caught fish, to roughly half of the total consumption, with landless and small farm households showing the largest gains.

Table 5: Sources of Fish Consumed by Household Type

Household Type	Baseline (1995)		Year One (1996)		Year Two (1997)	
	Caught (%)	Bought (%)	Caught (%)	Bought (%)	Caught (%)	Bought (%)
Landless	25.2	74.8	51.6	48.4	43.5	56.5
Small Farmers	22.3	77.7	46	54	55.7	44.3
Medium & Large Farmers	34.2	65.8	37.5	62.5	51.2	48.8
All Types	**27**	**73**	**46.1**	**53.9**	**49.3**	**50.7**

Bejurnala Beel

A CNRS project in Bejurnala *beel*, a 33-acre wetland that borders five villages in north-central Bangladesh, also illustrates the potential for community-based ecological restoration of inland fisheries. The *beel* is owned by the government, but 21 acres have been distributed among the local people on a long-term lease. In the dry season, the water area of the *beel* remains at least 20 acres, and it is open for both subsistence and professional fishing. In the past, there were several connecting canals between the *beel* and the nearby Singha River, which facilitated fish migration and supported rich fisheries production and species diversity. The *beel* also provided water for irrigation of adjoining lands in the dry season.

By the mid-1990s, however, the *beel* had become almost seasonal. Both the *beel* and the canal beds had been raised due to siltation over a long period. This not only resulted in a shortage of dry season surface water, but also led to crop losses in the rainy season due to rainwater congestion, and to declining fish production and species diversity. In low-flooding years, the *beel* disappeared in the dry season, leaving water only in privately owned *pagars*. To make matters worse, a local influential person excavated a big pond in the *beel* for fish culture, in effect enclosing part of the aquatic commons. The poor fishers were unhappy about this illegal occupation, but they could not stand against the rich man.

After discussions with CNRS, the local people expressed their desire to re-excavate the main canal between the *beel* and the Singha River. A PIC was formed in 1996, composed of project staff, a schoolmaster, fishers, and farmers from the five villages around the *beel*. Under the supervision of the PIC, the link canal was rehabilitated during the dry season in the following year, generating 600 person/days of local employment.

After excavation, water and fish entered the canal from the Singha River in April 1997, much earlier than in previous years. By mid-June, the canal became full of water. Some villagers started rearing ducks in the canal, and farmers began planting a local jute variety in nearby lands with the hope that the canal would reduce drainage congestion. The local people returned to fishing in the canal with fixed nets and enclosures during the monsoon. The project staff convinced them to remove fixed nets during the peak migration period, however, so that fish from the river could move onto the floodplain and into the *beel*.

The total fish catch and species diversity in Bejurnala *beel* increased greatly following the canal re-excavation. Fish production increased from a baseline of 970 kg to 5,700 kg. Particularly dramatic increases in major carp and catfish production were observed, indicating that the project facilitated fish migration from the river. After rehabilitation, the canal retained water for eleven months, compared to seven months before the project. Fish catch in the canal increased substantially, too, from 300 kg to 3700 kg. A particularly remarkable outcome was that more than 1,000 kg of major carps were harvested in the canal, whereas in the preceding year only one fish had been caught. As large, high-priced fish, major carps are rarely consumed by poor people, but the increased catch of these species contributed to higher fishing incomes for poor families. Various species of knife fish, minor carps, and large catfish were also found that were not observed in the canal before rehabilitation. The total number of fish species increased from 37 to 51, again indicating that the quality of the habitat had improved.

Conclusion

In recent decades, Bangladesh's physical landscape has been transformed in ways that have dramatically reduced the productivity of open-water floodplain fisheries. The CNRS approach to ecological restoration seeks to reverse this trend by mobilizing local communities to invest in natural assets. The success of this approach has inspired others to follow suit, and ecological restoration has now been taken up as part of the national fisheries policy agenda. Projects funded by the U.S. Agency for International Development and the World Bank have attempted to promote community-based ecological restoration. The success of these endeavors has yet to be independently evaluated. CNRS's own work continues to evolve, incorporating new ideas and lessons learned through participatory research and action. The restoration of submerged forests and aquatic vegetation, has become a recent focus in its activities. This work is demonstrating that humans and fish not only can co-exist in Bangladesh’s rich delta ecosystem, but that their relationship can be a mutually supportive one, in which each helps to sustain the other.

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