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# Freshwater fishes of Bangladesh: Fisheries, biodiversity and habitat

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*Fisheries play an important role in nutrition, income, employment and export earnings in Bangladesh. Fishes contribute to 63% of animal protein intake, about 5% of gross domestic product and 5% of export earnings; approximately 1.4 million people are directly engaged in fishing, 11 million in part-time fishing and another 3 million in aquaculture activities. The fisheries are highly diversified and comprised of inland open water capture fisheries, inland closed water culture fisheries and marine fisheries, which contribute respectively 35%, 44% and 21% to total fish production of 2.1 million tonnes. The major environmental factors having negative impacts on fisheries development are mainly: human impacts on riverine morphology, disruption of ecology, intensive agriculture, and modern developments. Fish conservation acts and regulations exist, but enforcement is difficult because of prevailing socio-economic conditions. Few regulatory mechanisms presently exist for protecting aquaculture environments.*

*Production from inland openwater capture fisheries is declining due to over-exploitation and habitat degradation. However, aquaculture production, which mostly follows traditional practices, has been steadily increasing. Fisheries research has made significant contributions to the large growth of aquaculture through generating a number of economically viable, socially acceptable and environmentally compatible technologies being used by different categories of farmers, large and small. Presently, formulation and implementation of strategies and policies for conservation and sustainable management of degraded aquatic habitats have been immensely effective along with the generation and wider application/dissemination of suitable aquaculture and management technologies, which are expected to ensure the conservation of aquatic genetic resources. This paper reviews all these subjects and emphasizes future needs for development and implementation of policies/regulations at the national level, before it becomes too late to conserve valuable aquatic biodiversity and their habitats.*

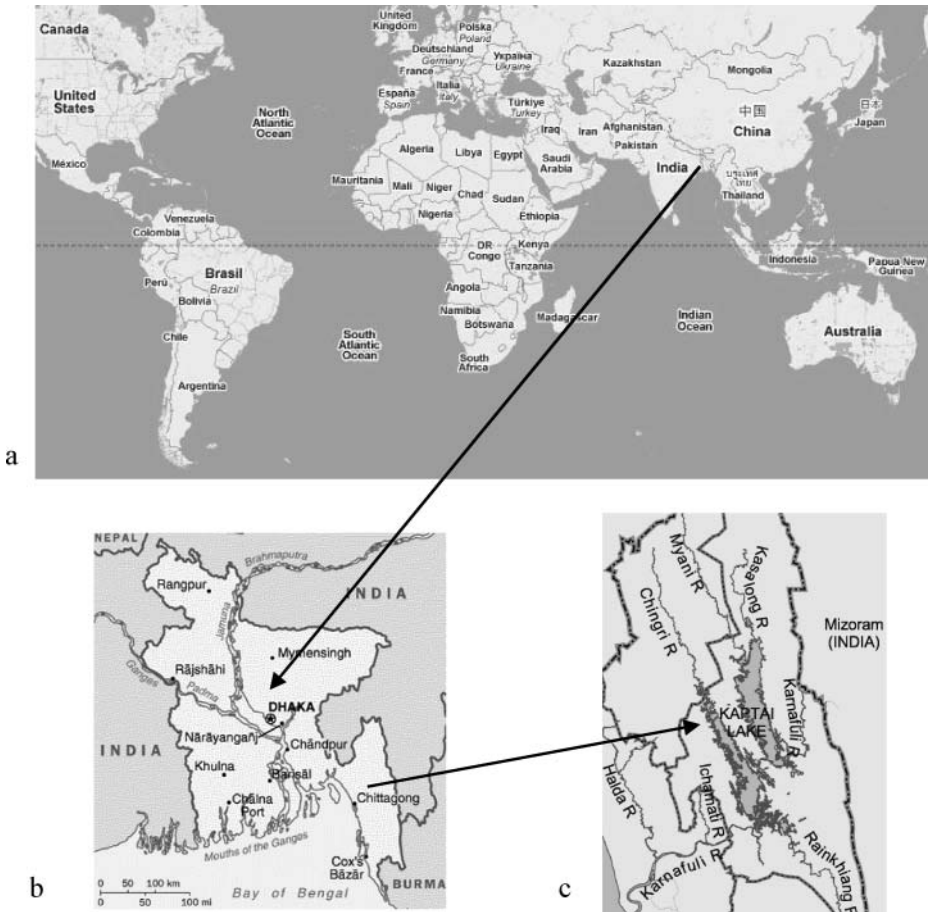
*Keywords:* conservation, aquatic ecosystem, aquaculture

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## Introduction

Bangladesh has the third largest aquatic fish biodiversity in Asia, after China and India, with about 800 species in fresh, brackish and marine waters (Hussain and Mazid, 2001). This species diversity has been attributed to the world's largest flooded wetland (Bengal Delta) and the three main river systems (Ganges-Padma, Brahmaputra-Jamuna and

Meghna) that flow from the Himalayas into the Bay of Bengal (Figure 1). In inland fisheries, Bangladesh ranks third among the top ten fish producing countries of the world. China is highest with 2.20 million tonnes, India second with 0.65, and Bangladesh third with 0.53 (FAO, 2000) representing respectively 28.5, 8.1 and 6.7 percent of world inland fish production. The fisheries sector plays an important role in the economy in terms of nutrition,



**Figure 1.** Bangladesh in relation to other countries in the world map(a) and location of major river systems viz. Ganges-Padma, Brahmaputra-Jamuna and Meghna(b) including Kaptai lake(c) in the country maps.

income, employment and earning foreign exchange. In 2002–03, the sector contributed to 4.91% of gross domestic product (GDP), 5.1% of export earnings and about 10% of total employment. Fish provide 63% of animal protein intake of the country's population. However, the average consumption is  $14.24 \text{ kg cap}^{-1} \text{ y}^{-1}$  compared to the required quantity  $18 \text{ kg cap}^{-1} \text{ y}^{-1}$  (DoF, 2005). Production cannot keep pace with the growth of Bangladesh's population.

Against a backdrop of over exploitation, degradation of fish habitats, and subsequent declining fish production from natural aquatic resources, inland capture fisheries contribution has declined from 50% to 35% of total fish production and marine capture fisheries production has remained static over the last ten years (Mazid, 2002). Aquaculture production (1995–2004) has progressively increased and its contribution to total fish production has gone up

from 27% in 1994–95 to 43% in 2003–2004 (DoF, 2005). Because of its high potential, promotion of aquaculture in suitable waterbodies has been identified as an important sub-sector of food security, poverty alleviation, rural employment and economic emancipation in the development programme of the government. Aquaculture has become an important means of livelihood and income in the country.

This paper highlights the potentials of the fisheries sector and the constraints faced in freshwater fisheries impeding realization of their potential in Bangladesh. The paper includes sections on water resources and species diversity, fish and aquaculture potential trends, issues, strategies and thrust areas of development, fisheries research, legal framework, fisheries act, ordinance and regulations and strategies, management measures and plans for the development of fisheries. Special emphasis is given to

**Table 1.** The extent and distribution of water resources in Bangladesh.

| Water resources           | Area (ha)   | % of Inland waters |
|---------------------------|-------------|--------------------|
| Open water bodies         |             |                    |
| Floodplains               | 28, 32,792  |                    |
| River and tributaries     | 1, 011, 563 |                    |
| Beels and haors           | 114, 161    |                    |
| Kaptai Lake               | 68, 000     |                    |
| Total open water bodies   | 4, 047, 316 | 93.27              |
| Closed water bodies       |             |                    |
| Ponds                     | 146,890     |                    |
| Oxbow lakes               | 5,488       |                    |
| Shrimp farms              | 140, 000    |                    |
| Total closed water bodies | 292,378     | 6.73               |
| Total inland water bodies | 4,339,694   | 100.0              |
| Marine fisheries areas    | 16,606,600  | —                  |

briefly explain freshwater habitat degradation status and impacts on aquatic ecosystems specifically on fish biodiversity. The effects of various developmental projects and future research and development needs are also presented.

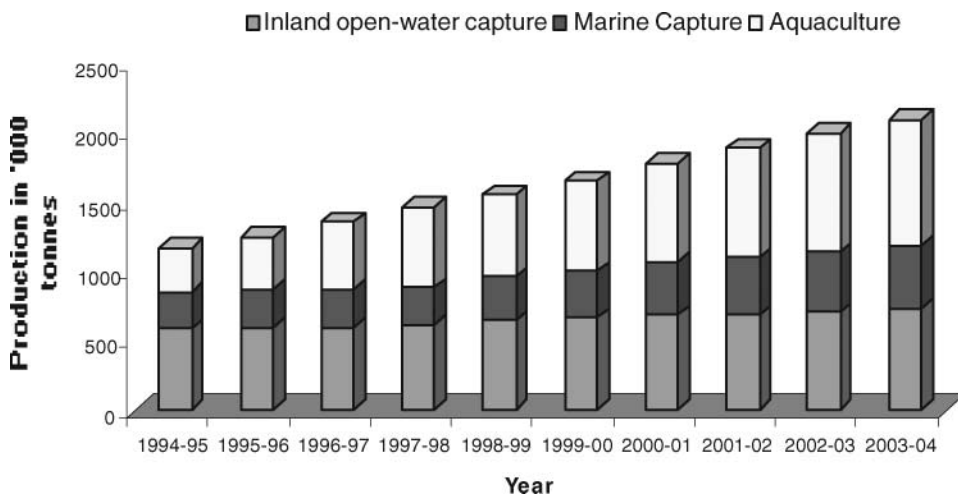
## Water resources and species diversity

Bangladesh is endowed with unique water resources comprised of both inland, open and closed waterbodies, and marine waters. The extent and distribution of different water resources of the country is shown in Table 1.

The fisheries of Bangladesh are rich resources from both physical and biological points of view. There are about 795 species of fish and shrimp available in the fresh and marine waters of Bangladesh. Fourteen exotic species have also been introduced in the country at different times. Besides fish and prawns, there are 10 species of pearl bearing bivalves and 254 species of edible tortoises and turtles (Mazid, 2002).

## Fish and aquaculture production trends

During 1995–2004, the total fish production of the country increased from 1,172,868 tonnes to 2,102,026 tonnes (Figure 2; DoF, 2005). Of the total fish production (2003–04), 35% came from inland open water capture; 21% from marine capture and 44% from aquaculture (DoF, 2005). Catches from open waters are declining due to over-exploitation and degradation of fish habitats all over the world including Bangladesh. Fish production from inland open waters of Bangladesh has declined due to massive construction of flood control structures, over-exploitation, abstraction of water for irrigation, intensive agriculture and development activities, pollution, destruction of mangrove forests, etc. (Hoq, 2003). Aquaculture has become the main source of supply to meet consumer demand for fish. Also, Bangladesh has emerged as one of the leading nations in freshwater aquaculture production during recent years with a growth rate comparable to those in China and India. Aquaculture production in

**Figure 2.** Aquaculture production trends compared to inland and marine capture fishery during last ten years (1995–2004).

Bangladesh has rapidly increased in recent years because of adoption of various improved aquaculture technologies. Aquaculture is now the dominant sub-sector, contributing 43% of the total fish production. Hence, development of this vital sub-sector is having a major impact on production and economic well-being of the people of Bangladesh.

## Issues, strategies and thrust areas of development

### Inland freshwater culture fisheries

Freshwater aquaculture involves fish culture in ponds and tanks scattered all over the country with an area of about 0.15 million ha. Exotic and native carp species account for 85% of the total aquaculture production of 0.66 million tonnes (DOF, 2002). Major groups like Tilapia, Catfish, Climbing Perch and Shrimp are being cultured in suitable fresh and brackish waterbodies. Floodplains including rice fields and oxbow lakes are also gradually coming under culture-based capture fisheries practices. All technologies so far developed for freshwater aquaculture are highly profitable. Because of the high profits in scientific aquaculture, the number of ponds and the rate of adoption of technology-based aquaculture are both increasing. However, the reliable growth of this sub-sector is constrained by the following limitations: i) basic inputs like fish eggs, fish feeds and other on-farm inputs are not available to most pond owners. More specifically, non-availability of quality seeds is the single largest limitation in expansion of aquaculture; ii) poor quality fish stocks due to inbreeding depression at private hatcheries which results in poor fish growth; and, iii) disease epidemics and loss of fish crop due to water quality deterioration resulting from inappropriate management.

### Current status of inland open water capture fisheries

The overall management of inland open waters is complex. They are the primary source of food fishes for the common people of Bangladesh. Therefore, even a small increase in growth in this sector is bound to have a major impact. Hilsa, (*Tenualosa ilisha*), is the largest single fishery in this sub-sector with an annual production of about 0.27 million tonnes (DOF, 2007). About 2%, i.e. 2.5 million people of the country are directly or indirectly involved

in the hilsa fishery for their livelihood (Mazid, 1998) and Bangladesh has the largest share (about 75%) of the total world fishery for this species. It presently (2005–06) represents about 12% of fish production in Bangladesh, is an important food fish for the consumers and is rich in omega-3 fatty acids unlike other marine fish. At present the fishery has severely declined upstream and is mainly concentrated in the downstream rivers like Padma and Meghna, their estuaries, coastal areas and the sea. Efforts to protect, rehabilitate and maintain water bodies and, thereby, conserve aquatic biodiversity have not yet been undertaken seriously. As there is open access for fishing in open water bodies, increased production from this resource will improve both food consumption and livelihoods, particularly for subsistence fishermen. The natural fisheries of inland open waters have been in decline due to a variety of reasons (Mazid, 2002): i) over-exploitation and indiscriminate killing of juvenile fish due to unregulated fishing pressure and total removal from water bodies that completely dry up in the dry season; ii) reduction, alteration and degradation of natural habitats due to human development activities and aquatic pollution reducing natural populations through retardation of reproduction potential and growth; iii) siltation in river basins and floodplains affected aquatic habitats, feeding grounds and migration paths leading to loss of biodiversity; iv) loss and destruction of breeding and nursery grounds due to flood control, water management, road and river embankments, hampering natural recruitment; v) the lack of alternative livelihoods for fishermen leads to injudicious fishing and over-exploitation; and vi) pollution of aquatic ecosystem due to industrial and domestic wastes and pesticides is seriously affecting fish habitat and overall aquatic ecosystem.

## Freshwater habitat degradation and impacts on aquatic ecosystems

### Effects of development projects on freshwater aquatic ecosystems

Since 1960, hundreds of water resource development projects have been implemented in Bangladesh including Flood Control and Drainage (FCD), Flood Control, Drainage and Irrigation (FCDI), closures of river and canals, channel diversions and withdrawal of water from rivers and natural depressions

for irrigation in the dry season (Ali, 1997). Through these projects the entire country has been converted into a series of polders with earthen embankments. The potential impacts of these development projects on fish and aquatic resources were not considered at the time of planning, design and implementation. The natural migration and recruitment of fishes, and other aquatic animals between rivers and floodplains have been obstructed. As a result, many fish and prawn species of rivers, floodplains and estuaries have become threatened and endangered (The World Conservation Union (IUCN), 2000).

The Jamuna Multipurpose Bridge, which was constructed recently has caused serious impacts, particularly on the existing ecosystem, the capture fishery production, and fish spawn collections in Jamuna river both upstream and downstream of the bridge site and in its adjacent rivers and floodplains downstream (Ali, 1997).

The negative and deleterious impacts of water resource development projects on fish and fisheries of Bangladesh have been studied regionally under the Flood Action Plan (FAP) of the Ministry of Water Resources (MWR). Impact studies of Northwest and Southwest regions (Ali, 1997) covering most of the Ganges-Padma and Brahmaputra-Jamuna river systems were conducted under FAP-2 and FAP-4.

The Northwest Regional Study conducted under FAP-2 (1991) revealed that fisheries have been identified as one of the worst sub-sectors affected by flood control developments in Bangladesh. It was estimated that the Northwest Region's contribution to national fish production fell from 14% in 1983–84 to 10% in 1988–89 and, in particular, riverine fish production decreased from 24,500 tonnes in 1983–84 to 3,940 tonnes in 1988–89 (Ali, 1997). Construction of a large number of flood protection embankments around and within the floodplain areas under FCD and FCDI projects adversely affected the ecosystem and the habitats of fish populations. An estimated 2.0 million ha of floodplains will be lost to fisheries due to water development projects by 2005 with a loss of fish production of over 1.0 million tonnes per year (Mazid, 2002).

The Brahmaputra and Ganges/Padma Rivers run throughout the Northwest region. Tsai and Ali (1985) identified the existence of two stocks of major carps in these rivers. The reasons for the decline of the Brahmaputra River stocks are: i) construction of embankments on the banks of Brahmaputra-Jamuna River that eliminated large proportions of the habitats of major carps, particularly in the

Rangpur, Bogra and Tangail basins; ii) heavy sedimentation that occurs in the main stem of the Brahmaputra-Jamuna river and Old Brahmaputra river. For the Ganges-Padma River, the causes of stock decline are: i) construction and operation of Farrakka Dam in India has changed the water flow regime and hydrology of entire Padma river basin, destroying most of the major carp habitats and also hilsa migrations; ii) construction of embankments on both banks by the Ganges-Kobadak project further reduced carp habitats; and iii) sedimentation occurs in the Padma and Gorai rivers (Master Plan Organization (MPO), 1987b).

Due to the above changes in the upper and lower Padma River fisheries there showed major changes with production declining from 5,000 tonnes in 1983–84 to only 1,000 tonnes in 1991–92 (Figure 3, Rahman et al., 2003). The negative impacts of the Farrakka and other barrages severely affected spawning, nurseries, feeding migrations, and also increased fishing pressure in the upstream river. As a result, landings of hilsa and other fishes from Ganges-Padma, Brahmaputra-Jamuna and Meghna rivers have sharply declined recently in the country (Mazid, 1998). In particular, reduction of hilsa catches in those water bodies alone threatened the livelihood of about 2.5 million people engaged in full time fishing.

The Northwest Regional Study conducted under FAP-4 (1993) also revealed that flood control structures destroyed fisheries and caused the destruction of many resident brood stocks of fish. River flows have been altered in both in depth and the duration of flooding, and with it changes in the pattern of siltation that caused detrimental effects on riverine fishes and prawns. Consequently, fishermen's catches and earnings have been reduced and some full-time fishermen had to seek other work or move elsewhere (Ali, 1997).

The annual inland capture fisheries in the Southwest Region declined from 169,600 tonnes/year in

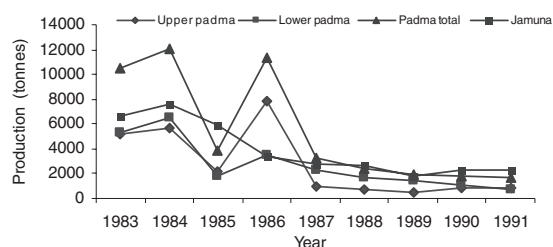


Figure 3. Fish production trends in the upper and lower Padma River and River Jamuna.

1983–84 to 119,100 in 1988–89, a net decline of 50,500 over a span of only 6 years (DoF, 2005). In the upper Padma River where fisheries showed major changes, fish production was 7,600 tonnes in 1984–85, but reduced to only 1,100 tonnes in 1988–89, a fall of 85% (Ali, 1997).

## Habitat degradation impacts on fish biodiversity

Aquatic biodiversity is under severe stress all over the world. An estimated 39% of all freshwater species of the global aquatic ecosystem are extinct, endangered, or vulnerable (IUCN 2000). Recent environmental modifications, water quality degradation and fishing pressure have increases the vulnerability of fish genetic resources in Bangladesh. As a result, many fish species of floodplains, rivers and estuaries have become threatened and endangered.

Alteration of aquatic ecosystems has direct and indirect adverse effects on fish flora and fauna through their reproduction, migration and survival. Adverse environmental conditions can affect natural reproduction of populations and ultimately hinder recruitment in stocks from spawning. Similarly, fish migration can be hampered due to negative impacts. For example, hilsa fish migrate into estuaries and most of the river systems of Bangladesh to spawn. There, the essential exogenous semi-saline or freshwater ecological parameters trigger the reproduction of hilsa stocks. The river waters nurture the millions of larvae where they grow and develop into juvenile and adult hilsa. At that stage, they migrate towards the sea. The recent siltation problems on the upstream reaches of the Padma and other rivers as well as in floodplain systems have affected the normal cycle of spawning and migration in hilsa and other fishes. Other than siltation, many human activities, as discussed above, can also interfere directly or indirectly with vital life history stages of fish biota. As a result, many valuable fish species have been threatened or endangered and some are already in the line of extinction. According to the Red Book figures of Bangladesh (IUCN, 2000) about 54 freshwater fish species are critically or somewhat endangered in the country. Among them, 14 species are listed as critically endangered; 27 as endangered and 14 as vulnerable. In this group, the highest number of species (19) belong to the family Cyprinidae.

## Fisheries research

Fisheries research has made significant contributions to the large growth of aquaculture by generating a number of economically viable, socially acceptable, and environmentally compatible technologies being used by different groups of farmers, large and small. In consonance with Government plans for the development of the fisheries sector, the Bangladesh Fisheries Research Institute (BFRI) has played a significant role in the evolving demand for aquaculture and management technologies through intensive research at its regional stations and sub-stations. BFRI has so far developed more than 45 technologies, majority of which have been disseminated into the field by the Department of Fisheries (DoF), NGO extension workers, and interested entrepreneurs. Some of the Institute's important technology packages are: i) breeding and hatchery management of carps, catfish, tilapia and freshwater prawn; ii) improved nursery management practices for carps, catfish and freshwater prawns; iii) artificial propagation and culture of certain endangered fish species; iv) polyculture of carps and *Pangasius*; v) culture of tilapia, and silver barb in seasonal ponds; vi) integrated fish-poultry and rice-fish farming; vii) fish culture in pen; viii) development of low cost fish feed from indigenous ingredients; ix) backyard prawn hatchery technologies; x) improved culture method of shrimp, *Penaeus monodon*, and mud crab, *Scylla serrata*; xi) control of fish and shrimp diseases; xii) hilsa fisheries management and development; and, xiii) management and development of floodplain fisheries.

Since 1994 BFRI has been conducting research on the conservation of fish biodiversity and has successfully developed a number of technology packages for artificial breeding and seed production of some of the important threatened fish species using *in vitro* fertilization. The Institute successfully initiated fish genetic research program in 1988 to generate better fish breeds and improved stocks, i.e., improved germplasm of tilapia, silver barb and rohu to increase aquaculture production. So far the genetically improved strain of BFRI silver barb, *Puntius gonionotus*, the BFRI GIFT (Genetically Improved Farmed Tilapia) strain of *Oreochromis niloticus* and the BFRI rohu, *Labeo rohita*, developed by several generations of genetic selection showed 35%; 32% and 10% gains in body weight compared to non-selected control groups of these species. These

technology transfer programs resulted in a massive response throughout the country, which ultimately led to: increased aquaculture production, improved nutrition, and generated employment for resource-poor rural people. To develop sustainable, low-input aquaculture technologies for different aquaculture ecosystems and social groups, the Institute also undertook farming system research in different agro-ecological zones of the country. The adoption of technology based aquaculture practices, particularly in fresh and brackish waters, has led to tremendous increases in aquaculture production over the last 10 years. At present, average yield per unit area of water, in the case of carp polyculture in freshwater ponds is nearly 1800–2000 kg ha<sup>-1</sup> and in case of shrimp 300–350 kg ha<sup>-1</sup> in brackish water enclosures.

Previously the research thrust of BFRI was by and large on production-oriented technology generation, especially for freshwater aquaculture. However, with dynamic changes taking place because of human made modifications to the water courses, coupled with shrinking land to population ratios and increased sedimentation and pollution, the emphasis is shifting to prevention of fish habitat degradation through the management of open water inland fisheries and marine fisheries resources. Controlling the disruptions of the environment, productivity management and maintenance of soil and water quality have assumed paramount importance in society. Socio-economic aspects in traditional society have given special attention to supplement the effort of Government in alleviating the misery of fish farmers and fishermen.

## Legal framework: Fisheries act, ordinance and regulations

The “East Bengal Protection and Conservation of Fish Act, 1950” was the first act promulgated for conservation of fisheries resources. Since then much legislation has been formulated and enacted for the management and development of fisheries (Table 2).

The Ministry of Environment and Forest (MEF) announced an “Environment Policy” in 1992 along with an “implementation schedule” for conservation and development of the environment with ecological balance. The Department. of Environment under MEF is responsible for overall development and

protection of the environment. However, the present emphasis of the Department is mainly on industrial and other chemical pollution control. Under the present system, different aspects of environmental impact assessment (EIA) are examined carefully before undertaking a new development project. However, EIA is not mandatory for aquaculture projects. The Department of Fisheries (DOF) is also responsible for overseeing the degree of intensification of aquaculture practice and its impact on environment. The department is also entrusted with the responsibility of framing regulations to control adverse effects.

Given the importance and the tremendous potential of the sector, the government adopted a National Fisheries Policy in 1998 to improve degraded habitat, conserve aquatic biodiversity and properly guide fisheries development in Bangladesh.

## Strategies, management measures and plan for development of fisheries

Changing ecological, economical and environmental conditions are affecting productivity and livelihoods in the fisheries sector. To harness the sector’s development potential in a coordinated and integrated manner with all the users involved in water resource development and management, strategies and programmes are now being planned to achieve the four major goals: i) build up nutritional food security; ii) achieve rural economic security; iii) develop aquatic environmental,; and; iv) conservation of fish protection and biodiversity. To achieve these goals, the government has a range of major programs: i) bring more rural poor people in aquaculture business through transfer of technologies; ii) providing financial support to rural farmers for production, marketing, distribution and processing of fish and culture-based capture fisheries development; iii) motivating people in establishing and maintaining fish sanctuary for enhancement of natural fishery as means of sustainable livelihood of communities who depend on fishing; iv) strictly implementing existing fish conservation regulations; v) formulating new legislation in consonance with the current changing situation; vi) banning of harmful fishing gears and practices; vii) introducing closed fishing seasons; viii) prohibiting and punishing people for crime for filling in and converting

**Table 2.** Formulated acts, ordinances and regulations for management, development and conservation of fisheries in Bangladesh.

| Sl. No | Act/Ordinance/Regulation   | Functions   | Comments  |
|--------|--|---|---|
| 01     | East Bengal protection and conservation of Fish Act 1950             | Vessel licensing, construction of dam and embankments, regulate destructive use of chemicals. | Government of Bangladesh formulated some acts/regulations/ordinances for the development & conservation of fisheries. However, due to lack of proper execution of these policies, development in this sector had yet not reached up to the desired level. |
| 02     | The Bangladesh Fisheries Development Corporation Act, 1973           | Corporation was created, which described its functions and responsibilities.                  |   |
| 03     | The protection and conservation of fish (amendment ) ordinance, 1982 | Certain amendment to increase the effectiveness of the above act                              | Government should provide much attention in implementing laws and regulations related to industrial and other chemical pollution control for the protection of aquatic habitat.   |
| 04     | The marine fisheries rules, 1983                                     | Period of license, area of fishing, species and quantity of fish to harvest etc.              | Government should give major thrust on:   |
| 05     | The protection and regulations for conservation of fish rules, 1985  | Conservation of fisheries   | - Improvement of degraded habitat   |
| 06     | The new fisheries management policy, 1988                            | Made provisions for leasing fisheries to the genuine fisherman                                | - Biodiversity conservation under in situ and ex situ condition   |
| 07     | Environment Policy, 1992   | Conservation of the environment for ecological balance  | - Banning indiscriminate fishing practice   |
| 08     | Aquatic environment protection law                                   | Monitoring freshwater environment and observation on coastal zone management.                 |   |
| 09     | National Fisheries Policy, 1998                                      | To properly guide the fisheries development in the country                                    |   |

water bodies into uplands; and; ix) strengthening of the institutional capacities for research and development in fisheries.

## Conclusions

Although Bangladesh's resources for fish production are vast, there are biological, social and economic constraints, where research needs to be strengthened to harness this potential. Fisheries and aquaculture research support in Bangladesh are still in the early stages and investments made in this sector in the past were negligible. To conserve and manage fishery resources for the benefit of the present

and future generations, the resources need to be managed and exploited on a sustainable basis. On the other hand, a firm political will and suitable legislation along with appropriate plans of action to formulate necessary strategies and policies including short and long term research as well as development projects are essential. Strong funding support from government and donor agencies will be needed in order to undertake future surveys, research, and training including implementation of management issues concerning preservation of aquatic ecosystems, habitat rehabilitation and protection, biological conservation and improvement of fisheries as a whole in all the existing waterbodies of Bangladesh.

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