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# INTEGRATED PROTECTED AREA CO-MANAGEMENT (IPAC)

## STUDY ON THE CONSERVATION AND MANAGEMENT OF FISHERIES RESOURCES OF THE SUNDARBANS (DRAFT)

**December 19, 2010**

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# Abbreviation

SRF = Sundarban Reserved Forest

FD = Forest Department

FAO = Food and Agriculture Organization

DOF = Department Of Fisheries

UNDP = United Nation Development programme

FMP = Forestry Master Plan

FMS = Fisheries Management System

MZ = Marine Zone

IUCN = International Union for Conservation of Nature

ARD = Aquatic Resource Division

SBCP = Sundarban Biodiversity Conservation Project

TAC = Total Allowable Catch

MSY = Maximum Sustainable Yield

WSR = Wildlife Sanctuary Regulation

IPAC = Integrated Protected Area Co-management

BLC = Boat License Certificates

STR = Sundarban Tiger Reserve

COR = Compounded Offence Report

DFO = Divisional Forest Officer

DFC = Dry Fuel Wood Consumption

WS = Wildlife Sanctuary

MAP = Management Action Plan

CMFRM = Coastal Marine Fisheries Resource Management

NGO = Non Government Organization

BN = Bangladesh Navy

BDR = the Bangladesh Defense Regiment

MPHA = Mongla Port Harbour Authority

BWDB = Bangladesh Water Development Board

BPC = Bangladesh Parjatan Corporation

DCF = Deputy Conservator of Forest

GOB = Government of Bangladesh

ADB = Asian Development Bank

GEF = Global Environment Facility

GoN = Government of the Netherlands

EMP = Environmental Management Plan

# Executive Summary

Sundarbans fisheries constitute an important source of livelihoods for millions of people living in close proximity of the Sundarbans Reserved Forest. The growing threats to sustainable fisheries arise from excessive exploitation of the resources, indiscriminate fishing disregarding specificity fishing gears, locality and season and destructive fishing like use of poisons in the closed creeks and khals, reduction of freshwater flow, intrusion of salinity in the elaborate parts of the forest leading to severe environmental degradation; these are but the prime concerns for the sustainability of the resources. The main purpose of the study was to provide information needed to assess the current situation of fisheries resources exploitation and to identify recommendations for management interventions and actions that could be implemented to ensure the long term conservation, improved fisheries ecosystem and habitat management, and sustainable utilization of the Sundarbans fisheries resources to support developing an Integrated Resource Management Plan (IRMP) for the Sundarbans Reserved Forest. The study has been carried out in the Sundarbans areas where people are supposed to live in a balance with mangrove forest in which fisheries resources are esteemed as highly important for livelihoods.

Following the recommendation of the Forest Department (FD), Department of Fisheries (DoF), Department of Environment (DoE) and other government officials and local communities regarding conservation of the Sundarbans Reserved Forest in April 2009, the IPAC line government agencies specially the FD and DoF have requested the IPAC to carry out a comprehensive fisheries study on the Sundarbans Reserved Forest. In line with the terms of reference the current short-term study was conducted by the Fisheries and Marine Resource Technology Discipline, Khulna University, Bangladesh. Three line government agencies such as FD, DoF, DoE, two international agencies, NGOs, and local communities were concerned in this study. The study was designed into three parts viz., i) literature review and consultation with the stakeholders, ii) assessment of the current situation through field visits, discussion with government agencies (specially with FD and DoF) and perception study, and iii) development of recommendations in line with the finding obtained. Efforts were made to identify the senior and mid level officials of Forest Departments, Department of Fisheries, Department of Environments and other linked organizations/Departments, stakeholders having concerns for sustainable management and conservation of the fisheries resources of the Sundarbans.

The lack of accurate information on Sundarbans fisheries is really a detriment to obtaining information that are vital to address the declining state of SRF fishery resources which is so important for contributing to the livelihoods of the millions. This document presents a synthesis of the results of the analysis carried out so far. The main findings include:

- The future long term sustainability of the Sundarbans has been at a serious stake for, the rivers/distributaries of the Ganges on the west bank starting from the Indian border at Rajshahi are at highly moribund conditions;
- Growth of population and over exploitation of aquatic resources is already evident and fisheries resources of the forest are not properly managed through appropriate technical knowledge.
- The colonial laws on resource management (land, forest, wildlife, fishing, and mining) and revenue-oriented management system is still in operation, and only negligible amendments that are made so far for natural resources management are not enough.
- The important breeding and nursery grounds of the fishes have to be identified and reserved. Fishing has to be restricted in 5 kilometers in sea ward offshore waters of the Bay of Bengal through bans on gears, species and seasons.
- Access to forest resources should be limited and all the local communities and indigenous groups dependent on the Sundarbans should be registered and provided with identity cards and permits should be given directly to resource users.
- The suitable alternative livelihood options are to be experimented for in the impact zone of the forest during fishing ban season and some plausible livelihood options are; Apiculture, Pen culture (fish), Cage culture (fish), Brackish water shrimp nursery, Goat rearing, Poultry rearing, Beef fattening, Producing handicrafts, Small businesses (street vending), Tailoring, Basket making (bamboo), Rickshaw/van paddling, Bicycle repairing, Welding technician etc.
- There are incidences of unscrupulous acts on the part of a few of the Forest Department's people and commitment of corruption is often reported.
- An utmost collaboration and cooperation is vital between the government and non-government agencies for implementation of policies for conservation and management of the resources.

- There is a dire necessity of adequate and dependable data and statistics of the Sundarbans fisheries resources.
- In the areas of interface between the villages of human settlement and the forest, there have been always the tendencies on the part of the villagers for illegal cutting, felling of trees and clearance of the forest for agricultural lands, salt pans and fresh settlements: Lack of supervision observed through management.
- Pollution in the forest waters due to oil spillage from tankers and agrochemical wastes/wastes from shrimp farms, industrial wastes of various kinds, solid wastes generated from the nearby cities and towns.
- Good management and good knowledge are required to assure sustainable fisheries resources management in the SRF of Bangladesh.

The study focuses on discussion meetings, perception studies, field visits and review of literature on the management aspects of the fisheries resources of the SRF tried to provide a broad synthesis of present state of the affairs (details in appendix 1).

The information obtained was categorized into 11 different sections of major interests and concerns. These are: **I.** The fisheries resources of the Sundarbans and its extent, distribution, production, economic importance and seasonality. **II.** The biological and ecological parameters and significance of the parameters for biodiversity conservation, soil, microorganisms, climate, hydrology and salinity regimes. **III.** Current harvesting patterns in terms of fishing area, time, gears, user groups and beneficiaries: Fishing gear and catch composition, main fishing gears, user group and beneficiaries. **IV.** Trends regarding the productivity and use of Sundarbans fisheries resource. **V.** Importance and impact of current practices that are degrading or destroying the Sundarbans fisheries: Importance of Sundarbans fisheries resources, aquaculture purpose, protective purpose, impact of current practices, denudation of mangrove forest due to shrimp farming. **VI.** Potential use and fisheries management practices, main components of fisheries management system for Sundarbans, traditional approaches for fisheries management, potential management approaches, Sundarbans fisheries management polices of aquatic resource division, overall objectives and polices for Sundarbans fisheries management. **VII.** Rules and regulations for Sundarbans Fisheries Management and effectiveness of the current management practices, regulations on Sundarbans fishery, role of tourism in protecting conservation areas, tax, fines and offences. **VIII.** Operation and effectiveness of the existing declared fish and wildlife

sanctuaries. **IX.** Infrastructure and other facilities for sustainable use and improved management of the Sundarbans fisheries, land transport, water vessels, communication, field station and staff quarter, medical team, manpower, aquatic resource division, marketing, transportation and storage facilities, Early warning and signaling system for natural calamities, facilities to visit Sundarbans. **X.** Scope for reinforcing community based management of the Sundarbans fisheries: Indigenous and local communities, and the management of Sundarbans fisheries, community participation and NGO involvement, livelihood groups dependent on Sundarbans and **XI.** Institutional management aspects, the forest department, monitoring, control and surveillance from FD, promotion of aquatic resource division under FD, coastal marine fisheries resource management, role of NGOs, other departments and agencies, the role and responsibility of the GoB towards the Sundarbans, responsibilities and authorities of different establishments.

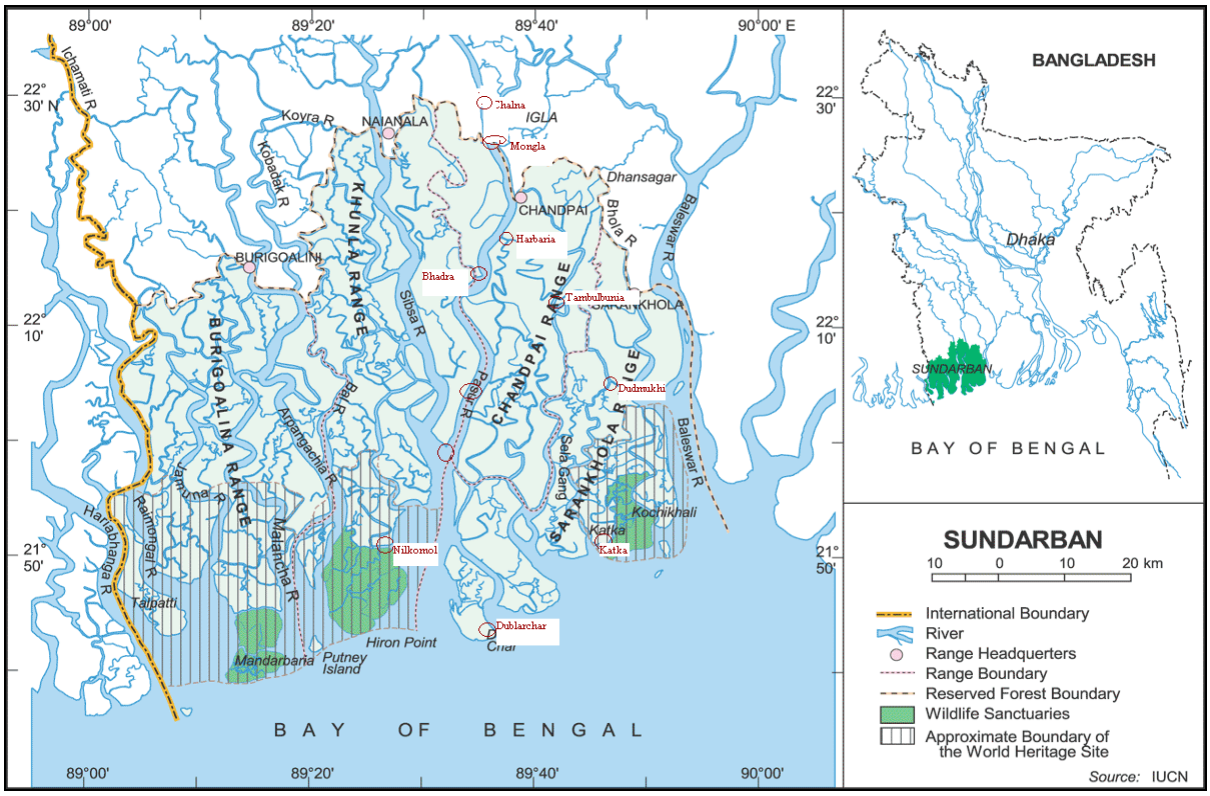
# 1. Fisheries resources of the Sundarbans

## 1.1 Extent and Distribution

Bangladesh is a subtropical country which is situated at the apex of the Bay of Bengal, having a vast coastal plain with 710 km of coastline. The Sundarbans is the largest mangrove forest in the world. It is located at the southwest corner of the Ganges river delta close to the Bay of Bengal. In 1998, UNESCO has declared this reserve forest as the world heritage. The Sundarbans Reserved Forest (SRF) (latitude 21°27'30" and 22°30'00" North and longitude 89°02'00" and 90°00'00" East) is one of the largest coastal belts with a total area of 7620 $Km^2$ (4143 $Km^2$ land; 1874 $Km^2$ rivers, streams and canals; and 1603 $Km^2$ marine zone). The Sundarbans ecosystem supports rich fisheries diversity. Its water-bodies support 27 families and 53 species of pelagic fish, 49 families and 124 species of demersal fish, 5 families and 24 species of shrimps, 3 families and 7 species of crabs, 2 species of gastropods, 6 species of pelecypods, 8 species of locust lobster and 1 family and 3 species of turtles (IUCN 1994). It is also noted that 90% of commercial fish and 35% of all fish in the Bay of Bengal rely on that area as a nursery for their young life stages. Total stock of fish in that area has been estimated at 2.9-3.7 tons/$km^2$, which contributes 5% of the total fish harvest of Bangladesh and the value of that sector has been estimated at US$ 209.9 million (46,0832 US$/km ) (Kamal, 1999). The total fisher population actively engaged in fishing in 1993 Bay of Bengal was about 200,000 and it was 88% of the total population (Chantarasri, 1994).

The mangrove forest of Bangladesh, the largest continuous mangrove forest of the world, is one of the most important coastal features of the country. The existence of the mangrove has increased the values of other coastal and marine resources such as the coastal and marine fisheries by increasing productivity and supporting a wide biological diversity. The mangrove forest and mudflats of the forest provide vital breeding and nursery ground for wide varieties of finfish, crustaceans and mollusks. The artisanal fishery, which is highly influenced by mangroves, has been contributing 85–95% of the total coastal and marine catch of Bangladesh. The mangrove also supports offshore and deep sea fisheries by playing a significant role as nursery ground for many deep sea fishes and shrimps including the giant tiger shrimp (*Penaeus monodon*) which is the major commercial species of the bottom trawl fishery of Bangladesh.

**Figure1: Extent of Sundarbans mangrove fisheries area**




The mangrove also contributes significantly in shrimp farming which has been the most significant export-oriented industry since the 1970s. However, the mangrove fisheries have been under intensive pressure from deleterious fishing activities and deliberate aquaculture development by destructing mangrove habitats. The impacts of mangrove have been reflected in the contribution of artisanal fishery catch that has been in a continuous decline since the 1980s. Shrimp farming has been the most destructive contributor to mangrove destruction with a corresponding loss of biological resources particularly the wild shrimp fishery.

Mangroves are characterized by a higher fisheries biodiversity as well as higher standing stock (Christensen, 1982; Chong *et al.,* 1990; Morton, 1990; Robertson and Blaber, 1992; Hong and San, 1993; Sasekumar *et al.,* 1994). The importance of mangrove ecosystems to coastal fisheries has been described and the linkage between mangrove and associated fisheries have been emphasized and discussed by many authors (Pauly, 1985; Staples *et al.*, 1985; Yanez-Arancibia *et al.*, 1985; Pauly and Ingles, 1986; Sasekuar *et al.,* 1992; Chong *et al*., 1994; Kathiresan *et al.*, 1994; Chong *et al.*, 1996; Twilley *et al.*, 1996; Vance *et al.*, 1996 a, b; De Graaf and Xuan, 1997; Baran and Hambrey, 1998; Kathiresan and Bingham, 2001). Also many authors have discussed the underlying causes and hypotheses why mangrove and fisheries are tightly linked (Daniel and Robertson, 1990; Vance *et al*., 1990, 1996 a, b; Robertson and Blaber, 1992; Mohan *et al*., 1997; Primavera, 1998; Rajendran and

Kathiresan, 1999). There are a good number of experimental evidence on the nature and cause of mangrove dependence of many fish and shrimp species (Erondu, 1990; Ramesh and Kathiresan, 1992; Primavera, 1997).

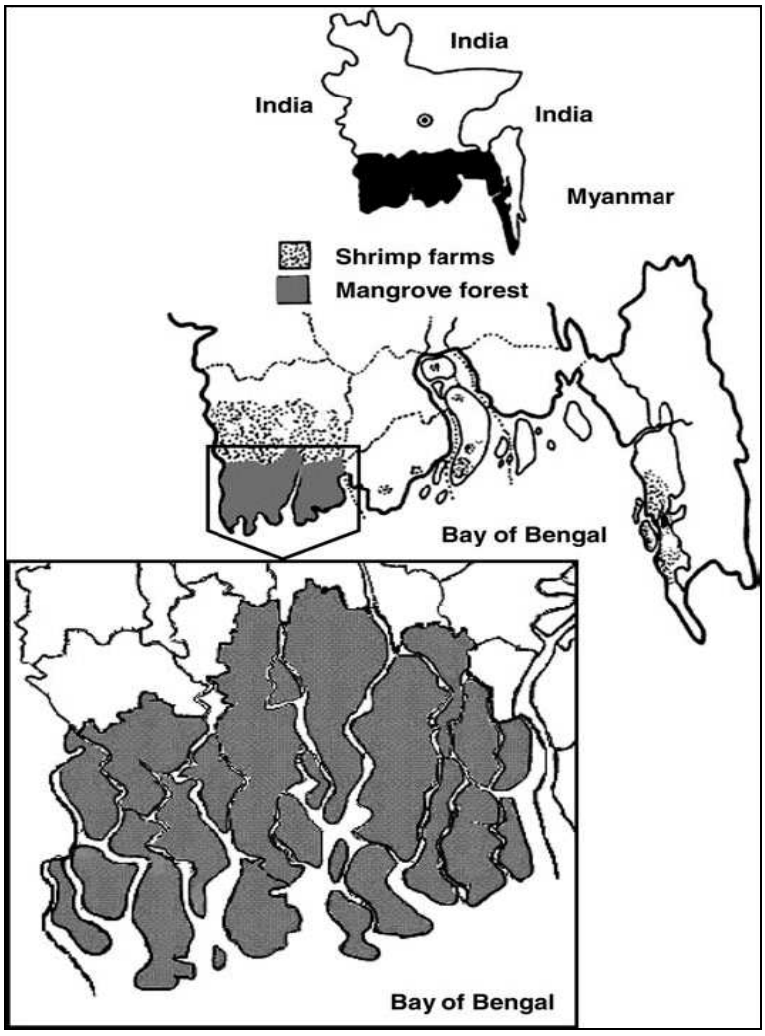



**Figure 2: Map showing the Sundarbans mangrove forest, coastal shrimp farming areas and associated coastal areas at the southeast of the Bay of Bangladesh.Bengal,**

## 1.2 Water area

The water area of Sundarbans quite huge and is about 2,000 sq.km which is about 33% of the total SRF. The water bodies inside the SRF are of secondary rivers, numerous canals originated from the rivers and chatals/beels at the end of the canals. The water systems comprise a complex and extensive network throughout the SRF.

There are four major river systems which run from the north and end up in the Bay of Bengal to the south. The river systems are:

a) ***Raimogal System***: The system is to the west of the SRF and border between Bangladesh and India. The river Raimangal and Jamuna comprise the system and ends at Raimangal estuary to the Bay.

b) ***Arpangasia system:*** It is in the west after raimangal. The river Arpangasia, Bhadra and a branch comprise the system and ends at Malancha estuary of the Bay.

c) ***Shibsha-Pasur System.*** It is in the middle of the SRF. The two rivers Shibsha and Pasur merge together to the extreme south of SRF and end at kunga estuary.

d) ***Baleshar system:*** The Baleswar makes the eastern boundary of the SRF. Baleswar along end at the Bay.

Two other rivers Shela gang originates from Pasur and Bhola river originates from shela Gang (now the connection is silted up) separately runs in between Pasur and Baleswar and end the Bay at Bangra estuary. The number and names of interlinking canals and chatals are many. Some of them have names but not all.

The wetlands of Sundarbans are very rich in Biodiversity. It is one of the most biologically productive of all natural ecosystems with great economic importance. The main aquatic resources of the Sundarbans are as flows-

1. ***Hilsa:*** Is single most important species of Sundarbans. It is caught form the estuarine area and the rivers inside the SRF. Lower part of the SRF is important for hilsa harvest. The Baleswar has been reported by fishers to be highly important for hilsa inside SRF.
2. ***White fish:*** there are many species of white and fin fish. The Sundarbans Biodiversity Conservation project reported 204 bony fish species. Some commercially important species are datney, taposhi, vetki, pangus, poma, churi, kain, tengra etc.
3. ***Prawn & Shrimp:*** The adult *golda* and *bagda* is highly important for commercial harvest. These are export items and has high price although the catch amount is not much. There are 26 species of prawn and shrimps in the SRF.
4. ***Cartilaginous fish***: These are non-bony fish. They are mainly marine but available in the estuary and SRF. There about 20 species of cartilaginous and some of them have economic value. *Himantura* sp. is sold in the market and people eat them. Shark has economic value as well.
5. ***Reptiles:*** The turtles are of economic importance. Other are crocodile, snake.

6. ***Crab:*** The mud crab is highly important and export item. There are about 44 species of crab.
7. ***Mollusks:*** 36 species. In some cases mollusk meat is used in shrimp farms as food. Its shell is also used to produce lime and decorative and ornamental items. Mollusks can be export item if necessary steps are taken by government and other authorities concerned.
8. ***Dolphin:*** The mammals. Dolphin is one of the most attractive marine mammals that can contribute in the expansion of tourism business. It does not have much economic value in terms of food.
9. ***Post Larvae of Prawn & Shrimp:*** The PL of Bagda and golda has high economic value.
10. ***Dry Fishery:*** At Dublar chard. Mainly white fishes of all species are dried.
11. ***Other invertebrates***: reported to be available in Sundarbans. Need to know more about them.

## 1.3 Production

A prominent feature of the SRF fishery is that, for as long as records have been kept, its size has been expanding. The magnitude of stock of fishery resources in Sundarbans waters has not been assessed systematically and there is very little information on their quality. The production figure gathered by the FD show sharp fluctuations from year to year and cannot be used to gauge possible availability of stocks. Estimates of the annual SRF fishery landed harvest vary considerably and a summary of available information is highlighted in Table 1 and 2.

**Table 1: Estimates of the annual fish harvest of the Sundarbans (Forest Department, 2010)**

| Year | Fish | | Bivalve | |
|---|---|---|---|---|
| | Harvest (MT) | Revenue (Tk.) | Harvest (MT) | Revenue (Tk.) |
| 2000-01 | 3102.52 | 5486381 | 2222.92 | 477600 |
| 2001-02 | 1204.54 | 2761060 | 1184.93 | 271234 |
| 2002-03 | 944.24 | 2926235 | 279.24 | 75470 |
| 2003-04 | 1017.28 | 3447381 | 550.34 | 125726 |

| | | | | |
|---|---|---|---|---|
| 2004-05 | 999.78 | 3189874 | 289.60 | 36135 |
| 2005-06 | 1108.63 | 3943505 | 1078.70 | 145790 |
| 2006-07 | 1442.96 | 4590021 | 53.10 | 32600 |
| 2007-08 | 4203.64 | 12906318 | 38.81 | 25740 |
| 2008-09 | 3539.31 | 9805040 | 0.41 | 400 |
| 2009-10 | 1119.55 | 5265808 | 0.11 | 150 |

**Table 2: Estimates of monthly fish harvest (in MT) from the Sundarbans during 2009-10 (Forest Department, 2010)**

| Month | Fish | Shrimp | Small Shrimps | Crabs | Revenue (Tk.) |
|---|---|---|---|---|---|
| July, 09 | 33.46 | 0.52 | 0.09 | 4.65 | 105951.50 |
| August, 09 | 68.99 | 1.65 | 0.22 | 13.14 | 249924.50 |
| September, 09 | 111.52 | 4.47 | 0 | 19.29 | 433674.00 |
| October, 09 | 101.79 | 3.59 | 0.33 | 14.18 | 376263.00 |
| November, 09 | 86.11 | 1.86 | 0.23 | 26.34 | 351812.00 |
| December, 09 | 74.99 | 1.61 | 0.27 | 27.50 | 304185.25 |
| January, 10 | 75.61 | 1.40 | 0.37 | 14.80 | 339537.80 |
| February, 10 | 65.54 | 1.50 | 0.25 | 16.23 | 371895.84 |
| March, 10 | 89.95 | 1.09 | 0.23 | 0.94 | 418535.76 |
| April, 10 | 69.23 | 3.26 | 0.82 | 13.57 | 411015.05 |
| May, 10 | 56.73 | 2.04 | 0.23 | 16.74 | 327656.50 |
| June, 10 | 84.51 | 4.29 | 0.75 | 21.01 | 609510.65 |
| Total | 888.43 | 27.28 | 3.79 | 188.39 | 4299961.85 |

## 1.4 Economic Importance

The fisheries of Sundarbans are very important for local economy and livelihoods of thousands of poor people living around and outside the landscape area. There are many other stakeholders. It produces 2-5% of the total capture fisheries (Rabbani and Sarker 1997). In 2003-04 the Forest Department (FD) production estimate was 433,000MT (Hoq, 2008). IPAC PRA finding is an average of 47% (Biswas, 2009; Ghosh, 2009) households within the

5km area in the landscape in Bagerhat & Satkhira district are engaged in fishing. Approximately 40,000-70,000 boats operate in the SRF for fishing. Forest Department revenue collection data has been considered for representing the value of different groups of fish. It is noticeable from the following figures that shrimp fry was providing higher revenue (4-13 million taka) than any other groups of fish during the last 5 years. White fish (list of major white fishes are in Table 3.9) and Golda (*Machrobrachium rosenbergii*) were second in rank (1.7-2.7 million Taka) for revenue whereas, dried fish (list of dry fishes in Table 3.10), Illish (*Tenualosa illisa*) and crab (*Scylla serrata*) were in third position. Bagda (*Penaeus monodon*), Golda (*M. rosenbergii*) are the most valuable shellfish species. Among the white fish *Plotosus canius, Lates calcarifer, Polynemous indicus, Pampus chinensis, Liza parsia* are more valuable than the others. The other shrimps, *P. indicus, Metapenaeus monoceros* and mud crab (*S. serrata*) are also valuable.

Mangroves are important nursery areas for many commercially important shrimp and crab species. In terms of value per unit catch and total value of catch, the penaeid shrimps are among the most important resources for coastal fisheries. Many species of palaemonid shrimps are also associated with mangroves, including the commercially important giant freshwater shrimp, *Macrobrachium rosenbergii* (Macnae, 1974; Matthes and Kapetsky, 1988; Singh *et al*., 1994). Mangroves also support vast numbers of small shrimp of which Acetes spp. (Sergestidae) are the most important to fisheries (Macnae, 1974; Macintosh, 1982). The Sundarbans mangroves support many nonpiscine species of very high commercial values. Hoq *et al.* (2001) reported 10 shrimp species occurring in the major river systems flowing through the mangrove forest in Bangladesh. The species are *Penaeus monodon, P. indicus, Metapenaeus monoceros, M. brevicornis, Palaemon styliferus, Macrobrachium rosenbergii, M. villosimanus, M. dyanus, M. dolichodactylus and M. rude.* The main macrozooplankton included *Acetes spp., mysids, alima larvae, copepods, isopods and megalopa* larvae. Crustacea accounts for by far the largest proportion of animal biomass, with an estimated 40 million kilograms of fiddler crabs and 100 million kilograms of mud crabs (Hendrichs, 1975). The nutrient-rich waters of the Sundarbans also yield a considerable harvest of shrimps, prawns and lobsters. The mangrove crab fauna is of major ecological and economic importance (Macnae, 1974; Macintosh, 1982; Matthes and Kapetsky, 1988), including the high-priced mangrove mud crab, Scylla serrata. Distributed from eastern Africa to the central Pacific, this crab is abundant enough to support local fisheries and aquaculture operations throughout the Indo-West Pacific region. Mangrove estuarine areas often support an

abundance of mollusk species that are largely sessile in nature and constitute an important in situ fishery (Macnae, 1974; Macintosh, 1982; Hamilton and Snedaker, 1984; Matthes and Kapetsky, 1988). The families of local fishermen collect edible species of oysters, mussels, cockles, and gastropods extensively for local consumption. Mangrove roots and lower parts of trunks provide substrate for oysters and mussels. Because these animals are filter feeders, they are confined to microhabitats below mean high water, and are usually only abundant in areas adjacent to open water (Macintosh, 1982). The blood clam, *Anadara granosa*, and other cockles are found in large numbers in mudflats on mangrove strands, where it lies partially buried in the sediment (Macintosh, 1982).

**Table 3: List of fish, crustaceans and mollusc species in the Sundarbans and adjacent marine waters**

**Finfish**

| Sl. No. | Family | Species | English name | Bangla name | Ave. TL (cm) | Max. TL (cm) |
|---|---|---|---|---|---|---|
| 1 | Cracharinidae | *Carcharhinus melanopterus* | Blacktip reef shark | Kala hangar | | |
| 2 | ” | *Scoliodon laticaudus* | Spadenose shark | Thutte hangar | | |
| 3 | ” | *Scoliodon sorrakowah* | Dog fysh | Thutte hangar | 60 | 90 |
| 4 | | *Scoliodon walbeehmii* | Scoliodon walbeehmii | Kamot hangar | 90 | 120 |
| 5 | Sphyrnidae | *Eusphyrna blochii* | Hammerhead shark | Haturi hangar | 150 | 500 |
| 6 | Rhynchobatidae | *Rhynchobatus djeddensis* | Gulter fish | Pitambari | 200 | 300 |
| 7 | Rhinobatidae | *Rhinobatos granulatus* | Skate | Pitambari | 120 | 185 |
| 8 | Dasyatidae | *Dasyatis zugei* | Pale-edged ray | Saplapata | | |
| 9 | ” | *Himantura fluviatilis* | Gangetic stingray | Saplapata | | |
| 10 | ” | *Himantura imbricata* | Scaly stingray | Saplapata | | |
| 11 | ” | *Himantura uarnak* | Stingray | Haush,sankush | 100 | 150 |
| 12 | Clupeidae | *Escualosa thoracata* | White sardine | Hichiri | 8 | 10 |
| 13 | ” | *Sardinella fimbriata* | Fringescale sardine | Takhia | 12 | 16 |
| 14 | ” | *Sardinella gibbosa* | Gold stripe sardine | Chandana, takia | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 15 | ” | *Sardinella melanura* | Sardine | Chandana,takia | | |
| 16 | ” | *Gudusia chapra i* | indian river shad | Chapila | | |
| 17 | ” | *Hilsa ilisha* | Hilsa shad | Ilish | 45 | 75 |
| 18 | ” | *Hilsa kelee* | Kelee shad | Garta ilish | | |
| 19 | ” | *Hilsa toli* | Toli shad | Chandana ilish | | |
| 20 | ” | *Hilsa filigera* | Bigeye ilish | Chouka | 20 | 30 |
| 21 | ” | *Hilsa megaloptera* | Bigeyeilish | Chaukka,chouk ya | | |
| 22 | ” | *Hilsa melastoma* | Indian ilisha | Chaukka | | |
| 23 | ” | *Anodontostoma chacunda* | Gizzardshad | Koi puti | | |
| 24<br>25<br>26<br>27 | ”<br>Dussumieridae<br>Engraulidae<br>” | **Raconda russelliana**<br>***Dussumieria acuta***<br>***Coilia dussumieri***<br>*Coilia neglecta* | Smooth back herring<br>Rainbow sardine<br>Pointed tail anchovy<br>Neglected anchovy | Fasha,fatra<br>Nailla<br>Olua,amadi<br>Olua | 12 | 17 |
| 28 | ” | *Coilia ramkoranti* | Tepertail anchovy | Olua | | |
| 29 | ” | *Setippina phasa* | Gangetic hairfin anchovy | Phasa | | |
| 30 | ” | *Setipinna taty* | Scally hair fin anchovy | Tailla phasa | 12 | 17 |
| 31 | ” | *Stolephorus tri* | Anchovy | Kata phasa | | |
| 32 | ” | *Thryssa mystax* | Moustached thryssa | Phasa | | |
| 33 | ” | *Thryssa dussumieri* | Dussumiers thryssa | Phasa | | |
| 34 | ” | *Thryssa hamiltonii* | Hamiltons thryssa | Ram phasa | | |
| 35 | Chirocentridae | *Chirocentrus dorab* | Wolf herring | Karati chela | 60 | 100 |
| 36 | ” | *Chirocentrus nudus* | Wolf herring | Karati chela | | |
| 37 | Elopidae | *Elops machnata* | Tenpounder,tarpon | Elope | | |
| 38 | Muraenesocida e | *Congresox tale* | Yellow pike-conger | Kamila | | |
| 39 | ” | *Muraenesox cineneus* | Daggertooth pike- | Kamila | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | conger | | | |
| 40 | Bagridae | *Mystus gulio* | Long-whiskered catfish | Guilla,nuna tengra | 15 | 25 |
| 41 | Schilbeidae | *Silonia silondia* | silondia | Shillong | | |
| 42 | ” | *Pangasius pangasius* | Fatty cat fish | Pangas | 90 | 120 |
| 43 | Ariidae | *Arius arius* | Tread fin sea cat fish | Mad, kata | 50 | 60 |
| 44 | ” | *Arius caelatus* | Engraved cat fish | Mad, kata | | |
| 45 | ” | *Arius gagora* | Gagor cat fish | Mad , kata | | |
| 46 | ” | *Arius maculatus* | Spotted cat fish | Mad , kata | | |
| 47 | ” | *Arius thalassinus* | Giant sea cat fish | Mad , kata | | |
| 48 | Plotosidae | *Plotosus Canius* | Canine ell tail fish | | 47 | 64 |
| 49 | ” | *Plotosus lineatus* | Striped ell tail cat fish | | | |
| 50 | Synodontidae | *Saurida tumbil* | Greater lizard fish | Tiktiki, achila | 30 | 45 |
| 51 | Harpadontidae | *Harpadon nehereus* | Bombay duck | Loytta | 25 | 45 |
| 52 | Batrachoididae | *Batrichthys grunniens* | Gangetic toad fish | | | |
| 53 | Hemiramphidae | *Hemiramphus georgii* | Georges half beak | Ek thuitta | | |
| 54 | ” | *Zenarchopterus ectuntio* | Ectuntio half beak | | | |
| 55 | Fistularidae | *Fistularia villosa* | Rough flute mouth | Bongshi | | |
| 56 | Syngnathidae | *Hippocampus kuda* | Sea horse | Ghora | | |
| 57 | Synbranchidae | *Monopterus cuchia* | Gangatic mudeel | Kuchia | | |
| 58 | Scorpaenidae | *Pterois russelli* | Russels lion fish | Rongilla | | |
| 59 | ” | *Pterois miles* | Miles lion fish | Rongilla | | |
| 60 | Platycephalidae | *Platycephalia crocodilus* | Spotted flat head | Fotta murbaila | | |
| 61 | ” | *Platycephalus scaber* | Rough flatted | Mur baila | | |
| 62 | ” | *Patycepahlus indicus* | Flat head | Mur baila | 30 | 45 |
| 63 | ” | *Rogadius asper* | Thorny flat head | Kata mur baila | | |
| 64 | Centropomida | *Lates calcarifer* | Seabass, | Bhetki, koral | 90 | 180 |

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|---|---|---|---|---|---|---|
| | e | | barramundi | | | |
| 65 | Ambassidae | *Chanda nama* | Elongate glassy Perchlet | Nama chanda | | |
| 66 | ” | *Pseudambassis baculis* | Himalayan glassy Perchlet | Kata chanda | | |
| 67 | ” | *Pseudambassis ranga* | Indian glassy perchlet | Lal chanda | | |
| 68 | Serranidae | *Cephalopholis miniatus* | Grouper | Bol | | |
| 69 | ” | *Epine phalus fasciatus* | Grouper | Bol | | |
| 70 | ” | *Epine phalus tauvina* | Grouper | Bol | | |
| 71 | Theraponidae | ***Therapon jarbua*** | Therapon porch | Barguni | 15 | 20 |
| 72 | ” | *Terapon theraps* | Band therapon perch | Gugu | | |
| 73 | Apogonidae | *Apogon novemfasciatus* | Nine-banded Cardinalfish | Duidea | | |
| 74 | ” | *Apogon septemstriatus* | Seven-banded Cardinalf 'ish | Gogla | | |
| 75 | Sillaginidae | *Sillaginopsis panijus* | Gangetic sillago | Hundra | | |
| 76 | ” | *Sillago siharna* | Silver whiteling | Hundra | | |
| 77 | ” | *Sillago domina* | Ladyfish | Hundra, tolar dandi | 25 | 45 |
| 78 | Carangidae | *Alectis Indica* | Threadfin trevally | Pakham mouri | | |
| 79 | ” | *Alepes djeddaba* | Djeddaba cravalie | Mood | 15 | 20 |
| 80 | ” | *Alepes melanoptera* | Blackfin crevalle | Dora mouri | | |
| 81 | ” | *Atropus atropus* | Kuweh trevally | Mouri | | |
| 82 | ” | ***Megala pis cordyla*** | Torpedo trevally, | Kauya | 30 | 50 |
| 83 | ” | *Scomberoides commersonianus* | Talang queenfish | Chapa kori | 50 | 80 |
| 84 | ” | *Carangoides malabaricus* | Malabar cavalla | Mood | 25 | 38 |
| 85 | ” | *Selar boops* | Oxeye scad | moori, salar | 15 | 25 |
| 86 | ” | *Selar crumenophthalmus* | Bigeye scad | Boro choka | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 87 | ” | *Seriolina nigrofasciata* | Black-bandid trevally | Kalo dora, moori | | |
| 88 | Lactariidae | *Lactarius lactarius* | False trovally | Sadha | | |
| 89 | Formionidae | *Formio niger* | Black ponfret | Hail chanda | | |
| 90 | Menidae | ***Mane maculata*** | Moonfish | Chan chanda | | |
| 91 | Leiognathidae | *Gazza minuta* | Toothed ponyfish | Taka chanda | | |
| 92 | ” | ***Leiognathus bindus*** | Orangefin ponyfish | Taka chanda | | |
| 93 | ” | *Leioghnathus equulus* | Common ponyfish | Taka chanda | | |
| 94 | ” | *Leioghnathus brevirostris* | Shortnoso ponyfish | Taka chanda | 10 | 12 |
| 95 | ” | *Leiognathus fasciatus* | Striped ponyfish | Taka chanda | | |
| 96 | ’ | *Secutor ruconius* | Deep pugnose pony fish | Taka chand a | | |
| 97 | | *Secutor insidiator* | Pugnose pony fish | Taka chanda | | |
| 98 | Lutjanidae | *Lutjanus johni* | John's snapper | Ranga choukya | 30 | 60 |
| 99 | ” | *Lutjanus sanguineus* | Blood snapper | Ranga choukya | 20 | 45 |
| 100 | ” | *Lutjanus malabaricus* | Malabar red snapper | Choukya | 20 | 45 |
| 101 | ” | *Pinjalo pinjalo* | Pinjalo snapper | Choukya | | |
| 102 | Nemipteridae | *Nernipterus Japonicus* | Japanoese threadfln bream | | 20 | 25 |
| 103 | ” | *Nernipterus nematophorus* | Double whip threadin bream | Sonabam | | |
| 104 | Lobotidae | *.Lobotes surinarnensi* | Tripletail | Sagor koi | | |
| 105 | Gerreidae | *Gerres filamentosus* | 'whiptail silver biddy | Dom | 15 | 25 |
| 106 | | *Pentaprion longirnanus* | Longfin silvr biddy | Jagiri | 11 | 13 |
| 107 | Haemulidae | *Pomadasys argenteus* | Silver grunt | | | |
| 108 | ” | *Pomadasys maculatus* | Blotched grunt | Guti datina | 15 | 45 |
| 109 | ” | *Pomadasys hasta* | White grunt | Sadha datina | 40 | 50 |
| 110 | Lethrinidae | *Lethrinus omatus* | Ornate emperor | Choikka | | |

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|---|---|---|---|---|---|---|
| 111 | Sparidae | *Acanthopagrus latus* | Yellow seabrem | | | |
| 112 | ” | *Argyrops spinifor* | ongspine seabream | Lal datina | 25 | 60 |
| 113 | Sciaenidae | *Astrobucca nibe* | Blackmouth croaker | Kala poa | | |
| 114 | ” | *Dentrophysa russelli* | Goatee croaker | Poa | | |
| 115 | ” | ***Johnius argentatus*** | Silvor croaker | Lalpoa | 30 | 45 |
| 116 | ” | *Johnius dussurnien* | Black croaker | Kala poa | | |
| 117 | ” | *Macrospinosa cuja* | Cuja bola | | | |
| 118 | ” | ***Otolilthes ruber*** | Tiger-toother croaker | Dato poa | | |
| 119 | ” | *Otolithes parna* | Pama croaker | Lambu | 120 | 180 |
| 120 | ” | *Otolithes cuvierl* | Lesser tiger toothed croaker | Poa | 40 | 70 |
| 121 | ” | *Panna microdon* | Panna croker | Poa | | |
| 122 | ” | *Pennahia macrop hthalmus* | Bigeye croaker | Choka poa | | |
| 123 | ” | *Protonibea diacanthus* | Spotted croakor | Kala datina | 100 | 155 |
| 124 [ | ” | *Pterolithus maculatus* | Blotched t1gor-toothed croaker | Goti poa | 40 | 45 |
| 125 | Siganidae | *Siganus javus* | Streaked rabbitfish | | 15 | 30 |
| 126 | Mullidae | *Upeneus sulphureus* | Yellow striped goatfish | Sonall bata | 12 | 19 |
| 127 | | *Parupeneus heptacanthus* | Goatfish, | Sonali batai | | |
| 128 | Toxotidae | *Toxotes jaculator* | Banded archerfish | | | |
| 129 | Drepanidaeie | *Drepane longimana* | Sicklefish | Pan | 30 | 40 |
| 130 | ” | *Drepane punctatus* | Spotted sickle fish | Pan | | |
| 131 | | *Ephippusus orbi* | Spadefish | Hatir kaa | | |
| 132 | Sscatophagida e | *Scatophagus argus* | Spotted scat | Bishtara | | |
| 133 | Mugilidae | *Liza parala* | Gold spot mullet | Pashia,bata | | |

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|---|---|---|---|---|---|---|
| 134 | ” | *Liza subilridis* | Grean Back grey mullet | Bhangan bata | | |
| 135 | ” | *Liza tade* | Tade grey mullet | Gool bata | | |
| 136 | ” | *mugil cephalus* | Flathoad grey mullet | khorul bata | 30 | 50 |
| 137 | ” | *Rhinornugil corsula* | Yellow tail mullet | Kholla,bata | | |
| 138 | ” | *Valamugill spelglerl* | Spelglers grey Mullet | patha bata | 15 | 20 |
| 139 | | *Sicarnugil Cascasia* | Blue spot mullet | | | |
| 140 | Rachycentridae | *Rachycentron canadus* | Cobla | samudro gajar | 90 | 180 |
| 141 | Sphyraenidae | *Sphyraena barracuda* | Barracuda | Darkuta | | |
| 142 | ” | *Sphyraena forsteri* | Forstoes barracuda | Dharkuta | 70 | 150 |
| 143 | ” | Sphyraena putnamiae | Sawtooth barracuda | Darkuta | | |
| 144 | Polynemidae | *Eleuthronema tetradactylum* | Fourfingor throadfin | Thailla | 90 | 125 |
| 145 | ” | *Polynemus pardiseus-* | Paradise threadfin | Tapasi | 20 | 30 |
| 146 | ” | *Polydactylus Indicus* | Indian threadfin | Lakhua | 90 | 145 |
| 147 | ” | *Polydactylus sexfilis* | Golden threadfin | Sona tailla | | |
| 148 | ” | *Polydactylus sextarius* | Black spot threadfin- | Kala tailla | | |
| 149 | Priacanthidae | *Priacanthus tayenus* | Purple spotted big eye | Parl | 20 | 25 |
| 150 | Uranoscopidae | *Uarmosopus guttatus* | Stargazer | Tara gazar | | |
| 151 | ” | *Ichthyoscopus inermis* | Stargazer | Buturn | | |
| 152 | Eleotridae. | *Butis melanostigma* | Blackspot sleeper | Kalo baila, kuli | | |
| 153 | | *Eleotris fusca* | Dusky sleeper | Budh baila,Kuli,i | | |
| 154 | Gobiidae | *Brachygobius nunus* | Bumblebee goby | Nuna baila- | | |
| 155 | | *Glossogobius giurus* | Tankqoby | Baila | | |
| 156 | ” | *Pogonogoibius Planiformes* | Goby | Baila | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 157 | ” | *Stigmatogobius sadanundio* | Goby | Baila | | |
| 158 | ” | *Apocryptes bato* | Goby | Chiring | | |
| 159 | ” | *Parapocryptes batoides* | Goby | Chewa, chirin | | |
| 160 | ” | Pseudapocryptes lanceolatus | Goby | Chewa chring | | |
| 161 | ” | *Scartelaos viridis* | Goby | Dahuk | | |
| 162 | ” | *Boleopthalmus boddarti* | Mud skipper | Dahuk | | |
| 163 | ” | *Periophalmodon schlossed* | Mudskipper | Dahuk | | |
| 164 | “” | *Periophthalmus koelreuteri* | Mudskippef | Dahuk | | |
| 165 | Gobioididae | *Odontamblyopus rubicandas* | Irubicundus ee!goby | Lal chewa | | |
| 166 | Trypauchanidae | *Trmauchan vagina* | Burrowing goby | Sada chewp- | | |
| 167 | Kuridae | *Kurtus indicus* | Indian lamphead | Juti | | |
| 168 | Trichiuridae | *Eupleurogrammus muticas* | Ribbonfish | Suri | | |
| 169 | ” | *Lepturacanthus savala* | Ribbonfish | Chhuri | 70 | 125 |
| 170 | ” | *Trichiurus leopturus* | Ribbon fish | Buri | | |
| 171 | Scombridae | *Euthynnus affinis* | Eastern little tuna | Born maittya | 50 | 60 |
| 172 | ” | *Rastrelliger brachysoma* | Indian mackerel | Champa | | |
| 173 | ” | *Rastrelliaer kanagurta* | Indian mackerel | Champa | 25 | 35 |
| 174 | ” | *Sarda orientalis* | Striped bonito | Bom maitya | 50 | 80 |
| 175 | ” | *Auxis rochel* | Bullet tuna | Bom maitya | 25 | 40 |
| 176 | ” | *Scomberomorus commerson* | Spanish mackerel, kinfiish | Maittya, surmai | | 90<br>125 |
| 177 | ” | Scomberomorus guttatus | Indopacific king ackclw | Maittya, Surama | 80 | |
| 178 | Stromateidae | *Pampas argenteus* | Silver pornfret | Foli chanda | 25 | 30 |
| 179 | ” | *Pampas chiensis* | Chiense pomfret | Rup chanda | 25 | 38 |

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|---|---|---|---|---|---|---|
| | | *Psettodes erumei* | Indian halibut | Samudra serboti | 35 | 60 |
| 181<br>182 | Bothidae | *Pseudorhombus arius*<br>*Pseudorho mbus elevatus* | Large tooth flounder<br>Deep flounder | Serboti<br>Serboti | | |
| 183 | ” | *Pseudorhombus malayanus* | *Malay*flounder | Serboti | | |
| 184 | Soleidae | *Synaptura pan* | Sole | Serbotit | | |
| 185 | ” | *Synaptura orientalis* | Oriental sole | Serboti katal pata | | |
| 186 | ” | *Zebreas altioinnis* | Zebra sole | Serboti,katal | | |
| 187 | Cynoalossidae | *Cynoglossus billneatus* | Fourlined tongueso'le | Ku kurjib | 25 | 35 |
| 188 | ” | *Cynoglossus cynoglossus* | Gangetic tonguesole | Kukurjib | | |
| 189<br>190 | ”<br>” | *Cynoalossus lingua*<br>*Cynoglossus versicolor* | Long tonguesole<br>Tongusole | kukurjib<br>Kukurjib | 20 | 45 |
| 191 | | *Paraplagusia,bilineata* | double lined tonguesole | kukurjib | | |
| 192 | *Balistidae* | Abalistes stellaris | Starred triggerfish | Sagor potka | | |
| 193 | Tetraodontidae | *Arothron stellatus* | Star puffer | Polka | | |
| 194 | ” | *Chelonodon fluviatilis* | Green puffer | Potka | | |
| 195 | ” | *Chelondon fluviatilis* | Gangetic puffer | Sagor potka | | |
| 196 | | *Tetraodon cutcutia* | Ocellated puffer | Potka | | |

## Crustacea

| Sl. No. | Family | Scientific name | English name | Bengali name | Ave.TL (cm) | Max. TL(cm) |
|---|---|---|---|---|---|---|
| 1 | Penaeidae | *Penaeus monodon* | Tiger shrimp- | Bagda chingri | 23 | 31 |
| 2 | ” | *Penaeus Indicus* | Indian white shrimp' | Chaga chingri | 14 | 23 |
| 3 | ” | *Penaeus japonicus* | Kuruma shrimp | dorakata chingri | 14 | 16 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 4 | ” | *Penaeus marguinensis* | Banana shrimp | baga chama chingri | 17 | 21 |
| 5 | ” | *Penaeus semlsulcatus* | Green tiger shrimp | Bagatara chingri | 20 | 25 |
| 6 | ” | *Metapenaeus brevicornis* | Yellow shrimp | lolla chingri,chamna chall | 8 | 13 |
| 7 | ” | *Metapenaeus affinis* | | Korkora chingr | | |
| 8 | ” | *Metapenaeus lysianassa* | Brown shri mp | Hanny | | |
| | | | | | | |
| 9 | ” | *Metapenaeus monoceros* | Brown shrimp | Horina chingri | 13. | 18 |
| 10 | ” | *Metapenaeus spinulatus* | Spotted Brown shrimp, | charna honney | | |
| 11 | ’ | *Parapenaeopsis sculptills* | Rainbow s.hrlmp | Ruda ChIngri | 12 | 17 |
| 12 | ” | *Parapenaeopsis uncta* | | | | |
| 13 | ” | *Parapenaeopsis hardwickii* | | Godda,gusha chingri | | |
| 14 | ” | *Parapenaeopsis stylifera* | Kddi shrimp | Ruda chingri | 8 | 14 |
| 15 | Solennoceridae | *Solenocera subnuda* | | Chama chingri, sura chingri | | . |
| 16 | Sergestidae | *Acetes indicus* | | Gura icha lotia icha | | |
| 17 | Palaemonidae | *Macrobrachiurn rosenbergii* | Giant freshwater prawn | Golda chingri | 14 | 34 |
| 18 | ” | *Macrobrachium birmanicus* | | Nazari icha, shul icha | | |
| 19 | ” | *Macrobrachium lamarrei* | | Thenga icha | | |
| 20 | ” | *Macrobrachium mirabilis* | | Luitta icha | | |
| 21 | ” | *Macrobrachiurn rudis* | | Kucha chingri | | |
| 22 | ” | *Macrobrachium villosimanus* | | Dimua icha | | |
| 23 | ” | *Nematopalaernon tenuipes* | Spider prawn | Gure icha | 5 | 8 |
| 24 | ” | *Palaemon styliferus* | | Gura icha | | |
| 25 | Alpheidae | *Alpheus euphrosyne* | | Goda chin ri | | |

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|---|---|---|---|---|---|---|
| 26 | Scyllaridae | *Thenus orientalis* | Locust lobster. cigale-de-mer | Bolsanasa | 15 | 25 |
| 27 | Portunidae | *Scylla serrata* | Mud crab | Kakra | 15 | 21 |
| 28 | ” | *Scylla oceanica* | | | | |
| 29 | ” | *Neptunus pelagicus* | Blue swimmer crab | Zaji kakra | 5 | |
| 30 | ” | *Neptunus sanguinolentus* | Swimmer crab | Zaji kakra | 3 | |
| 31 | Grapsidae | *Sesurma mederi* | | Kokrol | | |
| 32 | ” | *Metaplax elegans* | | | | |
| 33 | ” | *Metaplax crenulata* | | | | |
| 34 | Ocypodidae | *Macrophthalmus brevis* | | Kokrol | | |
| 35 | ” | *Uca dussumieri* | fiddler crab | | | |
| 36 | ” | *Uca forcipata* | | | | |
| 37 | ” | *Gelasimus annulipes* | fiddler crab | Lal kakra | 1.5 | |
| 38 | ” | *Carcinoscorpi s rotundicauda* | horseshoe crab | Sagor kakra, shakul kakra | | |
| 39 | ” | | smalI swimming crab | Gulli kakra | | |

## Mollusca

| Sl. No. | Family | Scientific name | English name | Bengali name | Ave.TL (cm) | Max. TL (cm) |
|---|---|---|---|---|---|---|
| 1 | Octopodidae | *Octopus vulgarls* | Common octopus | | 30 | 60 |
| 2 | Sepiidae | *Sepia sp.* | Cuttle fish | Nuna cheai | 10 | |
| 3 | Loliginidae | *Loligo sp* | Squid | Nuilla | 7 | 11 |
| 4 | Neritidae | *Nerita articulata* | Snail | | | |
| 5 | ” | *Neritina cornucopia* | Snail | | | |
| 6 | ” | *Neritina smithii* | Snail | | | |
| 7 | ” | *Neritina violacea* | Snail | | | |
| 8 | Ellobidae | *Cassidula multiplicata* | Snail | Jongra | 8 | 13 |
| 9 | ” | *Cassidula aurisfelis* | Snail | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | ” | *Ellobium gangetica* | Snail | | | |
| 11 | ” | *Pythis plicata* | Snail | | | |
| 12 | Littorinidae | *Littoraria melanostoma* | | | | |
| 13 | Potamididae | *Cerithidea alata* | Snail | | | |
| 14 | ” | *Cerithidea obtusa* | Snail | | | |
| 15 | ” | *Telescopium telescopium* | Snail | | | |
| 16 | Purouridae | *Cymia tissoti* | Snail | | | |
| 17 | !Thiarida | *Thiara tuberculata* | Snail | | | |
| 18 | Viviparidae | *Bellamya bengalensis* | Snail | | | |
| 19<br>20 | 'Volemidae<br>” | *Pugilina cochlidium*<br>*Indoplanorbis exustus* | Snail<br>Snail | | | |
| 21 | ” | *Lymnaea acuminata* | Patula form | | | |
| 22 | ” | *Lymnaea acuminata* | Typica form | | | |
| 23 | .Unionidae | *Lamellidens marginalis* | Clarn or mussel | | | |
| 24 | Corbiculidae | *Polymesoda bengalensis* | Clam | | | |
| 25 | ” | *Anadara sp* | Blood clam | | | |
| 26 | ” | *Meretrix meretrix* | Thick-shelled clam | | | |
| 27 | ” | *Hiatula sp* | | | | |
| 28 | ” | *Donax sp* | | | | |
| 29 | ” | *Pholas sp* | | | | |
| 30<br>31<br>32<br>33 | Ostreidae<br>” | *Crassostrea gigas*<br>*Crassostrea gryphoides*<br>*Ostera*<br>*Achatina fulica* | Gjant oyster<br>Rock oyster | Chinuk<br>kusturi,chiloon | 27 | |
| 34<br>35 | ” | *Pila globossa*<br>*Pila scutata* | <br>Inrassatula form | Schamuk | | |

Source: FAO/ UNDP (1998) and Rahman et al. (1995).

## 1.5 Seasonality

Seasonal resource exploitation is important for the management aspects of a particular resource. Monthly average for last five years fish extraction data from the Forest Department

is considered for indicating the seasonal changes. Month wise landing station data for Illish and white fish as well as community survey data are considered for comparison of trends. Seasonal trend of white fish extraction is supported by the information obtained from the community except one peak season during June, which does not match with the information. If a comparison of the dry fish extraction time is made with the information obtained from the literature (Anon, 2000), it is evident that fish drying activity started from October and continued up to February. In case of Illish, one of the major landing stations, BFDC was considered which also showed the same seasonal trend as Forest Department data but the highest peak is during September. For most months BFDC data exceeded the official data. Usually December to February is the breeding season of crab and brood crab is in high demand in foreign countries. One of the most interesting aspects of the diversity of the Sundarbans is that this diversity is maintained in a habitat that is anything but uniform. Extreme daily variation in temperature, salinity, depth, direction, and strength of water flow give mangrove swamps a variability that, at first, might be equated with instability, which can decrease the diversity (May, 1974). The coastal area has a gentle slope and major portion of it lies 7-8 m above mean sea level. Three distinct seasons in the tidal regime of the estuary were first discussed by Oag (1939). One season occurs during the southwest monsoon, when the effect of the flood tides is countered and almost completely nullified by freshwater inflow, and the ebb tides predominate strongly. Another season lasts from November to February, when the strength of the flood tide over the ebb tide reaches minimum. The third season occurs during the hot and dry months (May and June, just prior to the southwest monsoon), when the effect of the flood tides is much stronger than the ebb tides, and the estuary reaches maximum salinity.

## Summary

Fishery of the sundarbans reserve forest is quite diverse. The catch statistics dwindle from year to year and implicated to the unrealibity of the data, however, it is realized that the stock is diminishing. The number of dependants / stakeholders of the forest / fishery resources is quite big – 2,00,000 fishermen operate in the forest. Total number of fin fish species reported from the forest 294.

# 2. Important biological and Ecological parameters

## 2.1 Biological Parameters

The mangrove forest of Bangladesh, the largest continuous mangrove bulk, is one of the most important features of the coastal area of the country. The existence of the mangrove has increased the values of other coastal and marine resources such as the coastal and marine fisheries by increasing productivity and supporting a wide biological diversity. The deltaic mangrove of Bangladesh is ecologically and biologically different from the other, mostly non-deltaic mangroves of the world and is unique also in its floral and faunal assemblage; therefore, a number of endangered plants and animals that are extinct from other parts of the world are exist in Bangladesh mangrove. However, the mangrove has been under intensive pressure of exploitation for the last few decades which, in addition to direct clearance and conversion have placed the mangrove under extreme threat. Shrimp farming is the most destructive form of resource use the mangrove has been converted to, which contributed significantly to mangrove destruction with a corresponding loss of biological resources. Concerns have been raised among the ecologists, biologists, managers and policy makers since the early 1990s; deliberate destruction of mangrove and unplanned development of coastal aquaculture particularly shrimp aquaculture have been put under extreme criticism and the sustainability has been questioned. The Sundarbans is the single largest chunk of productive mangrove forest in the world and the most diverse and richest natural resource area of Bangladesh.

### Vegetation

The mangroves of the Sundarbans are unique when compared to non-deltaic coastal mangrove forest. Unlike the latter, the Rhizophoraceae are of only minor importance and the dominant species are sundri (*Heritiera fames),* from which the Sundarbans takes its name, and Gewa (*Excoecaria agallocha).* The reason for this difference is the large freshwater influence in the north-eastern part and the elevated level of the ground surface. The Sundarbans can be classified as moist tropical serial forest, comprising a mosaic of beach forest and tidal forest. Champion (1936) stated that, there are four types: low mangrove forests, tree mangrove forests, salt-water Heritiera forests and freshwater Heritiera forests. Sundarbans West occurs within the salt-water zone, which supports sparse *Ecoecaria agallocha*, a dense understory of Ceriops, and dense patches of hantal palm Phoenixpaludosa

on drier soils. Dhundal and passur *Xylocalpus spp*., and Bruguiera occur sporadically throughout the area. Sundri and gewa cover most of the Sundarbans but *Oryza coarctata*, *Nypa fruticans* and *Imperata cylindrica* are prevalent on mud flats (Khan, 1986). Large stands of keora *Sonneratia apetala* are found on newly accreted mud banks and provide important wildlife habitat (R.E. Salter, pers. comm., 1987). Prain (1903) gives an account of the flora of the mangrove forest of the Ganges-Brahmaputra delta. Seidensticker and Hai (1983) report a total of 334 plant species, representing 245 genera, present in the Bangladesh portion of the delta, and list principal woody and herbaceous species. Chaffey and Sandom (1985) provide a detailed list of trees and shrubs in the Bangladesh portion. Islam (1973) provides an account of the algal flora of the mangroves.

## Fauna

The Sundarbans is the only remaining habitat in the lower Bengal Basin for a variety of faunal species. The presence of 49 mammal species has been documented. Of these, no less than five spectacular species, namely Javan rhinoceros *Rhinoceros sondaicus* (CR), water buffalo *Bubalus bubalis* (EN), swamp deer *Cervus duvauceli* (VU), gaur Bosfrontalis (VU) and probably hog deer *Axis porcinus* (LR) have become locally extirpated since the beginning of this century (Salter, 1984). The only primate is rhesus macaque *Macaca mulatta*, considered by Blower (1985) to number in the region of 40,000 to 68,200, based on surveys by Hendrichs (1975) and Khan (1986), respectively, as compared to the much higher estimate of 126,220 derived by Gittins (1981). The Sundarbans of Bangladesh and India support one of the largest populations of tiger *Panthera tigris* (EN), with an estimated 350 in that of the former (Hendrichs, 1975). Again, Gittins' estimate of 430-450 tigers may be overoptimistic (see Blower, 1985). Spotted deer *Cewus axis*, estimates of which vary between 52,600 (Khan, 1986) and 80,000 (Hendrichs, 1975), and wild boar *Sus scrofa*, estimated at 20,000 (Hendrichs, 1975), are the principal prey of the tiger, which also has a notorious reputation for man-eating. Of the three species of otter, smooth-coated otter *Lutra perspicillata* (VU), estimated to number 20,000 (Hendrichs, 1975), is domesticated by fishermen and used to drive fish into their nets (Seidensticker and Hai, 1983). Other mammals include three species of wild cat, *Fezis bengalensis*, *F. chaus* and *F. viverrina*, and Ganges River dolphin *Platanista gangetica* (EN), which occurs in some of the larger waterways. Species accounts and a check-list are given by Salter (1984). The varied and colorful bird-life to be seen along its waterways is one of the Sundarbans' greatest attractions. A total 315 species have been recorded (Hussain and Acharya, 1994), including about 95

species of waterfowl (Scott, 1989) and 38 species of raptors (Sarker, 1985b). Among the many which may be readily seen by the visitor are no less than nine species of kingfisher, including brown-winged and stork-billed kingfishers, *Pelargopsis amauropterus* (NT) and *P. capensis*, respectively; the magnificent white-bellied sea-eagle *Haliaeetus zeucogaster* which, at a density of one individual per 53. lkm of waterways (Sarker, 1985), is quite common; also the much rarer grey-headed fish eagle *Zchthyophaga ichthyaetus* (NT), Pallas's fish-eagle *Haliaeetus Zeucoryphus* and several other raptors. Herons, egrets, storks, sandpipers, whimbrel, curlew and numerous other waders are to be seen along the muddy banks and on the chars or sandbanks which become exposed during the dry season. There are many species of gulls and terns, especially along the coast and the larger waterways. Apart from those species particularly associated with the sea and wetlands, there is also a considerable variety of forest birds such as woodpeckers, barbets, shrikes, drongos, mynahs, minivets, babblers and many others (Salter, 1984). Scott (1989) gives further details of the avifauna. Some 53 reptile species and eight of amphibians have been recorded (Hussain and Acharya, 1994). Of these muggers Crocodyluspalustris (VU) is now extinct, probably as a result of past over-exploitation, although it still occurs in at least one location nearby (R.E. Salter, pers. comm., 1987). Estuarine crocodile *C. porosus* still survives but its numbers have been greatly depleted through hunting and trapping for skins, there are also three species of monitor, *Varanus bengalensis*, *V. flavescens* and me? salvator, and Indian python *Python molurus* (NT). Four species of marine turtle have been recorded from the area, olive ridley *Lepidochelys olivacea* (EN) being the most abundant. Green turtle *Chelonia mydas* (EN) is rare due to excessive fishing, while loggerhead *Caretta caretta* (EN) and hawksbill *Eretmochelys imbricata* (CR) are not common although there have been some reported on the beaches (Hussain and Acharya, 1994). River terrapin *Batagur baska* (EN) is also present. The eighteen recorded snake species include king cobra *Ophiophagus hannah* and spectacled cobra *Naja naja*, three vipers and six sea-snakes (S alter, 1984). Over 120 species of fish are reported to be commonly caught by commercial fishermen in the Sundarbans (Seidensticker and Hai, 1983). According to Mukherjee (1975) only brackish water species and marine forms are found in the Indian Sundarbans, freshwater species being totally absent. This may be assumed to apply also to the Bangladesh Sundarbans, except possibly in the eastern portion where there is freshwater in Baleswar River. Mention should also be made of mud-skippers or gobys which occur in large numbers and are a characteristic feature of mangrove swamps. Crustacea accounts for by far the largest proportion of animal biomass, with an estimated 40 million kilograms of fiddler crabs and 100 million kilograms of mud crabs

(Hendrichs, 1975). The nutrient-rich waters of the Sundarbans also yield a considerable harvest of shrimps, prawns and lobsters. The area supports a varied insect population including large numbers of honey-bees, honey and beeswax being among the economically important products. The insect life of the Sundarbans has been little studied. There are different types of faunal communities in mangrove waters which are dependent on the water component in one way or the other. The planktonic and benthic animal communities also play a very important role in the mangrove ecosystem just like the terrestrial animals. There are different species of crustaceans like *Penaeus indicus, P. merguiensis and P. monodon*, while the crabs are represented by *Uca sp. Scylla serrata, Thalassina*, etc. The fishes are represented by several species like the mud skippers, carangids, clupeids, serranids, mullets, hilsa, seabass, milkfish etc. The wildlife of Indian mangrove forests is quite diverse and interesting. Apart from the famous Royal Bengal tiger and estuarine crocodile (*Crocodilus porosus*), there are different kinds of monkeys, otters, deer's, fishing cats, snakes and wild pigs. The mangrove swamps of India are favoured by a variety of birds, both migratory and resident

### Microorganisms

Microbial organisms like yeast, bacteria and fungi play a very important and dominant role in the decomposition of mangrove foliage, regeneration of nutrients and mineralization.

## 2.2 Ecological parameters

### Soils

The land is moulded predominantly by tidal action. An intricate network of waterways, of which the larger channels (often 1.5 to 2.0 km wide), run in a generally north-south direction, intersect the whole area. Innumerable small khals (creeks) drain the land at each ebb tide. Rivers tend to be long and straight, a consequence of the strong tidal forces and the clay and silt deposits which resist erosion. Easily eroded sands collect at the river mouths and form banks and chars, which are blown into dunes above the high-water mark by the strong southwest monsoon. Finer silts are washed out into the Bay of Bengal, but mud flats are formed on the leeward side of the dunes where they are protected from wave action. These mud flats become overlain with sand from the dunes, and develop into grassy meadows. This process of island- building continues for as long as the area on the wind- ward side is exposed to wave action. With the formation of the next island further out, silt begins to accumulate along the shore of the island and sand is blown or washed away (Seidensticker and Hai,

1983). Most of the soils derived from alluvial deposits are a zonal with little or no profile development (Chaudhuri and Choudhury, 1994; Sarkar *et al*., 1999). Clay loam is the predominating soil type in the Sundarbans, though silt and sandy loams also occur in many areas.

## Climate

The climate of the area is characterized by relatively high temperature and humidity (>80 %) throughout the year, and well distributed rainfall during the monsoon season. Temperatures rise from a daily minima of 2–4 °C in winter to a maximum of about 5-6 °C in March and may exceed 32°C during the monsoon. Recent reports suggest that the air temperature over the Sundarbans and adjacent parts of the Bay of Bengal are gradually increasing (Huq *et a*l., 1999; Agrawala *et al*., 2003). The cold season lasts from about the middle of November to the end of February and is followed by the summer from March to May. There is a six-month dry season during which evaporation transpiration exceeds precipitation. The rainfall over the Ganga-Brahmaputra deltaic region decreases from east to west and from south to the north. In the Bangladesh region, mean annual rainfall varies from about 1,800 mm in Khulna, north of the Sundarbans, to 2,790 mm on the coast. The average annual rainfall in the Indian region is only 1,661.6 mm. It decreases from 1,805 mm in the south on Sagar Island towards Kolkata in the north. Most of the rainfall (about 74 % of the total) occurs during the southwest monsoon period (June–September). Some precipitation is received in the latter half of the hot season and in October. There is relatively little variation in the rainfall Beth twine years. During the first half of the 20 century, the highest and lowest annual rainfalls were only 142 % (in 1933) and 62 % (in 1935) of the normal respectively. Only rarely have two or three consecutive years experienced below normal (<80 % of average) rainfall. On an average there are 80 rainy days (>2.5 mm rainfall) in a year. Winds are generally light to moderate with a slight increase in force during the summer and monsoons, but in the southern Sundarbans area, particularly near the coast, winds are stronger. Winds blow mostly from directions between the south-east and south-west during May to September. In October, winds vary in direction. During the winter, winds blow mainly from the north-west. In March and April they blow from the south and south-west. Thunderstorms are common during summer afternoons. These may be in association with severe squalls and occasional hail. These are commonly known as northwesters (because the associated squalls usually come from the north-west) or Kalbaisakhi (the disastrous winds of Baisakh, the first month of the Bengali calendar). Storms result in heavy rain and a sharp drop in temperature. Available

long-term records show that cyclones over the Bay of Bengal adjoining the Sundarbans are increasing in their intensity, but decreasing in their frequency of occurrence. This correlates with the rising trend in temperatures mentioned earlier and has a significant bearing on the extent of coastal flooding, erosion and saline water intrusion due to storm surges (Huq *et al*., 1999; Agrawala *et al.*, 2003).

## Hydrology and salinity regimes

The hydrology of the Sundarbans is dominated by the freshwater flows from Rivers Ganga, Brahmaputra and Meghna, which exhibit very high seasonal variation in their discharge, and the tides which range in height from 2 to 5.94 m. Tidal influence extends to more than 50 km inland from the shoreline and surges increase considerably during the cyclonic storms. The freshwater flows from the rivers and the tidal ingress result in a gradient of salinity that varies both spatially and temporally. In general, the salinity is higher nearer the coast and the water is nearly fresh on the inland side limit of the Sundarbans. Similarly, the salinity decreases from west to east. The eastern part of the Sundarbans in Bangladesh is oligohaline (<5 ‰ salinity) whereas most of the Indian Sundarbans is polyhaline. During the past few decades, however, the sources of all rivers in the western part of the Indian Sundarbans have progressively silted up, disconnecting the inflow of fresh water into the mangrove delta. Freshwater flows are much larger from Brahmaputra and Meghna rivers on the Bangladesh side particularly in the Baleshwar River on the eastern side of the Sunarban (Seidensticker and Hai, 1983). The reduced freshwater flow in western parts of the Sundarbans has resulted in increased salinity of the river waters, and has made the rivers shallower over the years. At the same time, during ebb tides, the receding water level causes scouring of top soil and creates an innumerable number of small creeks, which normally originate from the centre of the islands. The ebb tide eroding action is stronger in some islands than others within the Sundarbans.

**Table 4: Important ecological parameter of the Sundarbans mangrove forest (Hoq, 2008)**

| Factors | Key characters | Descriptions |
|---|---|---|
| Seasons | Pre-monsoon (March-May) | High temperature<br>Tidal inundation with increased salinity and evaporation/<br>transpiration rate |
| | Monsoon (June-September) | High rainfall, humid and cloud cover |
| | Post monsoon (October-November) | Hot and humid, rising salinity of river water |
| | Dry winter (December-February) | Cool, dry and sunny weather<br>Tidal level remains low and<br>No tidal inundation |
| Rainfall | West: 1600 mm mean annual rainfall | 80-85% during monsoon season |
| | East: 2000 mm mean annual rainfall | |
| Temperature | 26-34 °C | March to June |
| | 12-25 °C | December to February |
| Humidity | Mean annual humidity 70% to 80% | High: June to October<br>Low: February |
| Cyclone | Frequent: May to June<br>Severe: October to November | Frequency: 1 in 2 years |
| Surface water flow | Source: Ganges-Padma through Gorai-Modhumati; lower Meghna through the swarupkathi-Kocha river; and runoff from the local catchment areas | Mean monthly stream flows:<br>190 m3/sec in March to 7650 m3/sec in August |
| Ground water flow | Source- Fresh water from hinterland and marine recharge | |
| Tides | Semi diurnal<br>Period: 12 hours 25 minutes<br>Mean tidal height: 4 m | Greatest level of tide: June to August<br>Lowest level of tide: February |
| Water salinity | Oligohaline (0-5 ppt) | South-Eastern part |
| | Mesohaline (5-18ppt) | Middle Northern part |
| | Polyhaline (>18ppt | Western part |
| Water pH | 6.5-8.0 | No marked seasonal variation |

| Factors | Key characters | Descriptions |
|---|---|---|
| D.O. | 6.28 ppm (Low tide)<br>5.98 ppm (High tide) | Baleswer-Supoti river systems |
| | 7.13 ppm (Low tide)<br>7.36 ppm (High tide) | Passure-Sibsa river systems |
| | 7.78 ppm (Low tide)<br>7.82 ppm (High tide) | Arpangasia-Malancha river systems |
| | 8.10 ppm (Low tide)<br>22.19 ppm (High tide) | Jamuna-Malancha river systems |
| Soil salinity | Meiohaline (< 5ppt) | North-Eastern part |
| | Mesohaline (5-10ppt) | North central to South Eastern |
| | Polyhaline (>10ppt) | Western part |
| Soil pH | 5.3-8.0 | |

## 2.3 Significance of the parameters for biodiversity conservation

The large spatial and temporal variability in hydrological regimes (both freshwater inflows and the tides), topography and texture of the substratum, the salinity, and their interactions, result in very high habitat heterogeneity in the mangrove ecosystems, and thereby ensure an equally diverse biodiversity. There has been some discussion about the characteristic mangrove plants and a distinction is usually made between the “true mangrove” and “mangrove associate” species. However, following the definition of wetland species by Gopal and Junk (2000, 2001), here we consider all those species which depend directly or indirectly upon the mangrove habitats, or on any other organism living in the mangrove as mangrove organisms. However, the overarching gradients of salinity and freshwater that occur across the Sundarbans from west to the east, are clearly reflected in the distribution of biota. Recent surveys provide considerable information on several groups of plants, fishes, reptiles, amphibians and birds (Ismail, 1990; Hussain and Acharya, 1994; Seidensticker, 1991; IUCN-BD, 2002a, b, c). Differences in the nomenclature followed in the two countries also sometimes make comparisons difficult. The following account is based largely on the Indian part of the Sundarbans, with frequent comparisons with the information available from Bangladesh.

## Summary

The vegetational and faunal characteristics of the SRF is diverse and it got to be since, the soil, microbs, and the ecosystem with regard to salinity and climatic aspects make the whole Sundarbans is one of the most heterogeneous one and that in turn make the biodiversity one of the richest in the world.

# 3. Current harvesting patterns in terms of fishing area, time, gears, user groups and beneficiaries

## 3.1 Fishing Area, Time and Gears

There are two basic types of fisheries in the Sundarbans

- Inshore fishery
- Offshore fishery

Inshore fishery is carried out by small non-mechanized boats (5-12 m length) in relatively shallow waters, ranging from depths of 2 to 8 meters. Offshore fishery covers estuarine areas and coastal waters. Among different types of fishing gears, the most common are *behundi jal* (set bag net), *ilisha jal* (gill net), hook and line and fine meshed shrimp fry collection nets. Most of the fishing gears are operated from boat ranging from 4 to 15 m long and 2 to 5 peoples are needed for the operation of those gears. Hilsa gill net required 6-10 fishermen and the operational boat relatively large (10-15 m). The target species are commercially important fish and shrimp species, although large quantities of other species are caught in the nets. For collection of *Penaeus monodon* post larvae (PL), push or pull nets and set bag nets are widely used which are non-selective mesh size causes destruction to other non-targeted species.

## 3.2 Fishing gear and catch composition

There are at least 14 gears operating in the Sundarbans waters. It is possible to make 3 clusters of major groups based on their operation and target species.

**Group I:** Single species-single gear fisheries: *Tenualosa ilisha*, *Macrobrachium rosenbergii*, *Penaeus monodon* PL and mud crab, the bulk of the total catch of a single target species is taken by a single type of fishing gear. Only small quantities of these targeted species are caught by other gears, and minor by-catches of non-target species are caught by this type of gear e.g. hilsa gill net.

**Group II:** Single species-multi gear fisheries: generally a particular gear i.e. pangash gill net targeted for harvesting only *Pangasius pangasius*, but significant quantities of this target species are also caught by other gears.

**Group III:** Multi species-multi gear fisheries: shore net, various gill nets, set bag net, cast net and long lines etc. By these gears a varying degree of many non-selective species are harvested.

Based on major 3 classes the fishing gears operated in the SRF are classified into following categories:

**Class A:** Used in the inshore water to catch large fish and crustaceans. This class of gear has a relatively high selectivity (mean number of major species caught <10). The gears are in this class are:-

- ***Cast net:*** Cast nets are often used by fishermen operating "sit and wait" type gears, such as long lines, during inactive periods. The diameter of the nets ranges from 3.5 - 10 m. A large proportion of cast net fishermen increase their catches by using a ground bait of clay and fish meal to attract and aggregate fish in one area. Cast nets are used predominantly in the northern part of the inshore water.

- ***Canal gill net:*** A single panel of netting set at high tide across relatively narrow side channels of 20 - 50 m width. Fish are caught when they partially pass through the mesh of the net but are unable to pass completely through. When fish try to reverse from the net they become caught by their backward directed gill covers, hence the name "gill net". Canal gill nets are operated largely in the north and west of the inshore water.

- ***Crab hook and lines:*** A set of between 360 - 600 wire hooks (0.02 - 0.03 cm diameter) with a shank length of 2 - 2.5 cm, lay along the bottom of side channels. The hooks are baited with fish. The position of the line of hooks is often marked with a polystyrene float or plastic bottle. The line of hooks is deployed from a boat and hauled in every 3-4 hours. The target species *is Scylla serrata.*

- ***Gill net:*** This net would work on the same principal as the canal gill net, but is presumably set in the larger river and channels.

- ***Hilsha gill net:*** Used in both the inshore and offshore waters. In the inshore water nets are between 300 – 800 m long and deployed from non-mechanized boats. These nets are used primarily in the eastern part of the SRF from May to October. In the offshore water nets are 1,000-3,000 m long and deployed from mechanized fishing

boats from June to March. Hilsa gill nets are set mid-stream and suspended from a set of floats. The target species is *T. ilisha.*

- ***Long lines:*** A set of between 400- 800 hooks with a shank length of 2-2.5 cm, baited with fish. The line of hooks is weighted at intervals with a house brick to maintain it close to the river bed. The line is marked with polystyrene or a plastic bottle. Long lines are used in the inshore and offshore waters. They are deployed from boats during high tide for 5-6 hours. Target species are large catfishes and predatory perciform fishes.

- ***Otter gill net:*** A 100-300 m long gill net of 3-5 m depth into which fish are driven by trained otters *Lutra perspicillata.* This gear is operated from 9-12 m boats and requires at least 3 fishermen. The target species are *T. ilisha* and *L. calcarifer.*

- ***Pangash gill net:*** Details of pangash gill nets and their use in the SRF are not available the target species is *P. pangasius.*

- **Rod and lines:** A wooden stick of approximately 75 cm length to which is tied a length of nylon fishing line of sufficient length to reach the riverbed. A hook with a shank length of 2–2.2 cm is attached to the end of the line and baited with juvenile *P. indicus* (horina chingri) or a flour/fish meal paste. Up to 6 rods are operated by one fisherman. Rod and line fishing takes place in the northeast of the SRF in both main rivers and side channels. Fishermen usually operate close to the river bank, particularly in the Major River and channels and often at the confluence of small side-streams. The target species is *M. rosenbergii.*

**Class B:** This gear used offshore water to catch for large fish and crustacean. This class of gear has a relatively low selectivity (mean number major species caught > 10).

- ***Set bag net*** **(behundi jal)*:*** A large bag-shaped net suspended between two wooden poles driven into the substrate. The month of the net is held open by 2 vertical wooden poles. The net tapers from the mouth to a cod-end. The cod-end can be raised and lowered by fishermen in a boat positioned above it. The net faces the tidal flow and the direction of the net is reversed depending on the direction of the tide. Use of the set bag net is limited to a maximum water depth of approx. 25 m.

**Table 5: Weight and percentage of catch by set bag net in 1993 (Chantarasri, 1994)**

| Species | Weight (MT) | Percent |
|---|---|---|
| Scylla serrata | 374.8 | 97.2 |
| Other | 10.7 | 2.8 |
| Total | 385.5 | 100.0 |

**Table 6: Species composition, weight and percentage of catch by Behundi Jal in 1993 (Chantarasri, 1994)**

| Species | Weight (MT) | Percent |
|---|---|---|
| Macrobrachium rosenbergii | 203.7 | 89.6 |
| M. malcolsomini | 5.8 | 2.5 |
| Johnius argentatus | 6.9 | 3.0 |
| Other | 11.0 | 4.8 |
| Total | 227.4 | 100.0 |

**Table 7: Species composition, weight and percentage of catch by Set bagnet in 1993 (Chantarasri, 1994)**

| Species | Weight (MT) | Percent |
|---|---|---|
| Penaeus monodon | 1453 | 41.2 |
| Mugil spp. | 146 | 4.1 |
| Lates calcarifer | 126 | 3.5 |
| Polynemus spp. | 125 | 3.4 |
| Gobius spp | 136 | 3.8 |
| Stolepholus spp. | 155 | 4.3 |
| Metapenaeus spp. | 1109 | 31.0 |
| Penaeus spp. | 140 | 3.9 |
| Other | 131 | 3.6 |
| Total | 3521 | 100.0 |

- ***Shore seine net:*** A single panel of netting 150-300 m long and 2-5 m deep. The net may be deployed from the shore or from 2 boats in a half circle. After deployment, both ends of the net are hauled into the shore where the catch is beached. This gear

requires at least 4 fishermen and is used in sandy, estuarine areas. Shore seine nets are fished at high tide, typically from October to March.

**Table 8: Species composition, weight and percentage of catch by shore seine net (charpata jal) in Sunderbans in 1993 (Chantarasri, 1994).**

| Species | Weight (MT) | Percent |
|---|---|---|
| Setipinna taty | 64.4 | 24.7 |
| Pomadasys hasta | 56.8 | 21.7 |
| Johnius argentatus | 43.4 | 16.6 |
| Lates calcarifer | 19.8 | 7.6 |
| Polynemus spp. | 6.6 | 2.5 |
| Liza spp. | 6.2 | 2.4 |
| Lutjanus spp. | 3.8 | 1.4 |
| Gobius spp. | 3.6 | 1.3 |
| Arius spp. | 2.1 | 0.8 |
| Scatophagus argus | 1.1 | 0.4 |
| Stolepholus spp. | 1.0 | 0.4 |
| Penaeus indicus | 36.2 | 13.8 |
| Macrobrachium rosenbergii | 4.9 | 1.9 |
| Penaeus monodon | 2.4 | 0.9 |
| Metapenaeus monoceros | 5.1 | 1.9 |
| Palaemon spp. | 1.1 | 0.4 |
| Other | 2.3 | 0.8 |
| Total | 261 | 100.0 |

**Class C:** Used inshore water to catch crustacean larvae. This class of gear has a relatively high selectivity (mean number of major species caught < 10).

- ***Shrimp fry hand net:*** There are 2 types of shrimp fry hand-net, one having a triangular the other a rectangular wooden frame. Both are mobile nets that the user pushes or pulls through shallow water. The target species, *P. mondon* reproduces on a lunar cycle and peak larval abundance is typically 2-5 days following a full moon. After removing *P. mondon* larvae, unwanted fish and crustacean larvae are discarded

on to the shore to die. Shrimp fry hand-nets are operated throughout the inshore water though predominantly in the north of the SRF.

- ***Shrimp fry set bag net:*** This net operates on the same principle as the set bag net, but with a finer mesh. It is operated in the larger river channels in the northern area of the inshore fishery. Catches are sorted on boats, the cod-end being emptied approximately every 30 minutes. The catch is released from the net into a earthenware pot. A portion of the catch is poured into a white based dish where *P. monodon* larvae are removed using the single valve of a bivalve mollusc, *Unio* sp. Small numbers of edible juvenile fish are removed and dried by the fishermen for their own consumption.

Chakraborty *et al.* (1995) described 15 types of fishing gears including wounding gear and fish traps from inland waters of Bangladesh, few of them are common in the Sundarbans. No wounding gear or fish traps were found to use in the Sundarbans. Fish traps and trapping barrier are most common gear in some tropical mangrove forest. Types, numbers of fishers and boats are presented in Table 9.

**Table 9: Types and number of gears, numbers of fishers and boats in the Sundarbans (Hoq, 2008)**

| Fishing gears/methods | Nos.of gears | Nos.of fishers | Nos.of boats | Remarks |
|---|---|---|---|---|
| Shore net | 385 | 1,540 | 385 | Operates in the inshore water |
| Shore seine net | 20 | 120 | 20 | Operates in the offshore water |
| Hilsa gill net | 500 | 2,000 | 500 | Operates both in the inshore and offshore waters |
| Pangash gill net | 6 | 20 | 6 | Operates in the inshore water |
| Canal gill net | 250 | 800 | 250 | -Do- |
| Otter gill net | 420 | 1,500 | 420 | Operates both in the inshore and offshore waters for Indian salmon, croakers, mackerels, mullets, catfishes etc. |
| Otter lift net | 6 | 20 | 6 | Operates in the inshore waters |

| | | | | |
|---|---|---|---|---|
| Cast net | 2,505 | 5,000 | 538 | Operates from river bank/fishing boat in inshore waters |
| Set bag net | 2,963 | 17,000 | 1,902 | Operates in the offshore waters |
| Hooks & lines | 705 | 1,410 | 705 | Operates in the inshore waters |
| Stick hook | | | | |
| Crab hooks & lines | 3,000 | 6,000 | 3,000 | Operates in the inshore waters |
| Angling rods | 500 | 1,000 | 100 | -Do- |
| Shrimp fry pull net | 85,000 | 120,000 | - | Operates along the river banks in the inshore waters |
| Shrimp fry push net | 25,000 | 37,000 | - | -Do- |

**Table 10: Season-wise used gears and target species in SRF (Hoq, 2008)**

| Sl. | Local Name | Common Name | Main Fishing Season | Target species | Location of use |
|---|---|---|---|---|---|
| 1 | Chandi Jal/ Ilish JalGolsha jal | Gill net (drifting, multi/mono filament | Ashar- Aswin | Ilish | River and sea |
| 2 | Bebdi/Behundi Jal | SBN | Year round (peak: asar-Sarban) | chingri, parse, tengra, vetki, crab, dogra | River, canal and sea |
| 3 | Jhaki jal | Cast net | Year round | tengra, parshe, golda, | Bank of river and canal |
| 4 | Borshi-white fish | Hook and line | ashar-Kartik | pangas, vetki, kaow, jaba | River, canal |
| 5 | Borshi-Golda | Hook and line | Sravabn- chaitra | golda | River, canal |
| 6 | Khud jal | | Sraban - chaitra | golda | |
| 7 | Don dori | long line | kartik - magh | Crab | River, canal |
| 8 | Charpara/ Khorchi jal | Beach seine/Shore net | Year round (Main: Kartik-Magh) | Phasa, datina | bank of khal & river inside the forest |
| 9 | Gurijal/poa jal | gill net | | poa | |

| | | | | | |
|---|---|---|---|---|---|
| 10 | Pangas jal | Gill net (drifting, multifilament) | | Pangas & other large species | river |
| 11 | Khalpata Jal | Canal Gill Net | Year round (Main: Kartik-Magh | | Canal |
| 12 | Darey Jal | Lift/seine net | Year round | Large size fish | River, canal, |
| 13A | Net Jal-Bagda | SBN | Magh- Baishak | PL-Bagda | Close to bank of River & canal |
| 13B | Net Jal-Golda | SBN | Baishak- Ashar | PL-Golda | |
| 14 | Zatka Jal/current jal | Gill net (drifting, monofilament) | Pous - Ashar | Zatka (Ilish) | River |

## 3.3 Main fishing areas

- Coastal belt with total area –7620 Km2
- Marine zone –1874 Km2
- Land area –4143 Km2
- Number of rivers and khal-450
- Prohibited khal-18
- Seasonal fishing collection chars –11

## 3.4 User group and Beneficiaries

In Bangladesh, about 2.5 million people inhabit villages around the Sundarbans. As many as 300,000 of them are depend directly on the mangrove forest. The growth rate for the Bangladeshi population in general is 1.6% and because of high rural unemployment, there is some rural–urban migration as people search for alternative income sources. Only 35% of those living in the impact zone (0-20 km around the SRF) own agriculture land. Up to 50,000 people a day enters the Sundarbans to cut timber, collect honey and catch shrimp fry. Migratory fishermen also enter the Sundarbans and establish camps during the dry season, engaging in illegal trapping and hunting. The demand for irrigation water during the dry season has meant the diversion of 40% of the freshwater that would normally flow into the Sundarbans. A ban on shrimp fry collection went into effect in 2000 as concerns about its effect on fisheries and biodiversity increased. However, the law will be very difficult to

enforce because of the large number of fry catchers in the country and the lack of any viable alternative employment. It is also often the only source of income for thousands of rural women.

An estimated 14% of people living inside a 10 km border around the Sundarbans participate in shrimp fry collection. They include both males and females from all age groups. An estimated 225,000 people are involved in shrimp fry collection. To this another 20,000 who operate as primary and secondary traders must be added, who carry the fry from the primary collection points to the shrimp farmers in one, two or three stages. Population involvement in hilsa fishing and dried fish production is also high, but in these two activities, people from outside the Sundarbans region are engaged as part time employment.

In the impact zone of Sundarbans, 18% of the households are dependent on Sundarbans resources (PDO-ICZMP, 2004). Their livelihood depends on extraction of resources from Sundarbans. The review of past works and related literature (SBCP, 2001; PDO-ICZMP, 2004; Kabir and Hossain, 2008), revealed existence of 10 livelihood groups in Sundarbans which are: Bawali (wood cutter), Nypa collectors (golpata used as roof materials), Mawali (honey and bee wax collector), Jele (Fisher), Majhi (Boatman), Crab collector, Medicinal plant collector, Shrimp fry collector, Chunery (oyster and snail collector). After field observation and SLDs it was found that in practical sense these resource extractors have diversified their livelihood opportunities by extracting different types of resources in responding to decreasing productivity status of Sundarbans. Now Bawalis also collect Nypa, and other non-wood products, such as, mele grass (*Cyperus javanicas*) ulu grass (*Imoerata cylindrical*) and also provide labour to the Mawalis. Fishers also collect fish fry, timber and Nypa during harvesting season. Children and wives of fishers collect shrimp fry, snail and oyster. Based on the learning from the SLDs, it was decided to classify three broad livelihood groups: Bawali, Mawali, and Fisher. Table 2 presents the type of resources extracted by these three livelihood groups and the period of harvesting.

## Summary

Fisheries of the Sundarbans have been broadly categorized into inshore and offshore types. The inshore type fishery is limited within the depth zone ranging from 2 to 8 meters while the offshore fisheries area extends beyond 8 meters depth zones in the sea ward direction. At least 14 different gears operate in the Sundarbans waters. The gears are grouped into three categories like, single species single gear fishery; single species multi gear fishery; and multi species multi gear fishery. The gears are again classed into groups based on whether they are nets of different types, hook and lines for fishing fin fishes and crabs etc.; nets that are operated setting at fixed position in the estuaries or rivers called set bag nets or hand nets used for shrimp PL collection from the estuarine rivers.

# 4. Trend regarding the productivity and use of Sundarbans fisheries resource

Trend in fish production from the Sundarbans compared with total country's fish production since 1985 up to year 2005 has been presented in the following Table. Overall contribution of Sundarbans fishery in country's total fish production is about 1%, whereas its contribution to inland capture fishery is 2%. Inland aquaculture together with coastal shrimp culture, accounted for 40% of the country's total fish production during 2004-05, where, the inland capture fisheries contributed 39%. Aquaculture recorded an impressive growth rate in recent years, where coastal aquaculture plays an important role in terms of production and export earnings. It is worth mentioning here that the Sundarbans plays a significant role through supplying fish and shrimp seed in north-west coastal region. Hence, development of coastal aquaculture based on the Sundarbans is vital in the context of making a major impact on production and economic well being of the people of the country.

**Table 11: Comparison of country's total fish production and Sundarbans production (Hoq, 2008) (000 MT)**

| Year | Sundarbans production | Country capture production | Country production | % of capture production | % of country production |
|---|---|---|---|---|---|
| 1985-86 | 5 | 442 | 794 | 1.13 | 0.63 |
| 1986-87 | 5 | 431 | 815 | 1.16 | 0.61 |
| 1987-88 | 6 | 424 | 827 | 1.45 | 0.73 |
| 1988-89 | 5 | 424 | 841 | 1.18 | 0.59 |
| 1989-90 | 5 | 424 | 856 | 1.18 | 0.58 |
| 1990-91 | 7 | 443 | 896 | 1.58 | 0.78 |
| 1991-92 | 6 | 480 | 952 | 1.25 | 0.63 |
| 1992-93 | 7 | 532 | 1,021 | 1.32 | 0.69 |
| 1993-94 | 7 | 573 | 1,091 | 1.22 | 0.64 |
| 1994-95 | 7 | 591 | 1,173 | 1.18 | 0.60 |
| 1995-96 | 7 | 609 | 1,258 | 1.15 | 0.56 |
| 1996-97 | 9 | 600 | 1,360 | 1.50 | 0.66 |
| 1997-98 | 7 | 616 | 1,464 | 1.14 | 0.48 |
| 1998-99 | 11 | 649 | 1,552 | 1.69 | 0.71 |

| Year | Sundarbans production | Country capture production | Country production | % of capture production | % of country production |
|---|---|---|---|---|---|
| 1999-00 | 12 | 670 | 1,661 | 1.79 | 0.72 |
| 2000-01 | 12 | 689 | 1,781 | 1.74 | 0.67 |
| 2001-02 | 12 | 688 | 1,890 | 1.74 | 0.63 |
| 2002-03 | 14 | 709 | 1,998 | 1.97 | 0.70 |
| 2003-04 | 15 | 732 | 2,102 | 2.05 | 0.71 |
| 2004-05 | 16 | 859 | 2,216 | 1.86 | 0.72 |

Over the last decade, the fisheries of Sundarbans had a decline trend as per fisher, community people, fish traders, dadandars, and local level DoF & FD personnel although the FRSS production data shows an increasing trend while the FD data with decreasing trend. The FRSS production data shows 15,000 mt in 2004-05 and 5,000mt in 1985-86 with increase of 220% in 17 years. The FD data shows a decreasing trend. In 2003-04 the production was 4,333mt and in 1987-88 was 5,654mt with a 23% decrease in 12 years. There has been high reduction in white fish (61%), marketable shrimp (78%), undersize shrimp (81%) and Ilish (almost 100%) and tremendous increase in crab (almost 100%) in the similar period as per FD data over the same period. The fisher's assumption is 50-75% decrease in fish catch in last 10 years.

There have been changes in biodiversity but probably not to a great deal. No species has been extinct. Pangas, Iilish and Kain (Plotosus sp.) have greatly reduced in the rivers of Sundarbans. Other reduced species are tengra, vetki, boal, gajar, koi, magur, air, shilong. There is an overall decrease in all other species as well.

The clear understanding on livelihood changes is yet understood. As per present information there has been little shifting in occupation due to lack of choice but changes has been great deal ecumenical status and living standards. For fishers the livelihoods has been greatly reduced and having hardship. Nickerson (1999) assumed that biomass growth is limited by the two parameters: the productivity of the stock and the habitat carrying capacity and showed that keeping the productivity of a stock constant, the stock size of mangrove-dependent species is linearly related with mangrove habitat carrying capacity, i.e., mangrove area. Variations in survival of the species are caused by many factors including availability of a food supply, protection from predators and physical conditions including water quality,

temperature, salinity changes, and hydrology and the ways in which it affects the food requirements of larvae and juveniles.

The presence of mangroves contributes positively to these major factors. Nickerson (1999) showed that the unclaimed mangrove habitat is superior in terms of total net benefits and mangroves claimed for polyculture of shrimp generated negative total net benefits and the total net benefits in the semi-intensive culture are less than 3% of the unclaimed mangroves. The mangrove forest of Bangladesh, locally known as Sundarbans, is believed as the largest continuous mangrove forest of the world. The Sundarbans mangrove forest is used as the basis for various commercial and subsistence activities. About 10 million people of the coastal regions are dependent directly or indirectly on the mangrove for a variety of purposes such as agriculture, fishing, cattle rearing, human settlement, collection of housing materials, fuelwood and human foods and employment opportunities. Along with the subsistence fishing by numerous small fishermen, large-scale export-oriented aquaculture industries have been developed in the coastal areas of Bangladesh, using the mangrove as the basic productive unit. Thus, the mangrove is playing significant roles in uplifting the coastal regional as well as the national economy. However, little attention has been paid to explore the contribution of this valuable resource. Much less is known on the ecology of the fish and the commercial and subsistence fisheries activities and the spatial-temporal scale at which the mangrove system supports the coastal and offshore fisheries of Bangladesh. Consequently, there have been no sound management and research guidelines for the valuable mangrove fisheries. This paper reviews the mangrove-fisheries linkage, the present status of the mangrove fisheries and aquaculture and the impacts of mangrove exploitations on fisheries with emphasis on the importance of new management options and research requirements for the mangrove fisheries in Bangladesh. The connection between terrestrial primary production of mangroves and aquatic secondary production has four components (Odum and Heald, 1975); - the production of large quantities of organic matter by mangroves; the export of this organic matter, particularly the fallen leaf material from under the mangroves into surrounding deeper water; - the transformation, as It decays, of the leaf material into detritus particles covered with bacteria, microalgae, protozoans and permeated with fungi; the utilization of mangrove detritus particles as food by a large group of estuary and offshore consumer organisms. Many individual food chains are involved but the principle flow of energy follows the pathway: mangrove debris and detritus - bacteria and fungi - primary consumer (detritus consumer) -secondary consumers (lower, middle, and top carnivores)

(Tabb et al., 1976). The magnitude of the Impact of mangrove production on aquatic productivity will vary but a combination of shallow land slope and great vertical fluctuations in water level such as we have in the Sundarbans results in the generation of enormous quantities of particulate organic matter which is transported to the estuary (Odum aiid Heald, 1975), This can result in as much as 80% of the total energy budget of an estuary (Lugo and Snedaker, 1974). Over 120 species of fish are commonly caught by commercial fishermen In the Sundarbans and the shrimp, prawn, lobster and crabs hold a predominant place in the catch that is estuarine dependent.

With their protected waterways and high productivity, it is not surprising that the estuarine areas are important nursery areas. Many of the Bay fish and shrimps are estuarine-dependent at some point in their life cycle (Pillay, 1967; Clark, 1973). Thus, estuarine productivity is critically linked with the vegetated tidelands and of course, it is also coupled with the upland watershed.

Productivity in the coastal ecosystem is normally governed by the amount of available nutrients, (defined here as the cations and anions that are essential to life (Clark, 1973; Stark, 1978). The mangrove forest substratum is very active in removing essential elements from the circulating surface waters. This activity is attributable to the redox process of the soil, the activities of the periphyton on prop roots and other surfaces, uptake by extensive nets of fine roots at the surface of the soil, and the metabolism of microflora and macrofauna. Our crocodile example shows how important an animal can be in the redistribution of mineral elements and organic products in the system. Crabs (families Ocypodldae, Grapsidae, Xanthldae), especially, are responsible for great turnover of mud on the forest floor which results in nutrient recycling and we have indicated earlier some of the other factors that come into play in this process.

From these observations on ecological processes, as Incomplete as they are, we can derive the basic foundation upon which the successful management of the coastal ecosystem must he based (Clark, 1973); "Whatever its specific goals may be an environmental management programmers must embrace the whole ecosystem, Any attempt to manage separately one of the many interdependent components of a complex ecosystem will very fall."If we are to maintain the integrity and thus, the long-term productivity of any resource sector or, indeed, any of a host of values In the coastal zone, "the fundamental management goal is the maintenance of the coastal ecosystem at the highest level of quality, the level of best achievable ecosystem function,"

## Summary

The productivity of the waters is interlinked with the hydro-dynamics, temperature, salinity, the organic and inorgaic processes etc. To be able to foresee on the nature and dynamics of the productivity of the waters critical studies are to be conducted so that dependable information /data are made available. So, a research and monitoring agenda has to be there in the new system of management of the forest with suitable budgetary allocation, manpower and facilities.

# 5. Importance and impact of current practices that are degrading or destroying the Sundarbans fisheries

The Sundarbans is the most valuable and the richest natural forests in the country. It constitutes about 51% of the total reserved forest and contributes about 41% of the total forest revenue. The Sundarbans provides employment to about half a million of people. The Sundarbans constitute about 45% of all the timber and firewood supplied from the country's reserved forests.

The mangrove forests of Sundarbans is free from any encroachment and permanent human habitation and has a forest closure of about 70% according to the study of oversees Development Administration in 1985. The UNDP recently described Sundarbans as "the most important mangrove formation in the world ", producing protein fuel and raw materials for industry. Moreover the Sundarbans is the most attractive place for viewing wildlife. Nowhere in the countries forests will one get the quality of wilderness as in the Sundarbans. Many authorities have given credit to the Forest Department for being able to keep the forest intact and habitation and encroachment free inspire of severe pressure from the interested quarters.

## 5.1 Importance of Sundarbans fisheries resources

### Habitat of fishes

The water body of Sundarbans is a highly nutritional zone due to the presence of mangrove forest. About 425 species of fauna with 200 fish species, 38 species of crustaceans, 36 species of mollusks, crabs, decapods and other aquatic species use mangrove swamps as their habitat. Some of the species spend complete life cycle or a crucial part of it as obligatory e.g. Penaed shrimp.

### Breeding & nursery ground

Sundarbans is one of the largest natural nursing and breeding ground (Huq *et al.*, 2001). Various types of fish, shellfish largely depend upon Sundarbans estuaries as a nursery ground as well as shelter and source of their food e.g. *Penaeus monodon, Macrobrachium rosenbergii*. The mangrove forest and mudflats of Sundarbans provide the vital breeding and nursery ground for fish, crustaceans, and mollusks. Total stock of fish in the areas of SRF has

been estimated at 2.9-3.7 tons/$Km^2$, which contributes 5% of the total fish harvest of Bangladesh and the value of that sector, has been estimated at US$ 209.9 million (US$ 46,083) (Kamal, 1999). The total fishermen population actively engaged in fishing in 1993 was about 200,000 and it was 88% of the total population (Chantarasri, 1994). The Sundarbans ecosystem is extremely important both ecologically and economically as a nursery and breeding area for key fisheries including those of the Bay of Bengal. In recent years, concerns have been voiced by fishermen over the apparent declining stocks and productivity of fisheries in and around the Sundarbans. There are also indications of widespread illegal collection of crustacean larvae. Although there is inadequate monitoring of fish stocks, fishermen have noted that they are spending more time and effort to capture fewer and smaller fish. The resource conditions as well as increasing numbers of resource users are a condition that must be reconciled. The increasing demand for recreation and tourism activities is expected to continue and a system for more effective administration of these activities is necessary. The revenues associated with these activities represent a significant opportunity for community organizations and to increase awareness of the ecological importance of the SRF.

## Sources of nutrition

Sundarbans aquatic resources provide sufficient animal protein and prevent malnutrition thus contribute to the national nutrition sector.

## Aquaculture purpose

Adjacent areas of Sunderban are used for aquaculture particularly shrimp and white fish culture eg. Bagda, vetki, phaisa etc.

## Protective purpose

The numerous waterways (Rivers, khal, Marine zone) around Sundarbans act as the first line of defense against wild animal and bandits. Sundarbans being the nursery for nearly 90% of the aquatic species of eastern coast, the coastal fishery of eastern India is dependent upon Sundarbans. Jhingran (1977) recorded a total of 172 species from a variety of sources and also mentioned that the diversity of the Hooghly-Matlah estuary increases along an increasing salinity gradient. Numerous species (estimated to be 400) are known to use mangrove swamps as nursery grounds (Gundermann and Popper, 1984; Lowe-McConnell, 1987). Apart from fish species, there are 20 identified species of Prawns and 44 species of crabs including two edible ones. For fishes, the Sundarbans function as nursery grounds for important

commercial species of the continental shelf that are harvested in India and neighboring countries. The Sundarbans delta provides physiologically suitable environment with respect to temperature, salinity and other physico-chemical parameters. Generally estuary receives abundant supply of nutrients from land drainage and large quantities of organic detritus which is an important source of energy for a wide variety of estuarine consumers. Further, many commercial estuarine fishes grow to maturity there and make up a large part of the near-shore fishery of the northern Bay of Bengal. Other fishes and prawns that spend most of their lives in freshwater descend annually to the estuary for spawning. Therefore, many marine and freshwater prawn and fish require this environment to complete their lifecycle. Most commercially important marine and estuarine fishes are;

**Fin Fish species**

*Lates calcarifer, Hilsha ilisha, Liza parsia, Liza taede, Harpodon hehereus, Plotosus canius, Pompus argenteus, Rhinobatus, Pangasius pangasius, Polydactylens, Chanos chanos, Eleutheronema tetradactylum, Polynemous indicum, Polynemous paradesious and Pama pama* etc.

**Shellfish species**

*Panaeus monodon, Panaeus penicullatus,* and *Metapenaeus monoceros.*

**Crustaceans**

Edible crabs mainly *Scylla serrata* and *Neptunus pelagiens.*

A large number of Sundarbans populations are engaged in fisheries and allied activities. Fisheries remain to be the sole livelihood of fisherman and their family residing in Sundarbans. Collection of fish seeds and adults especially of *Panaeus monodon,* from the nature is one of the main sources of earning of the coastal fisher folk. The fisher folk are using mechanized as well as non-mechanized crafts. Trawlers, gill-netters, purse seiners, etc. are among mechanized crafts and plank built boats, dugout canoes and catamarans are under non mechanized crafts. A number of fishing gears are being used in Sundarbans viz. trawl nets, purse seines, drift/gill nets, boat seines, fixed bag nets, hooks and lines, shore seines, traps, scoop nets, etc.

## 5.2 Impact of current practices

Vast areas of mangrove are being destroyed throughout the world, either directly, or as a secondary result of other activities (Huq *et al*., 2004). The causes of mangrove destruction in various countries are very similar. The degree of destruction in each country depends on specific purposes. The main problem is that the population of each country increases, and this leads to increased demand for food, fuel, building materials, urbanization and land for

cultivation. However, it can be assumed that the causes of mangrove destruction around the world are many such as over-exploitation by traditional users, conversion to agriculture, aquaculture, salt pans, and urban development, construction of harbors and channels, mining, liquid waste disposal, solid waste of garbage disposal, oil spillage, and other hazardous chemicals.

Natural stresses such as cyclones and freshwater discharges also destroy mangrove forests, but the areas are minimal compared with those lost from human activity. Within the southern Asia region, the mangroves of Bangladesh has been exploited heavily for timber, fuel wood, bark tannin, animal fodder, native medicines and food (fish, shellfish, honey, wild animals) for centuries. Population pressure has greatly increased the rate of exploitation, leading to serious degradation. The area of pure Sundri mangrove (*Heritiera fomes* - the main economic species and a mangrove species unique to the Sundarbans) is reported to have shrunk from 31.6 to 21.0 % between 1959 and 1983 (Chaffey *et al.* 1985), representing a period of exploitation before the relatively recent expansion of shrimp aquaculture in Bangladesh.

## 5.3 Denudation of mangrove forest due to shrimp farming

Shrimp farming activities are mainly operated on the land area north of the Sundarbans. It is therefore apprehended that these shrimp farming may intrude southward into the Sundarbans. The aerial photographs and Landsat images of these areas have been visually interpreted by SPARRSO (1997) to locate sign of mangrove forest denudation along the northern boundary of the Sundarbans

### PL Collection

PL of Golda & Bagda collection is another detrimental for the fisheries. During the PL collection a huge number of spawn & PL of the other fish species are caught and destroyed. The major gear for PL collection is *net jal* (set bag net). The other gear is pull and push net is also used in small quantity. In the eastern part of Sundarbans, the major rivers of PL collection are Baleswar, Shela, Dudmukhi, Bhola and Pasur River. The bagda PL collection season is Pous – Chaitra (mid December – mid April) and for Golda PL Chaitra – Sraban (mid March – mid August).

### Zatka Fishing

This fishing takes out huge number of juvenile Ilish limiting their growth opportunity to adult. Thus the production rate of hilsa reduces very highly.

## Use of illegal and destructive nets (Behundi jal)

This set bag net catches eggs, spawn and larvae of all species along with adult fish. It is highly detrimental in fisheries decline. The set bag net is used both in the estuary and in the rivers of Sundarbans.

## Impact of using Gill nets

Fishermen of Sundarbans have started indiscriminate commercial exploitation of shrimps of all sizes by modern pvc gill nets, instead of traditional cotton nets, for its changeable mesh size, non-biodegradability, more hardness, endurance and invisible sea water color. But it is allowing increasing number of by-catch and immature catch by fishermen of Sundarbans. This vulnerable exploitation leads to an undesirable imbalance in the aquatic food chain of Sundarbans, ensuring future crisis of fish which is also supported by experts concerned.

## Acidification of soil

In general, large areas of mangrove forests have been reclaimed for agriculture/aquaculture production and human settlements in many parts of Asia. However, the experience in the case of forests, which have been reclaimed for agriculture and aquaculture, has been far from satisfactory. In the case of agriculture, particularly paddy crop production, the level of production has been low from the beginning, and often after a few years the level of production reaches such a low level that it was not economically viable to continue the practice. The experience in the case of shrimp farming has been similar. The production of shrimps continues to decrease until within a span of 3-6 years the yield reaches such a low level that the endeavor does not remain economically viable.

Mangrove soils developed from sea water sediments contain high sulphides which occur in the form of iron sulphide (FeS) and pyrites ($FeS_2$). A high amount of sulphidic material in the soil can be obtained if sulphate from the sea water is reduced by microorganisms which depend on organic matter in the soil for their energy.

## Freshwater supply

Mangrove species can thrive well in conditions where there is a steady infusion of freshwater any reduction in the supply of freshwater results in an increase in salinity, thereby restricting the growth of mangrove species. Shifting of the course of a river, siltation or complete drying of rivers can result in reduction or complete stoppage of freshwater supply to the mangroves, causing serious changes in the conditions for growth of different species. The shifting of the

main course of the river Ganges eastward over the past few centuries and the silting up of some smaller rivers feeding freshwater to western Sundarbans have caused a major reduction in freshwater supply to the western portion of the Sundarbans, and this has not only influenced change in the composition of the vegetation but has also.

## Siltation and rising of riverbeds and forest floor

The Sundarbans is now victim of excessive sedimentation. The siltation of riverbeds by waterborne particles often decreases the water-carrying capacities of rivers, causing a lesser supply of freshwater in lower riparian areas. The natural process of deposition of silt on forest floors results in a rise of the forest floor. Thus at one stage, the forest floor may rise above all or most high tide levels. In the absence of flushing of the forest floor by tidal water, the habitat conditions change and new species may start establishing themselves.

The siltation rate increases when water carries more silt from denuded catchment areas of other disturbed areas, including mangroves areas which have been converted to shrimp ponds, agricultural land or areas which have been mined. Through a process of natural development of sites and siltation of forest floor over a long period of time, some sites attain heights which are above high tide level. In such cases, soil undergoes gradual changes and non-mangrove species colonize such sites.

## Impact of Increased Trawling

Modern bull trawlers with 120 horse power engines are dragging bigger trawl net through ocean-bottom to chase tiger prawns leading to destruction of on-bottom habitat of prawn, other shell fishes, marine algae, seaweeds and plankton .This causes gradual narrowing of the baseline of aqua-mangrove food chain. This is likely to have contributed to the recent crisis of prawn seedlings and absence of some sea conch in coastal Sundarbans .The degree of intensification of trawling in coastal Sundarbans may also have an impact on the aqua-mangrove ecosystem.

## Fishing with poisons

Unauthorized fishing technique in the Sundarbans for fish and low-tide shellfish fishing as well as for catching fish trapped in inter-tidal canals. A variety of agro-chemicals found will stun fish when it passes through the gills or in some cases ingested. The fish then floats to the surface for easy capture. Sometimes, small canals would be partly blocked to slow down the water flow. Gathering the fish was usually done by hand, but baskets, spears and nets were

sometimes employed. The fisher reported two major types of poison for two specific target groups of white fish and shrimp. The poisons are those which are used in agriculture as insecticides and mainly three in number. Locally known names are *Sembush*, ripcord and *dhalai*. The first two are for shrimp and *dhalai* is for white fish. There are other two poisons Cythrine and Carette (New Forum Bangladesh, 2009). The poisons are liquid and marketed in bottles usually and are from India.

## Pollution in Coastal Water

Frequent oil leakage and regular washing of increasing numbers of petrol-operated trawlers and vessels is causing water pollution near local sand heads. It is suspected by local fishermen as an important factor for recent lack of fish gathering on those fishing spots. As a case study, according to local fishermen no fish gathering is found nowadays surrounding the sand heads near Diamond Harbour and population of Hilsa that enters inshore from deep sea has also been reduced greatly at Diamond Harbour, once famous site for Hilsa.

## Estuarine Water Pollution

Rapid pace of industrialization and urbanization in the lower Bhagirathi-Hoogly basin is specially polluting Hooghly-Matla estuarine mouth including Sundarbans by : a) Urban Domestic waste : 1,125 million liters of waste water is discharged per day through Hooghly estuary as per UNEP report and lower stretches receive sewage and 6 3 3waste load of 396x10 m /h with annual runoff of 493 km (Sinha,1998), b) Industrial waste from textile mills, chemical plants, pharmaceutical, plastic, detergent, jute, tire factories, etc. of Hooghly Industrial Belt is highly polluting estuarine and coastal water in Sundarbans (Sinha,1998), c)Agricultural waste containing residues of pesticides and insecticides

## Intensive Shrimp Monoculture & Coastal Aqua-culture

Intensive shrimp monoculture into berries discharging toxic waste water is likely to encourage flocks of fish away not to concentrate near the coastal Sundarbans. Moreover, Fresh Water Aquaculture or ‘fish cum paddy cultivation’ is purposively causing death to some ecologically valuable species of small indigenous fish, locally named as Vada, Khalisa, Mourala, Nados, Chanda, Khaira, etc. which are quickly becoming endangered in the vicinity of coastal Sundarbans.

### Shrinking tiger prawn population

The natural abundance of tiger shrimp seeds is fast reaching the threshold limit. It is fast dwindling away from the natural waters of Sundarbans. The reason is too much over fishing at various stages of its life cycle. As its post larval stage in estuaries, it is trapped by fine push and drag nets and fine meshed bag nets (meen jal); the juveniles are trapped by bag nets (behundi jal) in estuaries; the juveniles and pre adults are caught in marine waters by large bag nets; the pre adults and adults by trammel nets. Even the spawns are not spared and are caught from the open seas by trawl nets.

### Indiscriminate seed collection

Collection of seeds of *Panaeus monodon* is one of the main sources of earning for the small and landless fisher man and women of this area. During collection of economic prawn seeds, the rural people segregate the *Panaeus monodon* seeds and destroy other 90 to 95 % of fish and prawn seeds, which is leading towards the destruction of large number of estuarine species.

A man-made catastrophe that destroys major parts of a fish community (species) will have importance relative to the fact that a large part of the human population of an area has had its protein source eliminated or reduced. These problems calls for immediate steps to bring back a balance between the quantities of seeds produced in the nature and the quantity harvested of *Panaeus monodon*. Proper precautions are taken up to save ecological balance by keeping the prawn seed collectors informed about harm and danger created by their selective grading of prawn and fish seed collection.

## Summary

Sundarbans is an extremely important natural resource from view point of envronment, ecology, economy, sociology and nutrition etc. This is the habitat of a large group of fauna and frora; an important breeding and nursery ground of a vivid group of fish and aquatic species. It protect the human habitation from sea cyclones and tidal surges. The forest is being rapidly degrading due to ill-management of the resources. Lack of freshwater flow by the rivers, siltation, current practices of destructive fishing, shrimp PL collection etc. is the primary causes of depletion of the resources

# 6. Potential use and fisheries management practices

The Sundarbans is the world's largest remaining contiguous, biodiversity-rich mangrove ecosystem featuring habitats for fish, shrimp, and other wildlife. The forest also has immense protective and productive functions. Besides production functions of the Sundarbans, it provides natural protection to life and properties of the coastal population in cyclone prone Bangladesh. The Sundarbans is most likely to be changed directly or indirectly by human activities and a priority question in conservation planning is what to expect from the Sundarbans in the future. It is very difficult or almost impossible to rehabilitate a mangrove fishery to its original state once it is destroyed severely or completely. This is because the changes that the ecosystem undergoes and the conditions under which the natural fishing ground flourish are hardly likely to restore. However, like some other countries, some efforts and strategies have been made in Bangladesh to protect the Sundarbans, the most important area left for the long-term survival of many forms of wildlife because the area is large enough to support a large effective population size. The Sundarbans has a distinct forest management history. The area was mapped as early as 1764, soon after proprietary rights were obtained by the East India Company in 1757. The first Forest Management Division with jurisdiction over the Sundarbans was established in 1869 and the first management plan was introduced in 1892. Conservation of the Sundarbans mangrove is supposed to have started with its declaration as a reserve forest, under the Forest Act in 1878. In 1977, Bangladesh created three wildlife sanctuaries: the Sundarbans West (71,502 ha), Sundarbans East (31,226 ha); and Sundarbans South (36,970 ha), protecting about 23.5 % of the remaining Sundarbans under the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974. These sanctuaries (IUCN, 1997) lay on disjunctive deltaic islands in the Sundarbans Forest Division of Khulna District, close to the border with India and just west of the main outflow of the Ganges, Brahmaputra and Meghna rivers. In 1987, the Sundarbans National Park in India, and in 1997, parts of the Sundarbans in Bangladesh, was inscribed on the World Heritage list (IUCN, 1997) and thereafter it receives more attention. In view to maintain the ecological balance and to develop the resource for sustainable utilization, the Government of Bangladesh has formulated and established different management policies and action plans. At the same time, various non-government organizations (NGOs) and private organizations have engaged themselves in research, management and development processes. The

Government also provides institutional, infrastructural and legal support to encourage participation of such organizations. Moreover, International organizations such as CIDA, AIDAB, USAID, JSPS, UNDP, UNESCO, FAO, ADB, and World Bank have sponsored research programs on mangrove ecosystems and various development activities. Besides, many experts, however, are hoping that the Sundarbanss Biodiversity Conservation Project (1998) would help to reverse the negative trends at the Sundarbans in a great extent. At present, trials with all the commercially important plant species are being carried out with the objectives of accelerating the process of siltation and stabilization of soil, creating forest shelterbelts to protect life and property of inland from tidal bores, creating an urgently needed resource to add to the national wealth, creating job opportunities for the rural communities, and creating an environment for wildlife, fishes and other estuarine and marine fauna. The Forestry Master Plan (1993) suggested two scenarios. The first one proposed an annual planting target of about 18000 ha during 1993–2002 and 21000 ha during 2003–2012. However, use of quality planting material, site preparation and post-establishment maintenance has not been given adequate attention. Due to budgetary and legal constraints adequate protection of plantations from fire, grazing, illegal removal and encroachment has not been provided. The second scenario emphasizes on the development of wildlife sanctuaries although these three sanctuaries are not sufficient to provide long-term protection to the wildlife of the forest. Current management objectives as per the Master Plan aim at enhancing environmental preservation and conservation; introducing rational forest land use; increasing public participation and benefits from resource management; expanding the resource base; improving management practices; and undertaking efficient resource allocation; and forest management plans. In recognition of the importance to manage the forest resources in the Sundarbanss Reserve Forest (SRF) on a sustainable basis, the Forest Department imposed a logging moratorium in 1989 on all timber species except Gewa. The primary goal of the Aquatic Resource Program is to put into place an effective management system for the aquatic biodiversity (fishes, crustaceans and molluscs) of the Sundarbans, which will both protect vulnerable species and allow sustainable harvesting of fish resources over the long term.

## 6.1 Main components of Fisheries Management System (FMS) for Sundarbans

The FMS consists of the following main features and activities

- **Objectives and policy formulation:** Establishment of the main management objectives and supporting policies for Sundarbans fisheries.
- **Planning:** Drafting of fisheries Management Action Plan for each fishery.
- **Monitoring:** Collection of field and other data on fisheries environment, fish stocks and biodiversity, fishing effort, fish catches and fish markets.
- **Control:** Drafting and enacting of fishing rules and regulations concerned with closures, fishing gears, fishing effort, fish biology, fish catch and access limits.
- **Surveillance:** Detection of illegal and unlicensed foreign and domestic intruders into the Sundarbans Reserve Forest (SRF) and 20 km Marine Zone (MZ), and enforcement of rules and regulations.
- **Prosecution:** Litigation of cases in court against offenders breaking fishing rules and regulations.
- **Sustainability Evaluation:** Assessment of effectiveness of FMS using monitoring data.
- **Record Keeping and Reporting:** Archiving of data and reporting of results of activities and achievements of FMS to fishermen associations, government and other interest groups.
- **Consultation and Review:** Participation of fishermen and other interest groups in various components of the FMS, especially in setting objectives and policies, and review and comment on results of management initiative.

## 6.2 Traditional approaches for fisheries management

### Gear restrictions

Several management practices introducing gear restrictions and/or banning were practiced for the development of the coastal fisheries of Bangladesh. To reduce the impacts of Estuarine Set Bag Net (ESBN) fishery, a 30 mm cod-end mesh size was introduced for ESBN on the

assumption that the juveniles would escape. However, increased mesh size virtually resulted in no catch because this gear targeted mainly the juveniles (Hansen and Mustafa, 1992). Therefore, complete withdrawal of this gear from the estuarine environment was suggested (Khan and Latif, 1997). However, this option could not answer the question of how rehabilitation of about 50,000 ESBN fisherfolk would be made. Gradual reduction of fishing effort by ESBN fishery and, as a first step, closure of fishing during the peak recruitment periods, i.e. July to September and February to April in selected areas was suggested to reduce the juvenile mortality (Khan *et al*., 1994). Banning of particular fishing gears which involve few people but target big mass of fish might be useful option for management of particular fish stocks was also suggested (Islam, 2003).

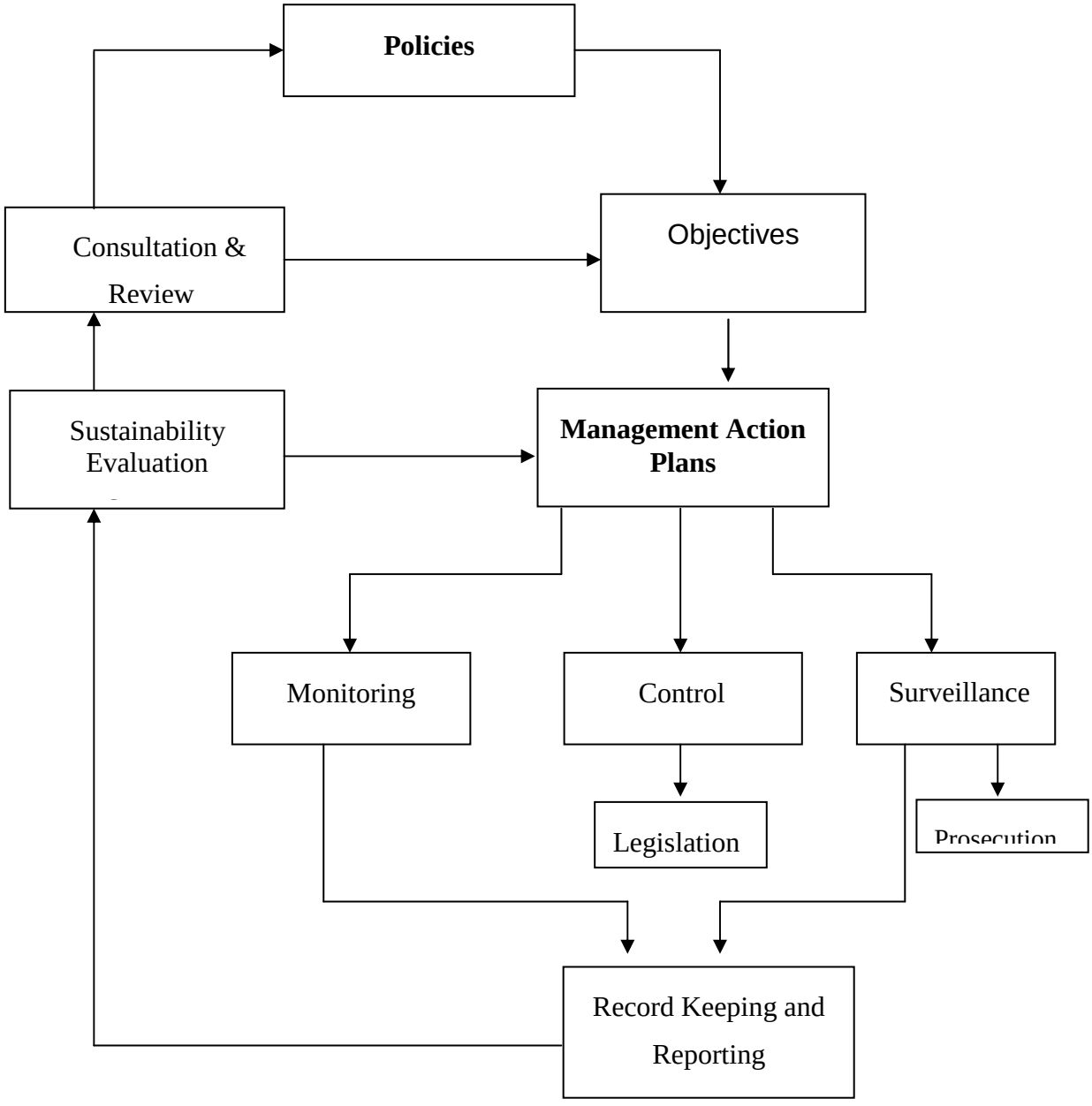


**Figure 3: Main Features of Fisheries Management System for the Sundarbans**

## Protected areas or reserves

Protected areas (also known as reserves, no-take areas, or sanctuaries are the areas where no fishing is allowed) have been an increasingly useful fisheries management tool in the face of disappointments with the standard management practices. Although it is argued that the fishery benefits remain of protected areas remain controversial, many authors have suggested that there have been some degree of success depending upon the regions and the type of fisheries. Roberts *et al.* (2001) showed that marine reserves in Florida and St. Lucia have enhanced adjacent fisheries.

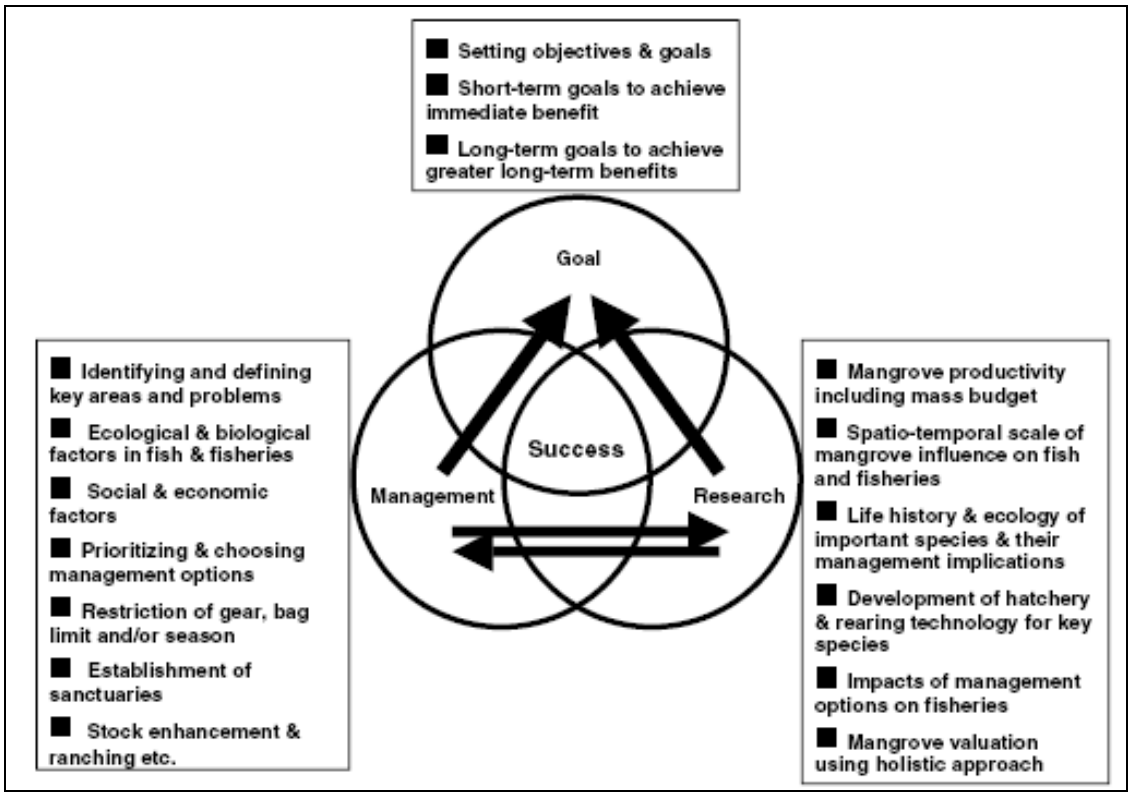


**Figure 4: Restructuring the past: factors affecting the success of management plan of mangrove ecosystem; the intertwined relations indicate that a successful management plan must be goal-oriented and guided by strong field research**

Within 5 years of creation, a network of five small reserves in St. Lucia increased adjacent catches of artisanal fishers by 46–90%, depending on the type of gear the fishers used. However, significant scientific questions remain regarding their design and ways of monitoring to measure their cost effectiveness and benefits. No report is so far available as to the practice of protected areas in the mangrove fisheries of Bangladesh. Although 'protected areas' is considered a powerful tool for offshore and marine fisheries management, it may not

produce expected result in mangrove fisheries management because spawners of most of the mangrove fisheries are dependent on the deep sea; however, for the same reason, protected areas in the mangroves can enhance the offshore fisheries.

### Integrated management

Past history indicates that Sundarbans Reserved Forests was created mainly for sustained production of timber, fuel wood, fish and other minor produces, along with maintaining a healthy habitat for game animals. The objectives however, now days have changed because of growing human pressure for wide variety of resources, ranging now from crabs and shrimp fry to multinational tourism. On the other hand during the present days of highly developed technologies, there are computerized systems, remote sensing growth and yield modeling for the management and harvesting the resources.

## 6.3 Potential management approaches

Considering the limitations of the traditional management tools, a number of management tools have been proposed that have proven performance in restructuring the depleted fisheries as well as in resolving the common problems with traditional fisheries management tools in many parts of the world. One of the most important advantages of these management tools is that they are highly effective in resolving the problem associated with community participation as well as the debate between the 'top-down' and 'bottom-up' approaches for fisheries management. Two such management tools include habitat improvement and restoration and stock enhancement.

### Habitat improvement and restoration

Habitat restoration tools (also referred to as habitat addition or augmentation) are also widely applied. Typically, these refer to the increase in available habitat and/or access to key habitat for at least some stages of a target species' life (e.g., Ahmad et al., 1998; FAO, 1999). Such an approach may range from increased connectivity between an estuary and adjacent ocean to the installation of artificial habitats and fish ladders. Although artificial habitats are popular and widely used, evaluation of the effectiveness of habitat restoration, especially in the marine environment, is generally lacking. Habitat restoration in the mangroves of Bangladesh was started in 1966, through the implementation of afforestation with artificially planted mangroves and, until 1990, and an area of 0.12 million hectares had been brought under plantations which have substantially increased the total area of mangrove (Islam and Wahab,

2004). Afforestation with mangrove species have been standardized and are implemented with varying degrees of success in sites which have not been too badly degraded (Siddiqi *et al*., 1993). However, afforestation did not aim as a fisheries management tool and no strategic information is available on the changes in the total fishery catch in the mangrove resulting from new habitat development. Generally, it is perceived that complete restoration of a degraded habitat to its original state through artificially planted mangrove is difficult to achieve and is a long process. Moreover, the newly developed habitat may not be equally capable of restoring and supporting fisheries as it was before; the success of restoring a fishery will depend on the degree of degradation occurred due to habitat degradation. However, these effects are subject to change with region, the habitat type, the fishery as well as many other factors and offer a potential area of research in the future.

## Stock enhancement in mangrove habitat

A final group of management tools are termed stock enhancement. Stock enhancement refers to hatchery production of fishes to a certain size prior to release into the wild fishery. Stock enhancement has a long history of over 100 years (e.g., Homarus spp. since 1850s; Bannister and Addison, 1998; Oncorhynchus keta in Japan since 1876; Kitada, 1999; Gadus morhua in Norway since 1884; Svasand, 1998; O. mykiss and Salmo trutta in Western Australia since the late 1800s; Molony, 2001) and has been widely popular due to its perceived simplicity (Travis et al., 1998). That is, by producing and stocking fish, catch rates and fishing success will be maintained or increased (Welcomme and Bartley, 1998). Stock enhancement is commonly perceived as being the ultimate and immediate solution to declining fishing quality, often preferable to unpopular changes in traditional management (Grimes, 1998; Borg, 2004). This view is perpetuated by the existence of production technologies able to produce large numbers of many Species of fishes (Hilborn, 1998; Fielder *et al*., 1999; Arnason, 2001; Costa-Pierce and Bridger, 2002). Without providing stakeholders with additional information, stock enhancement will continue to be seen as the simplest solution to maintaining and/or enhancing fish abundance, and thereby fishing quality. As a consequence, pressure to apply stock enhancement continues to grow. With current shifts in fisheries management towards a broader ecosystem approach (Link *et al*., 2002; Stergiou, 2002), it is now appropriate to consider stock enhancement in a similar context. Because stock enhancement is likely to remain topical worldwide, aquacultural science and hatchery technology will remain central to any successful stock enhancement project. The role of aquaculture in stock enhancement should be to apply the best production and husbandry

practices (e.g., effective breeding numbers, husbandry, nutrition, behavioral training, etc.; Masuda and Tsukamoto, 1998; Brown and Day, 2002) to the production of the most competent, high-quality fishes from endemic stock (Cross, 1999; Burke, *et al*., 2000) in the appropriate numbers and life stages. To allow stock-enhancement to achieve its full potential as a fisheries management tool, an objective scientific approach is required. Such an approach must be transparent to all stakeholders involved at all levels in the management of fisheries. Stock enhancement must be considered in conjunction with and parallel to other fishery management tools, and not in isolation (Molony *et al.*, 2004). In this way, the best outcomes for a stock/fishery and ecosystem management are more likely to result, and will benefit all stakeholders and increase the likelihood of long-term sustainability of the fishery (Wiley, 1999) and the ecosystem.

## 6.4 Sundarbans fisheries management policies of Aquatic Resource Division (ARD)

General objectives and supportive policies were established for the Sundarbans fishery as a whole by the ARD in consultation with user and interest groups. The general objectives and policies were to be reviewed and approved by the FD, before implementation by ARD. Specific objectives and policies were set for individual fish stocks and fisheries. These are designed to take into account the biology of the stock, nature of the fishery for the stock, other activities impacting the stock, and economic and social contributions of the fishery at local and national levels. According to ARD routine and special studies should be carried out in order to provide relevant data and information to allow formulation of the best possible objectives and policies for each fishery. Consultations should be held with fishermen and fishermen and other interest groups (fish traders, fish exporters, fish consumers, and institutions, government) in order to gain agreement on objectives and policies for each fishery.

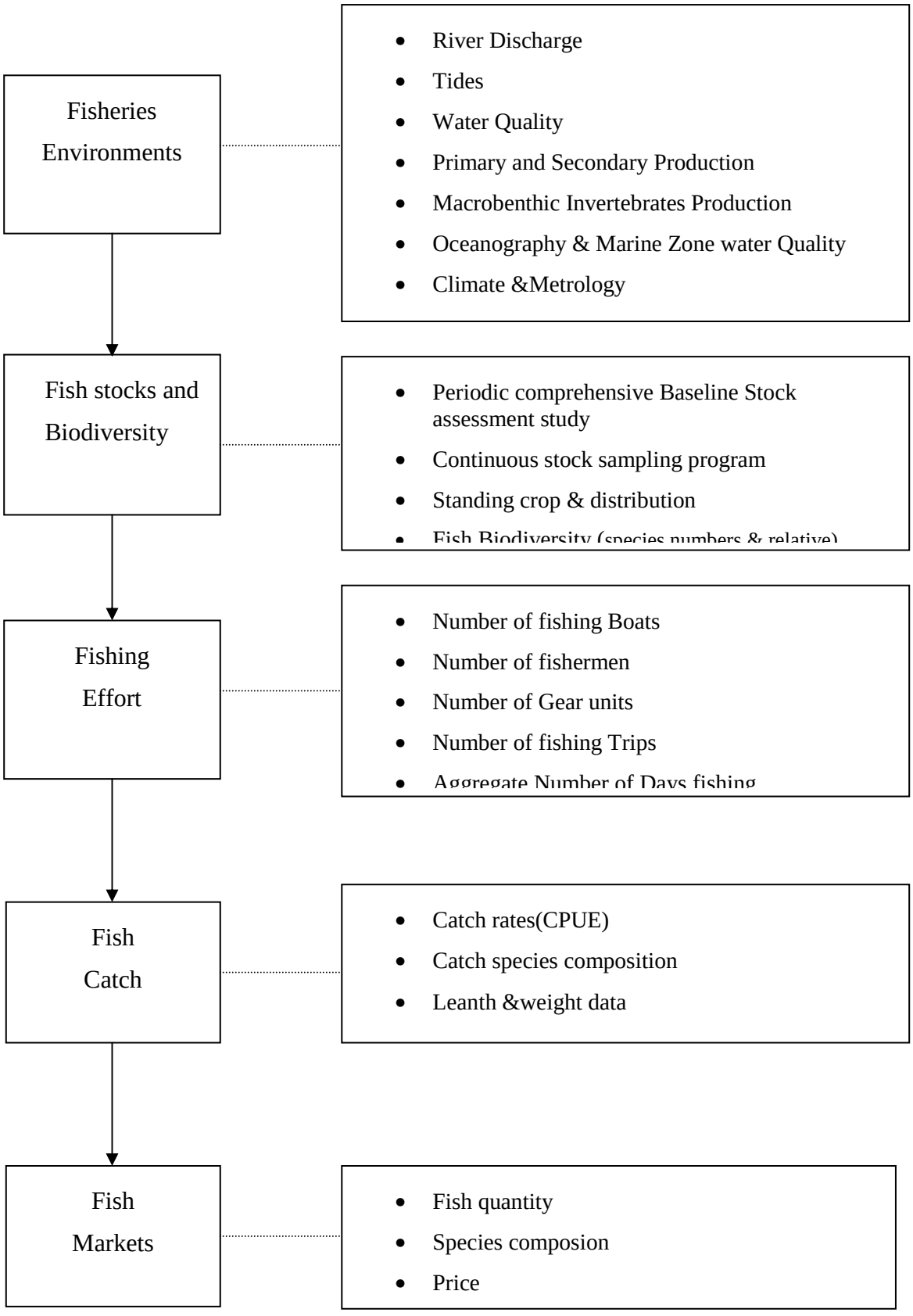


**Figure 5: Monitoring activates of Fisheries Management System**

## 6.5 Overall objectives and policies for Sundarbans fisheries management

There are five main objectives for Sundarbans fisheries as a whole:

1. To ensure that all individual fisheries and the fish processing activities that they support operate at a high level of productivity and are sustainable over the long term, so that the risk of collapse of the fisheries is reduced to a minimum.
2. To ensure the survival and continuing existence of all fish species and other aquatic biodiversity as healthy viable populations, and the protection and rehabilitation of stocks of threatened fish species.
3. To ensure the long-term health, integrity and viability of the mangrove forest and coastal marine ecosystems on which the fish resources are dependent.
4. To ensure that the fisheries workforce is able to earn a viable livelihood from fishing activity and achieve an adequate level of well being which allows the fishing communities to rise above the level of poverty.
5. To ensure that the mangrove forest and coastal marine ecosystems continue to provide benefits for other uses and users, including terrestrial biodiversity and wildlife, forest resources, scientific studies, intrinsic value, tropic networks, ecotourism and recreation, and that activities carried out by the fisheries sector do not undermine or harm these ecosystems values and uses.

To achieve these objectives, the ARD has adopted the following nine global policies for all Sundarbans fisheries:

1. It is the policy of the ARD to prohibit the use of any fishing gears, methods or practices which endanger the fish stocks in any way, and cause mortality to spawn, hatchlings, larvae, fry, fingerlings or juveniles.
2. It is the policy of the ARD to prohibit the capture of threatened fish species.
3. It is the policy of the ARD to prohibit the capture of any fish species whose stocks are depleted and in need of rehabilitation.

4. It is the policy of the ARD to prohibit the capture of very large individuals of threatened, rare or depleted species, such as ifisha hangar, hammerhead shark, freshwater Gangetic stingray, sawfish, large female bhetki broodfish and large pangas.

5. It is the policy of ARD to require fishermen to release back into the water (whether dead' or alive) all prohibited fish or wildlife caught accidentally or unintentionally.

6. It is the policy of the ARD to prohibit the use of any fishing gears, methods or practices which endanger the life of aquatic or terrestrial wildlife, or any other biodiversity, or harm the mangrove trees, bushes and plants.

7. It is the policy of the ARD to control the number of fishermen, fishing boats, fishing gears; time spent fishing in the forest and locations where fishing is permitted in the forest so that the fishing pressure will not become excessive and threaten either the livelihood or welfare of the fishermen or the fish resources.

8. It is the policy of the ARD to assist fishermen to form professional associations which will work for the welfare of the fishermen and fishing communities, and actively participate in fisheries management programs in cooperation with the ARD.

9. It is the policy of the ARD to promote the use of modern fish handling, processing and marketing methods to ensure that a high level of value is added to the catch from the Sundarbans, so as to increase incomes for fishermen, improve the supply of high quality fish on domestic fish markets, and increase earnings from fish exports.

## Summary

The Sundarbans fisheries resource is not only great resource for Bangladesh but it is a world heritage as well. It provides livelihoods to a huge group of people. It is important from view point of ecology, environment, economics, nutrition, sociology and culture of a big group of people in the periphery of the forest. The resource is a very diverse one; it is an important breeding and nursery ground of a vivid groups of estuarine, offshore and marine fishes. The resource is being degraded due to lack of proper management of the resource. The resource is being harvested on annual revenue earning basis and there is no guarantee that it is harvested optimally; the management has to be replaced fore fronted with biological resource management concept and exploitation has to be at optimal level keeping rooms for regeneration.

# 7. Rules and regulations for Sundarbans Fisheries Management and effectiveness of the current management practices

## 7.1 Regulations on Sundarbans fishery

The management aspect of fisheries in Sundarbans Reserve Forest (SRF) only covers revenue collection, although some Acts/Regulations exist. The management of fisheries resources in SRF from technical point of view was started in 1989 with the closing of 18 canals to accelerate fish breeding. Closed season and wildlife sanctuary regulations were introduced recently. Management measures are not effectively used include control on gear dimension, limit on fishing time, control on fish catch and access limitation. The control regime of SRF implemented under Sundarbans Biodiversity Conservation Project (SBCP) fisheries management systems are outlined in. Proposed new management regulations for the 17 fisheries of the Sundarbans are summarized below:

- *Pangasius pangasius* and *Lates calcarifer* harvest should be completely banned for 5 years.
- Fishing of *T. ilisha* is to be closed from November to April, that of mud crab from December to February, *M. rosenbergii, Plotosus spp.* And *Mugil cephalus* in May/June.
- Minimum size limits should be 23 cm for *T. ilisha*, 10 cm carapace width for male mud crab and 10 cm head length for male *M. rosenbergii*.
- It should be illegal to catch or be in possession of female mud crab, female *M. rosenbergii* and live giant oysters.
- All gears operated by fixed engine boats should be permanently prohibited. Gears having very small mesh netting which catch larvae of fish and shrimps should be permanently prohibited.
- *L. calcarifer* fishing is restricted to the marine zone, sport fishing is restricted to the wildlife sanctuaries, long lining for white fish is restricted to Satkhira Range and giant

oyster collection is locally restricted by certain revenue collection forest stations. Turtle exclusion devices are mandatory for set bag nets.

**Table 12: Existing and proposed fisheries management and conservation rules in SRF**

| Legislation | Summary of regulations | Implementing agencies |
|---|---|---|
| Indian Forest Act, 1878 | • Empowers the Forest Department to manage the inshore and offshore fisheries in the Sundarbans and near shore 20 km marine waters | Forest Department |
| Hunting and Fishing Rules, 1959 | • A fishing permit is required to fish in reserved or protected forests<br>• Royalty may be levied on fish caught in tidal waters of reserved and protected forests<br>• It is illegal to use poison, explosives or fixed engine fishing gears, or to dam or bale water in reserve and protected forests | Forest Department |
| Major Fisheries Regulations for SRF | • *Khal Closure Regulation (1989)*: closes 18 *khals* permanently for fishing to ensure natural fish breeding<br>• *Collection & Export of Live Crab Regulation (1995)*: closes the entire SRF for crab fishing from December to February to ensure crab breeding<br>• *Closed Season Regulation (2000)*: closes fishing in the entire SRF for five species (*P. pangasius, P. canius, L. calcarifer, M. rosenbergii, S. serrata*) during 1st May to 30th June to ensure natural breeding | Forest Department |
| Wildlife Sanctuary Regulations, 1999 | • Fishing is permanently prohibited in the three wildlife sanctuaries of SRF | Forest Department |
| Other Regulations for Fisheries in SRF | • It is illegal to place nets across a *khal* and thereby completely block it<br>• It is illegal to sting a rope transversely across a *khal* | Forest Department |
| *Proposed regulations*<br>Proposed by FAO through its project (BGD/84/056) in 1994 | • Introduction of closed season<br>• Introduction of protected zones i.e fish sanctuaries | Some of the FAO proposal have been |

| Legislation | Summary of regulations | Implementing agencies |
|---|---|---|
| | • Introduction of minimum size limit of two species—30 cm for *L. calcarifer* and 10 cm for *J. argentatus*<br>• Restriction on number of gillnets<br>• Maintenance of exploitation rates for commercial species at current levels except *P. monodon* fry<br>• Coordination of regulatory powers of Forest Department and Department of Fisheries for life-cycle management of migratory fish stocks i.e. *T. ilisha* and *L. calcarifer* | implemented by Forest Department |
| Proposed by World Bank through its project in 1998 | • Closure of small *khals* (less than 30 m wide) for 12 months within 5 km radius of Forest Stations in SRF, in alternating years<br>• Permanent closure for wildlife sanctuaries and any other protected areas<br>• Maintenance of records of permits issued and catch for individual fishermen<br>• Maintenance of annual harvest limit for various species, initially *T. ilisha*, all catfishes and mud crab<br>• Issuance of catch quota to individual fishermen based on a share of the total allowable catch (TAC)<br>• Restriction of shrimp fry catch to boundary rivers only<br>• Release of small fishes back to the water caught in shrimp fry collection nets<br>• Prohibition on harvesting of brood crabs or female crabs with egg<br>• Maintenance of minimum harvesting weight of 200 g for male and 120 g for female crabs<br>• Enforcement of National Fish Act to maintain minimum harvesting size limits and closed seasons<br>• Penalties are specified for fishing without a permit, fishing in restricted areas, using poison, explosives or banned materials, catching undersized fish during prohibited months or continuing fishing after having reached the individual allocated quota | Some of the regulations have been implemented and implementation of others are questionable |

## Closures

A closure is a very suitable management measure for a small-scale fishery because it is easy to design and publicize to fishermen, its purpose and goal is usually clear, intuitive and easy to understand, it is equitable and universal, and it is relatively simple to enforce (if the resources are available).

A major category of management measures is the closure. These can be for:

- Species: A prohibition on catching a particular species (i.e. the endangered species pangas).
- Areas: A prohibition on fishing in a particular area of the forest (i.e. khal, fish sanctuary, forest management range), or a restricted area where fishing is permitted (opposite of a closed area).
- Time periods: A prohibition on fishing during certain months of the year, or a rohibition on fishing for one or more years, or a permanent prohibition.

Several fisheries closures exist at present for the SRF. These are summarized in Table 13.

**Table 13: Some Existing Fisheries Closures and Rules in the Sundarbans (ARD, 2002)**

| Principal Agency | Legislation | Summary of Regulations |
|---|---|---|
| FD | Indian Forest Act of 1878 | Declares the Sundarbans a reserved forest.<br><br>Empowers the FD to manage the inshore and offshore fisheries in the Sundarbans and 20 km marine zone. |
| FD | Hunting, Shooting and Fishing Rules of 1959 | It is illegal to use poison, explosives or fixed engine fishing gears, or to dam or bale water in reserved and protected forests.<br><br>A fishing permit is required to fish in reserved or protected forests.<br><br>Royalty may be levied on fish caught in tidal waters of reserved and protected forests. |

| | | |
|---|---|---|
| FD | Three main FD fisheries regulations specific to the SRF | Khal Closure Regulation (1989): This regulation closes 18 khals permanently for fishing to allow fish breeding.<br><br>Collection and Export of Live Crab Regulation (1995): This regulation closes the entire SRF for crab fishing from December to February to allow breeding of crabs.<br><br>Closed Season Regulation (2000): This regulation closes fishing in the entire SRF for five species (pangas, k-horul, khaon magur, golda chingri and kakra) during the period 1 May to 30 June to allow breeding. |
| FD | Wildlife Sanctuary Regulation | Fishing is permanently prohibited since 1999 in the three wildlife sanctuaries. |
| FD | Other FD regulations applying to fisheries | It is illegal to place a net across a khal and thereby completely block it.<br><br>It is illegal to string a rope transversely across a water way. |
| DOF | Protection and Conservation of Fish Act of 1950 (and subsequent update amendments, ordinances and rules) | Minimum size limits and closed seasons for ilish and pangas. Thus ilish and pangas below 23 cm are illegal to catch during the closed seasons (November to April). |
| DOF | Marine Fisheries Ordinance of 1983 | Prohibits the use of poisons, explosives and other noxious substances for fishing.<br><br>Prohibits the use of small mesh nets. |

## Controls on fishing gears

A second major category of management measures is fishing gear restrictions. This can include destructive gears and method, mesh size, gear dimensions, mandatory by-catch reducers and turtle excluders

## Controls on fishing effort

Two main types of controls on fishing effort can be used:

- **Limit on the number of fishing permits issued:** This can be by fishing gear category, target species category, boat type category, revenue station or other parameter, or the grand total number of PTs issued for all categories combined.

- **Limit on the fishing time**: This can specify how much time a particular fishing boat/fisherman can spend fishing in the SRF (i.e. number of weeks per year), so that the aggregate total for the whole fishery does not exceed a certain desirable level.

Control of fishing effort is extremely important for reducing excessive fishing capacity and achieving sustainability. However, effort control has problems of allocation and implementation.

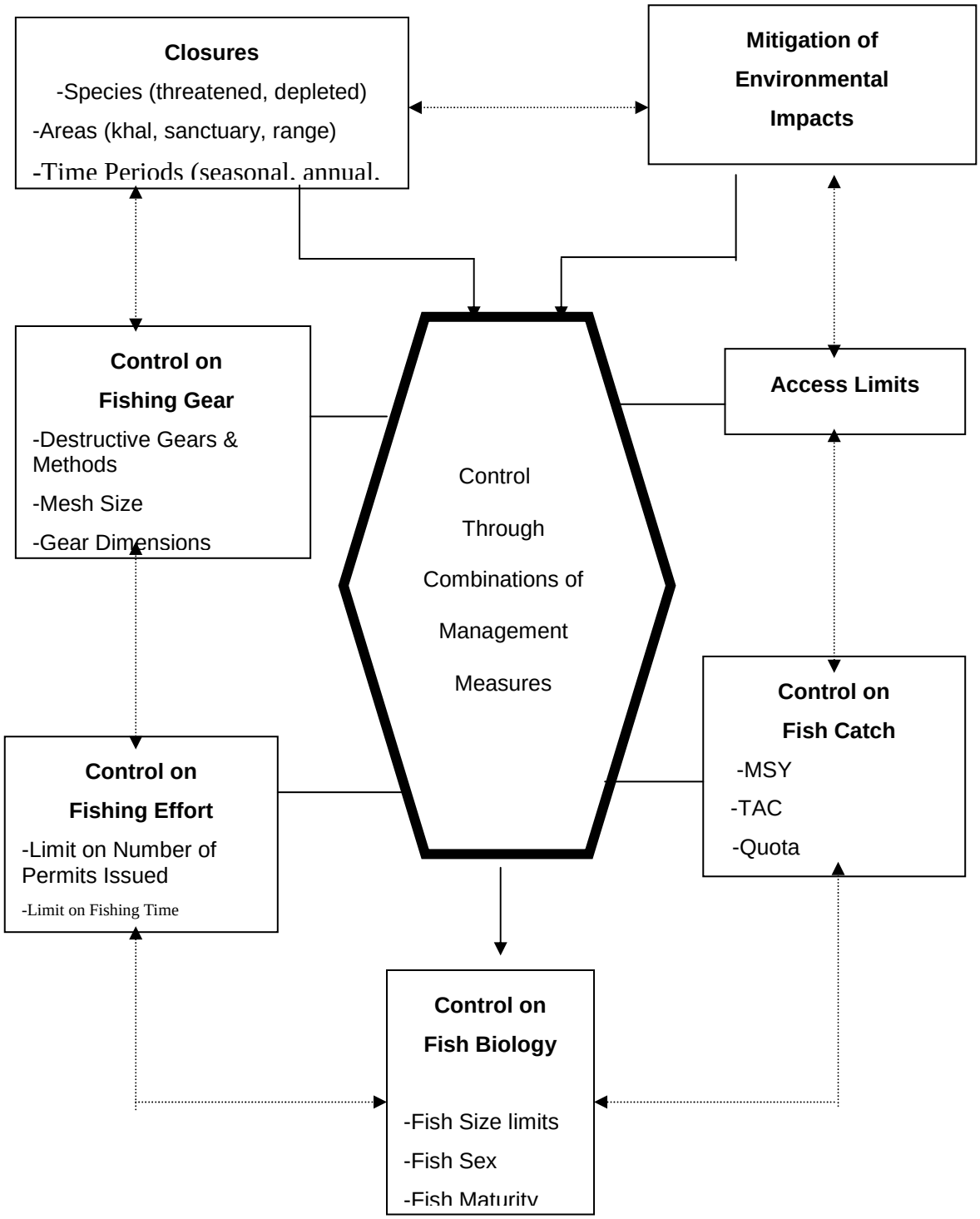


**Figure 6: Control Regime of Fisheries Management System (FMS)**

### Legislation

An important aspect of the FMS is the drafting, adoption and promulgation of appropriate and enforceable fisheries management rules and regulations for the various SRF fisheries. Existing fisheries laws, ordinances, rules, regulations, and notifications of the FD, DoF and other government agencies are compiled in FMS. Competent legal experts will carry out a legislation baseline review and analysis, and gaps and inconsistencies in the existing legislation will be identified. Once the individual Management Action Plans (MAPs) are finalized, appropriate enabling regulations will be drafted and progressed through the government approval process. The legislation will clearly define what constitutes an infraction. Penalties for each infraction will also be specified. One option which will be investigated is to issue all new enabling legislation as a comprehensive new rules and regulation for Fisheries of the Sundarbans. If a log book system is adapted to control fishing time, the rules and regulations could be printed in the log books.

## 7.2 Rules regarding the management and conservation of Sundarbans fishery

- FD is empowered to mange inshore and offshore fisheries in the SRF and 20km marine zone (Indian Forest Act, 1878).
- Poison, explosive or fixed engine fishing gear is illegal (hunting, shooting and Fishing Rules, 1959)
- 18 canals are under permanent fishing ban (Khal Closure regulation, 1989).
- No crab fishing in SRF from December to February (Collection and export of Live Crab Regulation, 1995).
- Fishing ban from 01 May to 30 June for five species of pangas, khorul, kaown magur, golda chngri and kakra (Closed season regulatio, 2000).
- Permanent fishing ban in three wildlife sanctuary (Wildlife sanctuary regulation).
- Placing net across a canal and complete blocking is illegal.
- Catching of Illish and Pangas below 23 cm is illegal during November-April (Fish Act, 1950).

- Use of poison, explosive and other noxious substance is prohibited (Marine Fisheries Ordinance, 1983).
- Small mesh net use is prohibited (Marine Fisheries Ordinance, 1983).

## Boat license certificates (BLCs), restricts fishing craft

- 914 BLCs issued for fishing in STR in early 1980s, active BLCs: 709
- BLC's non-transferable, only mutated in favour of blood relative
- Annual registration fees is paid based on the capacity of the boat
- Annual registration charge of BLC is (Rs. 15 to Rs.150) fixed according to the capacity of the boat
- Seasonal pass issued to BLC holders
- Amount Rs 40 per person per season, issued for period August to March annually
- Permits issued to BLC holders, for a period of 42 days, at the rate of Rs 5 per person per week
- Fines are charged for overstaying/ non-renewal of permit
- Closed fishing season from 1 April to 30 June every year
- Identity cards issued for STR fishers by Forest Department in 2008
- 555 cards issued to boat owners, and 2,119 cards to crew
- Covered by life insurance scheme

## BLCs (Boat License Certificate)

BLCs are issued for every year in July (at the beginning of the fiscal year) and are valid for one year. The pre-requirement for BLC is certificate and attested photograph from local union chairman. After having a BLC, fishermen have to pay annual fee for that BLC which is based on the "Maundage" of their boat. Maundage is calculated as follws:

$$M = LxWxHx0.356$$

Where, L=Boat Length

W=Maximum Boat Width (in feet)

H=Boat Height (in Feet)

One of the main issues highlighted by fishing communities is that the number of BLCs has remained fixed since 1980. Fishers point out that the process for distribution of BLCs was problematic in the first place. Fishers were required to register within a month of the notification. Many fishers, particularly those in remote villages, were unable to do so, and were thus not issued BLCs. The Forest Department, however, maintains that BLCs were issued to all those who had applied for them. Fishing communities also point out that though the population dependent on fishing has increased in the interim period, the number of BLCs has remained fixed—no new BLCs have been issued subsequently. At present, only 709 BLCs are active, leaving most of the other fishers without BLCs. Even though the Forest Department has recently estimated that the number of inactive BLCs is 104, no procedure has been initiated, as yet, to redistribute BLCs to active fishers. Informal arrangements exist within villages for active fishers who wish to fish, to lease BLCs from the owners, thus making the BLC a "leasable property". Fishers who cannot afford to pay the lease amount have little option but to fish illegally in the permitted areas, given that there are few other livelihood choices available for the fishers, this implies lengthy and complicated process.

## Permits

The mandatory procedure for renewing fishing permits (recorded as the amount paid for use of dry fuel during fishing trips) after 42 days is also problematic for fishers, as often fines are levied when renewal is not done on time. Fishers highlight that sometimes they do not wish, or are unable, to renew the permits after 42 days for various reasons—they may not be interested in continuing fishing over the next period; they may be engaged in some other livelihood activity; or they may lack accessibility to the Forest Range Office. However, these reasons are not regarded as valid by the authorities, and fishers are fined on the grounds that they have overstayed in the permit areas. The Forest Department says it is very difficult for their officers to keep track of the actual number of fishers if the licences are not renewed on time, and the fine amounts levied are reasonable.

**Table 14: Revenue collection practices in the Sundarbans (Divisional Forest Office, Sundarbans East, 2009)**

| Sl | Issue | Description | Rate (Tk.) | |
|---|---|---|---|---|
| | | | Registered vessel | Unregistered vessel |
| 1 | Entry Fee (per trip) | Helicopter/ Sea plane | 10,000 | 30,000 |
| | | Launch over 100 feet | 400 | 2500 |
| | | Launch over 50 feet and below 100 feet | 250 | 2000 |
| | | Launch below 50 feet | 150 | 1500 |
| | | Trawler | 100 | 800 |
| | | Country boat (with mother vessel) | 30 | 100 |
| | | Speed Boat (with mother vessel) | 50 | 300 |
| 2 | Staying Fee ( for one day sunrise-sunset | Launch | - | 300 |
| | | Trawler/Speed boat/country boat (staying not more than one day) | - | 200 |
| 3 | Travel Tax (per day stay) | Native | 50 | 50 |
| | | Foreign | 700 | 700 |
| | | Rash Mela/3 days, Native | 50 | 50 |
| | | Karamjol or equivalent spot/day/person | | |
| | | Native | - | 10 |
| | | Foreign | - | 200 |
| | | Student | 10 | 10 |
| | | Researcher | 30 | 30 |
| | | Foreign Researcher | 100 | 100 |
| | | Launce Crue | 0 | 50 |
| | | Tour Guide | 0 | 100 |
| 4 | Security Guide/guard | per day (minimu 2 #) | 150 | 150 |
| 5 | Telecommunication fee | Per trip | 200 | 200 |
| 6 | Video Camera rent | Native tourist/day | 100 | 100 |

| | | | | |
|---|---|---|---|---|
| | | foreign/day | 200 | 200 |
| 7 | Information center entry fee | person/entry | | 10 |

## 7.3 Conditions of visit in Sundarbans

- Carrying ammunition, killing of wild life, cutting of forest product and removal is prohibited.
- If ammunition is found cane seized lawful action can be taken unused wild life protection act 1973 (revised in 1974).
- Any illegal activities in reserve forest, action will be taken in accordance with law.
- Getting down into water into prohibited
- Travel prohibited in Badamtala area of Kotka.
- Playing loud speaker in the reserve forest and firing on land is prohibited.
- Launch is not allowd to land in jetties. Dingi boat is must with tourc launch.
- Environment polluting chemicals, food residue, food packet are not allowed to litter in open place is prohibited. Use of polythene bag is ban.

## 7.4 Tax, fines and offences

The Forest Department in the Sundarbans region reports violations under three categories—prosecution report/charge sheet cases (POR), compounded offence report (COR) and offence detected offenders not found (UDOR). Violations related to fishing are recorded under COR, and a fine amount (termed as compensation in official records) is collected from fishers for such offences. Reports from 2000-01 to 2007-08 show that COR offences, that is, violations for which fines are collected, but which are not charge sheeted and taken to court, have drastically increased from 361 to 2,086 (Appendix VII), while there has been no such increase in the other two types of violations. The Forest Department highlights that the increase in number of violations could also be due to the large number of fishers now moving to the STR area to fish, as there is not much fish available outside the area. Fishers in the area find it difficult to understand the maze of rules and regulations applicable to the various types of PAs, and the categories therein. They are also not familiar with the categorization of offences and the schedule of fines applicable to each kind of offence. The violations and

other details are recorded at the back of the BLC in English, a language incomprehensible to them. Under the circumstances, fishers feel more or less helpless and unable to raise any credible plea, even if they feel they have been booked for a violation they have not committed, or if they believe that the fine amount is not proportionate to the kind of violation committed.

The Divisional Forest Office at Khulna is responsible for the regulation of fishing within the Sundarbans. Issuing permits and collection of revenue at the forest stations controls fishing within the Sundarbans. Fishing license and registration is given by the DFO, Sundarbans.

For obtaining license it needs

i) Certificate of the chairman of Union Parishad

ii) One copy of attested photograph

iii) Tk. 5,000 as security money

iv) Tk. 1,500 for license fee

For renew al the license, a fee of Tk. 750 per year is taken. At the time of issuing pass from the forest station, tax for fishing and tax for staying in the SRF is determined at the rate of

Tk. 3 per man per week for fishing

Tk. 0.25 per man per day for staying in the forest

For the failure to come back in the designated time a fine is added at the rate of Tk. 3 per man per week; 1-7 days is treated as a week. For carrying the fish, a tax is determined at the rate of Tk. 25 per man per week. After fishing is completed, the fishermen return through the same forest station, they enter and show their pass and pay tax for the catch at the rate as follows:

**Table 15 Tax collection for aquatic resources from the Sundarbans**

| | |
|---|---|
| White fish | 50 Tk per mound |
| Big shrimp | 300 Tk per mound |
| Small shrimp | 50 Tk per mound |
| Dry fish | 65 Tk per mound |
| Hilsa fish | 75 Tk per mound |

| | |
|---|---|
| Crab | 40 Tk per mound |
| Shrimp & crab residues | 25 Tk per mound |
| Mussel | 1 Tk per 100 pieces |
| *P. monodon* fry | 5 Tk per 100 pieces |

The license is renewed in 30th June every year. In case of failure to renew the license in the due date, a fine of Tk. 100, Tk. 200 and Tk. 300 is imposed for the month of July and August to September respectively. In case of failure to renew the license in the month of September, Tk. 1000 is fined for every financial year. If the license is not renewed after two years, the license is rejected.

***There are two types of boat operated in the forest***

i) Boat with engine

ii) Boat without engine

Boats with engine can operate for carrying of fish or for fishing but boats without engine can operate only for fishing. These two types of boat also have BLC (Boat license certificate) from DFO (Divisional Forest Officer). The tax for BLC depends on loading capacity of the boat.

Fish loading capacity 25 mound = 1 unit.

The tax for 1 unit = Tk. 3 (Without engine)

The tax for 1 unit = Tk. 25 (With engine)

DFO issues permission for one month and after permission, the forest station will issue pass for 7 days for fishing or for carrying fish. At the time of applying for permission, one must mention the forest station where all the taxes have to be deposited. Fishing is permitted 3 times in a month. One time equals 7 days. Failure of fishing for 3 times in a month brings a penalty for the fishermen. This fine is Tk. 300 for 2 times fishing and Tk 500 for 1 time fishing.

Fishing activities are allowed within a range by obtaining permission from any of the forest station of the range. However, the fishermen can continue fishing in the deep forest with the same pass.In case of fishing in the deep sea, no tax is paid for staying but the tax for fishing is given. The rate of tax for deep-sea fishing is Tk. 5 per man per day. It is called DFC (Dry

Fuel Wood Consumption).If the boat for fishing in the forest sells the fish to carrying boat or catch in a small quantity of fish, they will give the revenue at the rate of 10% of the cost of shrimp and 90% of the cost of white fish of the total catch.

The tax for dry fish is fixed at 3 sher dry fish per man per day. The tax for Crab is fixed at Tk. 1.5 per man per week or 3-sher crab per man per day for carrying The tax for Mussel is fixed at Tk. 100-mound mussel per 21 days per 3 men. For deep-sea fishing, tax is only imposed if the fishermen go to the sea using a river way through the forest. Activities of the forestry department in the fisheries sector were almost exclusively focused on revenue collection. A number of closer regulation were enacted , but were not rigorously enforced .the current initiative to institute a comprehensive fisheries management system therefore marks the beginning of a new era or aquatic resource sustainability in the Sundarbans.

## 7.5 Role of tourism in protecting conservation areas

Birding and wilderness exploring is a popular form of eco-tourism, an activity that may ultimately help governments improve their management of natural resources. Ideally, eco-tourists visit sites to observe wildlife and as a result spend money in the area. Governments and local people have economic incentives to maintain these areas in a natural condition to ensure continued visits by eco-tourists. Ecotourism is therefore being promoted as a tool for bio-diversity conservation and rural development (Aronsson 2000). To achieve these goals, however, careful management and planning is required. Before promoting eco-tourism activities, authorities should assess and mitigate the potential impacts from eco-tourism.

## Summary

The rules and regulations that are in vogue in the Sundarbans Fishery are related to only revenue collection; with very little in regard to actual resource conservation and sustainability. There are however, acts and regulations but those are not in actual application for the betterment of the resources. Technicality of the management of Sundarbans Reserve Forest's Fishery started since 1989. Eighteen different khals within the forest that have been declared for breeding grounds and closed from fishing. There is no limitation on gear dimension, limit of fishing time, control on fish catch and access to the waters. Under the SBCP, control measures were exercised on 17 different fishery within SRF. These are 5 year fishing ban for Pangas and Vetki; hilsa fishing is banned from November to April every year and mud crab fishing ban is effective from December to February. For hilsa, minimum size

limit is 23cm and for crab 10 cm carapace lengths for male. All the gears with fixed engines were permanently prohibited from fishing with the forest; gear with very small mesh size that catch the larvae are prohibited from operating. Other than these the Forest Department exercises different acts and regulations on fisheries. These are Indian Forest Act, 1878; Hunting and Fishing Rules, 1959; Major Fisheries Regulations under SRF – 1989, 1995, 2000; Wildlife Sanctuary Regulations, 1999; moreover, FAO has proposed regulation under the project (BGD/84/056) in 1994; World Bank has also proposed a regulation in 1998. There are regulations in the form of closure on species to be caught, areas open for fishing, and time period open for fishing; there are controls on gears like destructive fishing gears, mesh size, gear dimension, mandatory by-catch reducers etc. Fishing efforts control is also exercised e.g., limiting the number of fishing permits and limit on fishing time.

The management history of Sundarbans mangrove is old. The mangrove fisheries plan was prepared during 1993-1994. Chaudhury (1997) prepared the working plan for fisheries of the forest based on inventory of Sundarbans for the period 1960-1980. Forestry Master Plan proposed and implemented two sanctuaries during 1993-2002 and 2003-2012. The second sanctuary paid attention for the development of wildlife and consequently three areas of the forest have been declared as wildlife sanctuaries however, the total areas covered was not sufficient to provide long term protection to the wildlife. The mangrove fishery is degrading rapidly. Fisheries area coverage, species diversity and ecosystem functions have been declined, even though several forest policies, laws and management plans have been enacted to protect them. The effectiveness of the policies and plans is limited due to poor implementation capacity on the part of the Forest Department. The Sundarbans Forest Department is poorly staffed. The main function is revenue collection since 1875. The security and protection function are not adequate; 69% fisherman face dacoits; 90% take shelter in the small khals during natural calamities like cyclones and storm surges and reportedly only 5% gets assistance of the Forest Department in time of needs.

# 8. Operation and effectiveness of the existing declared fish and wildlife sanctuaries

The Sundarbans mangrove area of Bangladesh when taken together forms one of the world's largest single patches: some one million ha. In terms of species richness, the mangroves of the lndomalayan Realm have the greatest diversity and the Sundarbans are the only mangrove area in the world inhabited by tigers. Some 18 countries have established protected areas in mangrove forests: In most of these countries the individual areas under protection are less than 1,000 ha. However, protection is afforded to a total of over 11,000 ha four reserves in Venezuela and 26 reserves totaling more than 80,000ha have been established in Australia. The Everglades World Heritage Site contains almost 100,000 ha mangrove making it the world's second largest mangrove protected area after the Sundarbans. There are also significant amounts of mangrove in Australia's Kakadu National Park and in the Wet Tropics and small amounts in the Aldabra and Belize Barrier Reef World Heritage sites. As the salinity gradient is from west to east, the most biologically rich areas of the Sundarbans are in the east where freshwater influences are greater. The existing Sundarbans site in India and the adjacent Sundarbans West Sanctuary in Bangladesh are thus in the strongly saline zone where diversity is lowest and the trees are stunted and have a poor form. All the above four protected areas in the Sundarbans collectively conserve the only remaining habitat in the lower Bengal Basin for a variety of faunal species, many of them threatened.

The Bangladesh part of the Sundarbans is occupied by water bodies in the forms of river, canals and creeks of width varying from a few meters to several kilometers. The interconnected network of waterways makes almost every corner of the forest accessible by boat. The forest lies under two forest divisions, and four administrative ranges viz Chandpai, Sarankhola, Khulna, and Burigoalini,Satkhira and has sixteen forest stations. It is further divided into fifty-five compartments and nine blocks

A new Khulna Forest Circle to preserve the forest was created in 1993 and a Conservator of Forests has been posted. The direct administrative head of the Division is the Divisional Forest Officer who is also based at Khulna. The Divisional Forest Officer has a number of professional, subprofessional and support staff and logistic supports for the implementation of necessary management and administrative activities. The basic unit of management is the

compartment. There are 55 compartments in four Forest Ranges and these are clearly demarcated mainly by natural features such as rives, canals and creeks.

The Sundarbans consist of three Wildlife Sanctuaries (WS). These are as follows.

1. Sundarbans East Sanctuary: It is consisting of the compartment no. 4, 5, 6 and part of 7 with an area of about 31,227 ha. Its head quarter is situated at Katka.
2. Sundarbans South Sanctuary: It is consisting of the compartment no. 43 and 44 with an area of about 36,970 ha. Its head quarter is situated at Nilkomol.
3. Sundarbans West Sanctuary: It is consisting of the compartment no. 53, 54 and 55 with an area of about 71, 502 ha. Its head quarter is situated at Notabeki.

The South WS is bounded by Kaga and Morjat River in the east, Malncha and and Boro Pangasia River in the west, Kaga River and Dobeki Canal in the north and Bay of Bengal & Putnichar Island in the south. East WS is located at the south-eastern part of SRF adjacent to the Bay of Bengal which was previously managed by Sarankhola Range of Sundarbans East Forest Division. Sundarbans East WS is bounded by SRF in the north and west, the Bay of Bengal in the south and the Baleshwar River in the east. Reserved Forests of Sarankhola and Chandpai Ranges are situated along the northern periphery of this WS. Further north and along the periphery of SRF of Sarankhola and Chandpai Ranges there are areas/localities called *Landscape Zone* under the civil administration. Sundarbans West WS is bounded by Jamuna River in the east, Harinbhanga River in the west, Burigang River in the north and Bay of Bengal & South Talpatti Island in the south.

## Date and History of Establishment

All three wildlife sanctuaries were established in 1977 under the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974, having first been gazetted as forest reserves in 1878. The total area of wildlife sanctuaries was extended in 1996. The entire Sundarbans is reserved forest, established under the Indian Forest Act, 1878.

**ALTITUDE**

Ranges from sea level to three meters

**STAFF**

There are 3 field stations in Sundarbans West Wildlife Sanctuary each with 95 staff (2 officers and 7 forest guards). There are respectively 2 station in South Wildlife Sanctuary and 3 in South East Wildlife Sanctuary.

## Summary

There are three wildlife sanctuaries in the Sundarbans. These are Sundarbans West, East and South. These sanctuaries were established in 1977 under the Bangladesh Wildlife Preservation (Amendment) Act, 1974. The total area of the sanctuaries was extended in 1996. The total area of the Bangladesh section of the forest is 5,95,000 ha of which 1,39,699 has is protected and the areas are Sundarbans West Wildlife sanctuary – 71,502 ha; Sundarbans East Wildlife sanctuary- 31,226 ha and Sundarbans South Wildlife sanctuary – 36,970 ha. Sundarbans National Park – 1,33,010 ha (World Heritage Site). There are three field stations in the Sundarbans West Wildlife sanctuary each with 9 staff (2 officers and 7 guards). There are 2 field stations each at the East and South sanctuary with similar number of staffs. Out of the total 4,110km$^2$ area of the Bangladesh part of the forest, about 1,700 km$^2$ is occupied by waters in the form of rivers, canals and creeks of varied width ranging from a few meters to several kilometers. The interconnected network of rivers/ creeks makes every corners of the forest accessible by boats. The forest is under two divisions and four ranges; these are Chandpai, Saronkhola and Nalian in Khulna and Burigoalini in Satkhira and has sixteen forest stations. These are further divided into fifty-five compartments and nine blocks. A forest circle in Khulna was created in 1999. The divisional head of a division is Divisional Forest Officer; under him are the professional and support services staff with logistic support for implementation of necessary management and administrative activities.

# 9. Infrastructural and other facilities for sustainable use and improved management of the Sundarbans fisheries

## 9.1 Land transport

Transportaion facilities are very essential to perform the schedule work effectively and timely. So required transport systems such as car, jeep, pick up, motor byke, van etc. should be provded to forest officials of the Sundarbans.

## 9.2 Water vessels

A considerable amount of budget is required to provide the means of working in the Sundarbans. Without the launch, boats (mechanized/speed) no activities can be performed in SRF area. Well equipped research vessels are required for conducting research activities.

## 9.3 Communications

Communication network such as radio, television, modern wireless telephone, mobile phone, internet, video conference technology should be strengthened to coordinate activities over the vast reaches of the Sundarbans Forest as well as to exchange information among the officials of FD. Communication facilities will be set up at each station/sub station according to the requirements.

## 9.4 Field station and staff quarter

Forest station with sufficient space and residencial facilities should be developed for proper management of planned activities and safe living of the staff with their family whenever deemed necessary. Special attention should be given to secure living of the officers and other staff who are staying in different station/sub stations since Sundarbans mangrove forest is natural calamity (typhoon, tidal surge, flood etc) prone area. Even threats come to them from wild animals, pirates etc and these issues must be taken into consideration.

## 9.5 Medical Team

There should be a mobile medical team in SRF to offer medical support for FD personnel and other stakeholders. The team will visit the forest station/sub stations at least once a week and should have the option to give emergency service.

## 9.6 Manpower

There should be sufficient trained manpower (forest expertise, researcher, physician, administrative, security officials, driver, office staff, peon, boatman, etc) in every sector mentioned above for effective use and sustainable management of Sundarbans mangrove resources.

## 9.7 Aquatic Resource Division (ARD)

For efficient management and conservation of Sundarbans fishery a new aquatic division called ARD has been proposed under the Sundarban Biodiversity Conservation Project (SBCP).

### Proposed actives of ARD

- To properly manage the aquatic resources of Sundarbans, Sundarbans coastal area and marine zone.
- To manage the research on fish resources of Sundarbans reserved forest.
- To confirm logically fish collection from Sundarbans reserved forest.
- To collection the data of fishing in Sundarbans area and coastal area.
- To examined the water quality of Sundarbans and Sundarbans coastal area.
- To research on fish eggs of Sundarbans reserved forest.
- To determine the rate of fish population.
- To prohibition of fishing in reproductive area after identification.
- To determine the season of fish reproduction.
- To identify the nursing area of fish.
- To identify why and how many ways the aquatic resources destroyed.
- To protect destroy of aquatic resources of Sundarbans reserved forest.

- To implement the fish ordinance and acts for proper management of aquatic resources of Sundarbans reserved forest area.
- To co-ordinate with other offices of forest division of Bangladesh Navy, Coast guard and other related establishment of Bangladesh.
- To take some program to develop the fishermen acts of coastal and Sunda5rban area.
- To aware the fishermen to preserve for aquatic resources by giving proper training.
- To manage drinking water and medical treatment for the fishermen of Dubla char area.
- To market the raw fish and drying fish by modern technology of Dubla char.
- To establish for so many cyclone center for saving life at the time of cyclone.
- To develop the whole status of Dubla char and to develop the life status of fishermen.

## 9.8 Marketing, transportation and storage facilities

The spoilage of fish starts from the time it is caught. Inadequate proper storage, preservation and prompt disposal or transport service are causing a lot of hardship especially during Monsoon when up to 20 to 30% of the produce are lost. Proper storage, preservation and prompt disposal or transport service are essential. This is a vital area to be addressed and may result in increased economic returns to those dependent on the fishery without any increase in fishing effort. Therefore, strengthening of post harvest infrastructure such as storage facilities, ice plants, and transportations etc. and as well as effective marketing system are the requirement for the betterment of the stakeholders. This would ensure higher profit margins to the fishermen.

## 9.9 Early warning and signaling system for natural calamities

Natural calamities such as cyclone and low pressure are perennial climatic and weather aberrations which had taken lives of a large of fisherman in the Sundarbans. An early warning and signaling system of cyclonic storm development and proper linkage between Meteorological Station and SRF is urgently required to save the lives of fisherman.

## 9.10 Facilities to visit Sundarbans

Nature based tour operators must possess strong knowledge of, and an even stronger affinity for, natural areas. The knowledge must extend to the natural history of the area, flora and fauna, and an understanding of the ecological processes that sustain their existence. Operators must not only have a dedicated love and knowledge of the areas visited but also posses the skills necessary to cope with the rigors of managing a tour. Operators identified a variety of competencies, including vehicle maintenance, bushcraft, the pitching of tents, the assessment, management and avoidance of risk, cooking, cleaning and skills that minimise impact on the environment (McKercher and Robbins 1997).

## Summary

Efforts have been made by the FD for creation of facilities targeted for management improvement of the forest; however, those are indequate. The facilities for transport, housing, security etc. are barely insufficient for the manpower engaged in the management and administration of the forest. A separate Aquatic Resource Division has been established since the time of implementation of the SBCP in 1999-2000 but mere creation of the division does not suffice the needs.

# 10. Scope for reinforcing community based management of the Sundarbans fisheries

In Bangladesh, about 2.5 million people inhabit villages around the Sundarbans. As much as 300,000 of them depend directly on the mangrove forest. The growth rate for the Bangladeshi population in general is 1.6% and because of high rural unemployment, there is some rural–urban migration as people search for alternative income sources. Only 35% of those living in the impact zone (0-20 km around the SRF) own agriculture land. Up to 50,000 people days enter the Sundarbans to cut timber, collect honey and catch shrimp fry. Migratory fishermen also enter the Sundarbans and establish camps during the dry season, engaging in illegal trapping and hunting. The demand for irrigation water during the dry season has meant the diversion of 40% of the freshwater that would normally flow into the Sundarbans. A ban on shrimp fry collection went into effect in 2000 as concerns about its effect on fisheries and biodiversity increased. However, the law will be very difficult to enforce because of the large number of fry catchers in the country and the lack of any viable alternative employment. It is also often the only source of income for thousands of rural women.

An estimated 14% of people living inside a 10 km border around the Sundarbans participate in shrimp fry collection (Table 16). They include both males and females from all age groups. An estimated 225,000 people are involved in shrimp fry collection. To this another 20,000 who operate as primary and secondary traders must be added, who carry the fry from the primary collection points to the shrimp farmers in one, two or three stages. Population involvement in hilsa fishing and dried fish production is also high, but in these two activities, people from outside the Sundarbans region are engaged as part time employment.

**Table 16: Population involved (%) in exploiting SRF resources**

| SRF resource Exploitation | | Participation rate | | Nos. of persons (000) involved in exploitation | |
|---|---|---|---|---|---|
| | 0-10 km | 10-20 km | 0-10 km | 10-20 km | 0-20 km |
| 1. Any resource | 16.2 | - | 155.0 | 81.0 | 236.0 |
| Wood | 2.1 | - | 20.1 | - | 20.1 |
| *Nypa* leaves | 0.8 | - | 7.7 | - | 7.7 |
| Honey | 0.6 | - | 5.7 | - | 5.7 |
| Shrimp fry | 14.3 | 7.6 | 137.6 | 87.9 | 225.5 |
| White fish | 1.1 | 0.8 | 10.5 | 9.3 | 19.8 |
| Crab | 0.1 | 0.75 | 1.0 | 0.9 | 1.9 |
| Gastropod & oyster shell | 0.04 | 0.002 | 0.4 | - | 0.4 |
| Turtel | 0.35 | 0.17 | 3.3 | 2.0 | 5.3 |
| Total | - | - | 185.3 | 100.1 | 286.4 |
| 2. Hilsa fishing | | | | | 30.0 |
| 3. Dried fish | | | | | 25.0 |
| Grand Total | | | | | 291.0 |

Source: ADB/BCP, based on MARC (1995)

## 10.1 Indigenous and Local Communities, and the management of Sundarbans fisheries

The traditional resource users of the Sundarbans are the indigenous Munda community and local Bawali (wood cutters), Mouali (honey collectors), Golpata (nypah palm) collectors and Jele (fisherman) communities (Kabir and Hossain, 2006). It was found through some studies that in the villages that depend on the SRF for their subsistence, there is a high level of awareness of the long-term problems that result from overexploitation of the SRF. Unsustainable practices are due to commercial contracts for the use of *Gewa*, and uncontrolled harvesting of forest, aquatic and wildlife resources by users from the impact zone. There is a very strong interest among villages in the impact zone in conserving resources, in stopping unsustainable practices, and in pursuing alternative income-earning opportunities. So there is an urgent need to fully involve indigenous and local communities in

policy and practice concerning the sustainable use and conservation of the Sundarbans fisheries.

## 10.2 Community Participation and NGO Involvement

Participatory approaches will be adopted to organize the resource user/extractors into groups, as well as to improve their access to productive resources, social services, and infrastructure. The impact zone strategy should focus on empowering resource user/extractor groups so they can participate meaningfully in resource conservation and management of the SRF through collective selfregulation. Strengthening the capacity of NGOs to effectively manage programs relating to social forestry, income opportunities, community mobilization and group formation, improved access to alternative sources of finance, social services, and infrastructure, and a public awareness program focusing both on conservation issues for the SRF and on the objectives of the community work and social investments, will also be another priority issue of the governments.

## 10.3 Livelihood Groups Dependent on Sundarbans

In the impact zone of Sundarbans, 18% of the households are dependent on Sundarbans resources (PDO-ICZMP, 2004). Their livelihood depends on extraction of resources from Sundarbans. The review of past works and related literature (SBCP, 2001; PDO-ICZMP, 2004; Kabir and Hossain, 2008), revealed existence of 10 livelihood groups in Sundarbans which are: Bawali (wood cutter), Nypa collectors (golpata used as roof materials), Mawali (honey and bee wax collector), Jele (Fisher), Majhi (Boatman), Crab collector, Medicinal plant collector, Shrimp fry collector, Chunery (oyster and snail collector). After field observation and SLDs it was found that in practical sense these resource extractors have diversified their livelihood opportunities by extracting different types of resources in responding to decreasing productivity status of Sundarbans. Now Bawalis also collect Nypa, and other non-wood products, such as, mele grass (*Cyperus javanicas*) ulu grass (*Imoerata cylindrical*) and also provide labour to the Mawalis. Fishers catch fishes, collect shrimp fry and are also involved in fish drying, timber and Nypa collection during harvesting season. Children and wives of fishers collect shrimp fry, snail and oyster. Based on the learning from the SLDs, it was decided to classify three broad livelihood groups: Bawali, Mawali, and Fisher. Table 17 presents the type of resources extracted by these three livelihood groups and the period of harvesting.

**Table 17: Sundarbans Dependent Livelihood Groups**

| **Livelihood group (*translated in english*)** | **Extracted resources** | **Harvesting season** |
|---|---|---|
| Bawali (wood cutter) | Timber, | December to March |
| | Nypa palm, grass for matting, reed for fencing | Mid November to mid March |
| Mawali (honey collector) | Honey, bee wax | March to June |
| Jele (fisher) | Fish, prawn fry, oyster, snail, crab | Round the year |

## Summary

The scope of reinforcement of community based management of the Sundarbans fisheries does not seem to be promising for, the area involved around the forest and number of stakeholders in the impact zones and beyond is quite big and thus it is quite daunting that the communities involved can be engaged in sustainable management of the forest waters. About 25,00,000 people live in the villages around Sundarbans; about 3,00,000 people depend directly on the forest and only 35% of those living in the impact zone (0-20km) own agricultural land. Up to 50,000 people per day enter into the forest to cut timber, collect honey and catch shrimp larvae. Migratory fishermen also enter in the forest to stay temporarily there during dry season engaging in illegal trapping and hunting. About 14% numbering 2, 25,000 of the people both male and female of all ages living inside 10 km from the periphery of the Sundarbans participate in shrimp fry collection. The secondary traders of the business also numbers about 20,000. The number of hilsa fishermen and people involved in fish drying is also very high however; these people are migratory and come from outside the impact zones. Mainly artisanal fishery is operated inside the forest which is labor intensive, capital extensive, traditional in nature for subsistence, commercial purpose or for both. Ban on shrimp fry collection was enacted in 2000 however, achieving success in resource conservation is quite difficult because the number of stakeholder is very big and there are no viable alternative livelihood options for these people.

# 11. Institutional Management Aspects

## 11.1 The Forest Department

The responsibility for administration of the SRF is vested by law to the Forest Department and to those whom the Department wishes to delegate its authority. The Chief Conservator of Forests is the Administrative Head and is responsible for overall administration of the department and acts as adviser to the Ministry of Environment and Forest. The next operational administrative and management unit is the Conservator, Khulna Circle who has overall administrative responsibility for the SRF. Recently, they established a new division called Aquatic Resource Division (ARD) under the Sundarbans Biodiversity Conservation Project (SBCP) as a fisheries unit of the SRF. Presently it is headed by one Divisional Forest Officer (DFO) and tentatively worked collaboratively with other divisions. The ARD is responsible for all operations of aquatic and fisheries regulations based on sustainable resource utilization criteria, survey data and analysis.

## 11.2 Monitoring, control and surveillance from FD

The BFD does not monitor actual catches from the SRF. The main focus of the BFD is on revenue collection and a set fee is charged to fishermen. It is approximately related to a national (or minimal) daily catch rate for different types of fisheries. There are two things required for all fisheries activities in the SRF. One is a Boat License Certificate (BLC) and another is a fishing Permit (PT). The BLC's are issued for every year in July (at the beginning of the fiscal year) and are valid for one year. There is a boat patrolling the rivers to check on licenses and permits. But it is quite inadequate for the supervision of the fishing effort. The BFD field officers may also be negligent in patrolling and enforcing regulations in the SRF regarding overstaying and fishing in the declared closed *khals (canal)* and wildlife sanctuaries by fishermen (Anon 2000a).

## 11.3 Promotion of Aquatic Resource Division (ARD) under FD

The goal for the ARP is "the conservation of aquatic biodiversity and sustainable development of fisheries resources within the Sundarbans". ARD also considers aquaculture as an alternative income source in their proposed plan (Anon, 2000a). There is a regular work program (RWP) which consists of aquatic biodiversity conservation, fisheries research and stock assessment, fisheries management and regulations, monitoring control and surveillance,

and fish processing and marketing. Due to the lack of personnel and facilities, a portion of the RWP is fulfilled by service providers for the first few years of the project where ARD focuses on drawing up the work program, TOR and tender documents and supervising implementation of the work by the service provider. ARD already proposed a preliminary Fisheries Management System (FMS) for Sundarbans where they described the various components of the system and presented a Management Action Plan (MAP). They also proposed a summary of the management measures for the SRF fisheries.

## 11.4 Coastal Marine Fisheries Resource Management (CMFR)

This project is under the Department of Fisheries and was established in July, 1997. Khulna zone, under this project, covers the Sundarbans coastal area. The main objective of this project is to increase the production of marine fisheries through marine fisheries management and conservation and to improve the socioeconomic conditions of coastal fishermen.

## 11.5 Role of NGO's

IPAC, CODEC, World Vision International, Caritas, Shushilon, Rupantar etc are working for resource utilization, conservation and sustainable management of Sundarbans resources, and socio-economic development of coastal people. Some NGOs built up the cyclone shelter and is involved with social awareness and educational capacity building activities in the bordering areas (Joymonirgol) of the SRF and also involved in credit programs.

## 11.6 Other Departments and Agencies

Other departments and agencies such as the District Administration, Bangladesh Navy (BN), Rapid Action Batalion (RAB), Bangladesh Police, The Bangladesh Defence Regiment (BDR), Mongla Port Harbour Authority (MPHA), Bangladesh Water Development Board (BWDB), Bangladesh Parjatan Corporation (BPC), Bangladesh Fisheries Research Intitute (BFRI), BFDC, Universities specially Khulna University, DFID, WB, IUCN etc are also involved with SRF in various capacities.

## 11.7 The role and responsibility of the GoB towards the Sundarbans

In addition to their own role, the Bangladeshi government must also take on the responsibility of providing support for the World Heritage Site, which was designated in 1997. They are responsible as a state to preserve the forests and mangroves of the Sundarbans, but also to

create a dynamic economic community within them, and to utilise fully the resources which they provide in a self sustaining manner. However, the evidence shows that the world importnce of the Sundarbans has taken over in the country, and increasingly, supranational organisations are making the decisions and planning for the preservation and management of the area.

## 11.8 Responsibilities and authorities of different establishments

Responsibilities and authorities of different personnel's working at different establishments vary widely. Sometimes people having same official status are found to working at different hierarchy of the establishment with different responsibilities. The major responsibilities of different staffs and their number along with the establishment are presented in Table 18.

**Table18: Establishment wise number and responsibilities of staffs**

| Name of the Establishment | Major responsibilities of the Establishment | Staffing No. | |
|---|---|---|---|
| Range Office (04) | Overall supervision of all subordinate establishments2. Supervision of accounts3. Supervision of revenue collection4. Supervision of protection of forest5. Supervision of development works | Range Officer (ACF) Asset. Range Officer (Forester) | I22.5L7/8 |
| Forest Station (17) | 1. Issuing boat license, entry permission for entry into Sundarbans for extraction ofresources.2. Collection of Revenue3. In case of Goran and Goalpata extraction, assignment of coupes4. Protection of Forest5. Supervision of patrol posts6. Carrying out development works | Station Officer (Deputy Ranger) Asset. Station Officer (Forester)Boatman Trawler driver Forest Guard askers | 112-54-121-2 |
| Patrol post (49) | 1. Protection of resources Protection of stakeholders | Officer-in-Charge(Forest rarely Deputy Ranger)Forest Guard Boatman | |
| Coupe Office (seasonal)Goran coupe: 1Goalpata: 7 | Supervision of extraction activities | Coupe Oficer (Forest Ranger or DeputyRanger) Asstt. Coupe Officer(Deputy Ranger or Forester)Forest GuardBoatmanTrawler DriverLasker | 122-204-302-6 |

| Name of the Establishment | Major responsibilities of the Establishment | Staffing No. | |
|---|---|---|---|
| Depot Office (02) At DhangmariAnd Kassiabad | Storage of confiscated resources.2. Management and account of confiscated resources. | Depot Officer (Deputy Ranger/ForestOfficer) Asstt. Depot Officer(occasional; Forester)~ Forest GuardBoatman | 11/244/5 |

Source: FD, 1999

## Summary

Chief Conservator of Forest is the highest authority for management and administration and he acts as the advisor to the Minister, Ministry of Environment and Forest. A forest circle was created in Khulna; DFO, ARD sees the interest of fishery for sustainable resource utilization, survey data generation and analysis. These bodies apply the different acts and regulations in the forest. The ARD severely lack logistic supports; has 16 staffs with only 3 officers. It does not have program on monitoring the catches; only focuses revenue collection; issues Boat License Certificate (BLC) and fishing permit. There is a boat that patrols the rivers for illegal fishing but that is barely insufficient. Different NGOs that operate in the vicinity of the forest are World Vision International, Caritas, Rupantar, IPAC, Shushilon etc and the different public organizations are Navy, Coast Guards, BDR, RAB, Mongla Port, Bangladesh Water Development Board, BPC, KU and IUCN.

# Recommendations

Emanating from what have been discussed in the foregoing sections, for conservation and sustainable management of the fisheries resources of the Sundarbans, the following recommendations can be made.

1. **Massive development program to ensure flow of freshwater in major river systems**

   The future long term sustenance /sustainability of the Sundarbans has been at a serious stake for, the rivers/distributaries of the Ganges on the west bank starting from the Indian border at Rajshahi are all either dead or in highly moribund conditions; these rivers historically used to provide nutrient supplement to the forest. Without having a continuous supply of nutrient by the deltaic rivers the mangrove Sundarbans will not sustain. The impact is, in fact, already realized in the western part of the forest; the trunk and canopy sizes of the trees have been greatly reduced. So also, the salinity has intruded in the elaborate parts of the forest because of reduction of on-rush of freshwater through the rivers in the area. A massive development program is imperative in the area for digging up of the principal rivers so that there can be flow of freshwater in the rivers, at least from the local catchment areas of the greater Jessore and Khulna.

2. **Technical expert/expertise in the field of aquatic resources**

   Aquatic resources of the forest must be looked after and managed by people having proper technical knowledge and expertise on biological resource management. People having degrees and diplomas on fisheries management supplemented with ecology, physiology, genetics, population sciences/ dynamics etc, are to be deployed in the forest/aquatic service.

3. **Amendment of existing laws, rules or resolutions**

   Necessary amendments should be made to policies and laws to promote and support customary use of natural resources, and the related cultural practices of local and indigenous communities. Steps should also be taken to ensure proper implementation of the laws/acts. The legal regime should also be updated taking into consideration key terms of the Community Based Development.

**4. Adjustment of reformation with sectoral paradigm**

Legal and policy reforms should be adjusted with sectoral paradigm. The colonial sectoral laws on resource management (land, forest, wildlife, fishing, and mining) should be reviewed and amended to reflect the aspirations of a free nation and adopt more progressive and participatory management notions.

**5. Fisheries management policy reform**

There has to have a drastic reform in the present policies of management of the resources. The revenue-oriented management system has to be replaced by a true biological resource generation–based management. The Sundarbans is not only a great resource for Bangladesh but it is a world heritage as well, so its value cannot be judged merely by the index of annual revenue income by the Bangladesh government. A comprehensive planning has to be done through dialogue between different stakeholders for the development and sustainable management of Sundarbans fisheries resources.

**6. An effective and functional Aquatic Resource Division (ARD)**

The Forest Department has established an Aquatic Resource Division since last time when the project on Sundarbans Biodiversity Conservation was undertaken; however, merely creating a division in the name of aquatic resource will not suffice the aim. For conservation and sustainable management of the Sundarbans fishery a meaningful Aquatic Resource Division should be formed and all logistic and financial supports should be provided to keep this body effectively functional.

**7. Support and services for the forest officials/staff/department**

For improved management of the Sundarbans resources there is an urgent need to provide the following Infrastructural and other facilities.

- Proper manpower with regard to quality and number has to be deployed with sufficient facilities in their job and services. The corruption committed by the forest department people is a common complaint. This must be seriously dealt with; it must be seen if the matter has anything to do with the low paid salaries and other job facilities of the people engaged in the activities. There should be sufficient trained manpower (forest expertise, researcher, physician, administrative, security officials, driver, office staff, peon, boatman, etc) in every sector for effective use and sustainable management of Sundarbans mangrove

- Forest station with sufficient space and residential facilities should be developed for proper management of planned activities and safe living of the staff with their family whenever deemed necessary. Special attention should be given to secure living of the officers and other staff who are staying in different station/sub stations.
- The access to the vast area of the forest has always been daunting for a purposeful management. Thus proper transport facilities both on the land and water, accommodation, security etc, have to be ascertained for the people engaged in management.
- Radio, television, modern wireless telephone, mobile phone, internet, video conference technology should be used wherever possible to coordinate activities over the vast reaches of the Sundarbans.
- There should be a mobile medical team in SRF to offer medical support for FD personnel and other stakeholders. The team will visit the forest station/sub stations at least once a week and should have the option to give emergency service.
- All the forest officials/staff should be taken under insurance coverage.

**8. Alternative livelihood option**

The protection and conservation of the resource is very intricately woven with the life and livelihoods of the huge number of stakeholders living in the impact zone of the forest. They are the fishermen, wood abstractors, honey collectors and the people engaged in the secondary/ancillary processes. They have to be provided with alternative livelihood options. This is as important as imposing ban on fishing season, fishing gear, species to be harvested and demarcation of reserve areas of forest waters. The suitable alternative livelihood options are to be experimented for in the impact zone of the forest. Some plausible livelihood options can be thought of as follows:

- Apiculture
- Pen culture (fish, crab)
- Cage culture (fish, crab)
- Brackish water shrimp nursery
- Goat rearing

- Poultry rearing
- Beef fattening
- Producing handicrafts
- Small businesses (street vending)
- Tailoring
- Basket making (bamboo)
- Rickshaw / van paddling
- Bicycle repairing
- Welding technician etc.
- Crab fattening
- Brine water/salt production

**9. Credit and Insurance facilities for the resource users**

To bring the marginal people out of the grip of mohajans/moneylenders, the government should provide the marginal people with interest-free micro-credit. Special micro-credit program should be introduced for the different stakeholders adopting any alternative livelihoods for generation of income at the household level. It is reported that every year hundreds of fishermen/coastal/marine resource users are sacrificing their boat/craft, gear and other harvesting tools, houses etc, even lives. So it is very much essential to take their lives and properties under insurance coverage by the government or NGOs as well as sufficient sufficient interest free loan has to be provided so that they can afford well equipped crafts, gears, life jackets and other essential tools.

**10. Training and motivation program for resource users**

Together with the options for alternative livelihoods, the stakeholders are to be mobilized into groups and motivated for the importance of resource conservation. The principal consideration of conservation of a biological resource is to keep the exploitation at optimum level; the stakeholders have to be trained on the value of the regeneration of the biological resources and necessity of optimum resource exploitation and thereby providing the chance of regeneration the resource for their long term benefit.

**11. Control of fishing**

Fishing has to be restricted in 5 kilometers in sea ward offshore waters of the Bay of Bengal through bans on gears, species and seasons. Closure/ban on fishing should be imposed during breeding season. There is allegation of poison fishing in SRF by some of the fishermen. If it is true or any evidence is found appropriate steps should be taken to stop it immediately. Most importantly a detailed harvest policy should be developed for the fishermen community through consultation with different stakeholders of fisheries sector. There should also be a policy for the fishermen who become engaged in seasonal fishing in Dubla char area.

**12. Protection of breeding and nursery grounds**

After comprehensive research work the identified important breeding and nursery grounds of the fishes have to be protected and reserved.

**13. Habitat restoration and sanctuary development**

Since many of the river systems of the Sundarbans have experienced considerable morphological change due to siltation, insufficient water flow, rising/formation of underwater island at the river mouth and many other factors massive development program has to be taken to ensure sufficient water flow which ultimately will facilitate fish movement/migration and habitat restoration.

**14. Artificial breeding and stocking of important fish species**

Due to improper management and uncontrolled fishing it is assumed that the stock of many of the aquatic species has been depleted in SRF. So research initiatives can be taken to breed some of the commercially important fish species and to stock the offspring in the water bodies of the Sundarbans. These could help enhance the abundance of that particular species and total stock as a whole.

**15. Provision of ID card and work permit**

All the local communities and indigenous groups dependent on the Sundarbans should be registered and provided with identity cards. Access to forest product should be limited to these users. All permits should be given directly to resource users not to the traders or mohajans.

**16. Monitoring and surveillance team**

The Sundarbans has two major challenges. These are corruption with some of the Forest Department people and robbery in the forest areas. To deal with the latter it is recommend that a special law-enforcing agency like the RAB (Rapid Action Battalion) combining the Bangladesh Army, the Coast Guard, forest officials and community representatives will have to be formed. The task of monitoring and surveillance can be given to this law enforcing agency to monitor the execution of fisheries rules/acts and to protect the breeding/nursery grounds and fish sanctuaries of SRF. Coordination should be maintained between forest division and the monitoring and surveillance.

**17. Role playing from responsive organizations**

Of all the organizations/departments which have their meaningful role to play in strengthening of conservation and management of the Sundarbans, the Forest Department, Khulna University's Fisheries and Marine Resource Technology Discipline, Center for Integrated Studies on the Sundarbans (CISS) and other Disciplines of relevance of the University, Department of Fisheries (DoF), Bangladesh Fisheries Research Institute (BFRI), Navy/Coastguards, Bangladesh Fisheries Development Corporation, Mongla Port Harbour Authority (MPHA), Bangladesh Water Development Board (BWDB), Bangladesh Parjatan Corporation (BPC) and Local Government's bodies in the impact zones, different NGOs, like IPAC, CODEC, World Vision International, Caritas, Shushilon, Rupantar DFID, WB, IUCN etc working in the peripheral zones are the principal ones. For suitable means of implementation of the policies for conservation and management of the resources, an utmost collaboration and cooperation between the bodies is but an utter necessity. The role of Khulna University in finding out results of critical areas of intervention can not be overemphasized. The Navy and Coast Guards can play a very vital role in patrolling for unauthorized resource exploitation and pilferage of the products from the forest. The Local Government's bodies and the NGOs operating in the areas can similarly play partnership roles in providing training and mobilization of the people for purposeful intervention for management and conservation of the resources.

**18. Research initiatives for generating reliable fisheries related information**

There is a dire necessity of reliable data and statistics of the Sundarbans resources, but the irony is that the data and information available are not reliable at all. The gaps are everywhere in the management. The trends of production and the dynamics of the

resources can not be ascertained from the available data and that is easily ascribed to the inefficiency of management of the Forest Department. The productivity of the waters is linked with the hydrodynamics, temperature, salinity, organic and inorganic processes etc. To be able to say about the nature and dynamics of productivity of the waters, critical studies are to be conducted so that dependable data on stock abundance, spatial distribution, species assemblages, seasonality, breeding and nursery areas, Maximum Sustainable Yield (MSY), endangered/threatened species, allowable fishing grounds, dynamics of geo-physico-chemical parameters, environmental degradation, climate change impact on Sundarbans fishery, pollution sources etc, are made available. For better management of the resources fisheries database development with the integration of spatial and non-spatial data should also be a priority. With the available aquatic species a museum can also be developed for Sundarbans fishery. So, collaborative research with people from different fields (fisheries, forestry, environment, social science etc.) at regular intervals and monitoring agenda has to be added in the new system of management of the resources together with enough budgetary provision, manpower and other facilities.

**19. Ban on shrimp fry collection**

The impact zones and in the zones beyond, there has been the development of a burgeoning brackish water shrimp culture farms. A huge number of people of all ages are engaged in the collection of shrimp post larvae from the waters of Sundarbans and reportedly the process claims a colossal damage of the resources; for collecting a single PL of the shrimp species up to 70 other ichthyoplanktons are killed. Other than the damages done by the larval killing of the living resources, the shrimp culture practice had had a serious encroachment in the forest areas from sometimes past. The government should develop a clear policy with comprehensive planning support on prawn fry collection from the Sundarbans and to address the social and environmental problems caused by prawn farming.

**20. Close monitoring in the periphery**

In the areas of interface between the villages of human settlement and the forest, there have been always the tendencies on the part of the villagers for illegal cutting, felling of trees and clearance of the forest for agricultural lands, salt pans and fresh settlements.

These are actually the important oversights of the existing management and implicate to the whole issues of failure of protection and conservation of the forest.

**21. Controlling water pollution**

Pollution in the forest waters due to oil spillage from tankers operated in the vicinity of the forest areas especially from the Mongla Port, agrochemical wastes, wastes from the shrimp farms, industrial wastes of various kinds, solid wastes generated from the nearby cities and towns is also a problem. Moreover, the forest attracts a huge number of visitors annually and the wastes gernerated from littering by the trour makers has also been a serious concern in the recent time. Together with the dealing of known pollution sources other possible pollution sites should be identified and controlled accordingly. These all are to be seriously handled by the management.

**22. Discourage to future oil and gas exploration program**

Future oil and gas exploration program, if there is any, in the offshore areas of the forest has to be seriously discouraged.

**23. Early warning and signaling system for natural calamities**

Natural calamities such as cyclone and low pressure are perennial climatic and weather aberrations which had taken lives of a large of fisherman in the Sundarbans. An early warning and signaling system of cyclonic storm development and proper linkage between Meteorological Station and SRF is urgently required to save the lives of fisherman.

**24. Marketing, transportation and storage facilities**

Proper storage, preservation and prompt disposal or transport service are essential. This is a vital area to be addressed and may result in increased economic returns to those dependent on the fishery without any increase in fishing effort. Therefore, strengthening of post harvest infrastructure such as storage facilities, ice plants, and transportations etc. and as well as effective marketing system are the requirement for the betterment of the stakeholders. This would ensure higher profit margins to the fishermen.

**25. Resource knowledge of the tour operators**

Tour operators must possess strong knowledge of, and an even stronger affinity for, natural resources of the Sundarbans. The knowledge must extend to the natural history of the area, flora and fauna, and an understanding of the ecological processes that sustain their existence.

**26. Protection of aquatic wildlife**

In and around the Sundarbans a lot of aquatic animals like dolphin, whale, sharks, crocodile etc are inhabiting. We should take appropriate steps so that these valuable animals can be saved from fishermen (who after harvest collect different organ of these animals) and from environmental degradation as well to keep the natural ecosystem and biodiversity sustainable.

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# References


Agrawala, S., Tomoko Ota, Ahsan Uddin Ahmed, Joel Smith and Maarten van Aalst, 2003. Development and Climate Change in Bangladesh: Focus on Coastal Flooding and the Sundarbans. Report no. COM/ENV/EPOC/DCD/DAC(2003)3/FINAL. Organisation for Economic Cooperation and Development, Paris. 70 pp.

Ahmad, I., Bland, S.J.R., Price, C.R. and Kershaw, R.,1998. In: Petr, T. (ed.), Inland Fisheries Enhancements. FAO Fisheries Technical Paper 374, pp. 337–350.

ANON 2003. Fish biz bonanza to boost state. The Times of India, Kolkata, November 25th 2003 Vol. 5 no. 4

Anon, 2000. Fisheries of the Sundarban (Draft), Interim Technical Report. Main Report. Technical Report-TR No. 02A, Sundarban Biodiversity Conservation project, Bangladesh. Vol.1.1 pp

Anon, 2000a. Fisheries of the Sundarbans (Draft), Interim Technical Report.1, Main Report. Technical Report-TR No. 02A, Sundarbans Biodiversity Conservation Project,Bangladesh. Vol.1.1 pp

Anon, 2000b. Coastal Marine Fisheries Management in Khulna Region. Minister's report – 2000. Coastal Marine Fisheries Management Project, Khulna Region, Khulna. Marine Fisheries Sector, Fisheries Department, Bangladesh.

Anon, 1999. Primary Survey Report, Coastal Marine Fisheries Management and Development Project, Khulna Zone, Khulna. Marine Fisheries Sector, Fisheries Department, Bangladesh.

Baran and Hambrey, 1998. A forest Inventory of the Sundarbans Bangladesh. Main Report, ODA, Londan.196p

BBS (Bangladesh Bureau of Statistics), 1988. Report of the Proverty Monitoring Survey. Bangladesh Bureau of Statistics, Dhaka, 105pp.

Blower, J.,1985. Sundarbans Forest Inventory Project, Bangladesh. Wildlife conservation in the Sundarbans. Project Report 151. Overseas Development Administration Land Resources Development Centre, Surbiton, UK, 39 pp.

Borg, J., 2004. Fish stock and fishery enhancement in Western Australia. A discussion paper. Fisheries Department of Western Australia. Fish. Manage. Pap. 175, 1–86.

Chaffey, D.R., Miller, F.R. and Sandom, J.H., 1985. A forest Inventory of the Sundarbans Bangladesh. Main Report, ODA, Londan.196p

Chakrabarti, P., 1995. Evolutionary history of the coastal quaternaries of the Bengal Plain, India. Proceedings of the Indian National Science Academy 61A: 343–354.

Chantarasri, S., 1994. Fisheries Resources Management for the Sundarbans Reserve Forest (4th draft report).

Chantarasri, S., 1994. Fisheries Resources Management for Sundarban Reserved Forest. Integrated resource Development of the Sundarbans Reserved Forest, Bangladesh. BGD/84/056, UNDP and FAO.

Chaudhuri, A. B. and A. Choudhury, 1994. Mangroves of the Sundarbans. Volume 1: India. World Conservation Union, Gland, 247

Chong, V.C., Sasekumar, A., Leh, M.U.C. and D'Cruz, R., 1996. The fish and prawn communities of a Malaysian coastal mangrove system, with comparison to adjacent mud flats and inshore waters. Estuar. Coast. Shelf Sci. 31(5).

Chong, V.C., Sasekumar, A., Leh, M.U.C. and D'Cruz, R., 1994. The fish and prawn communities of a Malaysian coastal mangrove system, with comparison to adjacent mud flats and inshore waters. Estuar. Coast. Shelf Sci. 31(5).

Chong, V.C., Sasekumar, A., Leh, M.U.C. and D'Cruz, R.,1990. The fish and prawn communities of a Malaysian coastal mangrove system, with comparison to adjacent mud flats and inshore waters. Estuar. Coast. Shelf Sci. 31(5), 703–722.

Choudhury J. K., 1997 Sustainable management of coastal mangrove forest. Development and social needs. XI World Forestry Congress, Antalya, Turkey. Vol 6, T.38.6.

Chowdhury R. A., Ahmed I., 1994 History of forest management Bangladesh. In: [Mangroves of the Sundarbans]. Hussain Z., Acharya G. (eds.), pp.155–180.

Christensen, B.,1982 Management and Utilization of Mangroves in Asia and the Pacific. FAO Environment Paper No. 3, FAO, Rome, 160 pp.

Clark, C.W., 1973. The economics of overexploitation. Science 181: 630-634.

Clark, J., 1971. Coastal ecosystems. The Conservation Foundation, Washington, D.C., 178 pp.

Clough, B.F.,1992. Primary productivity and growth of mangrove forests. Coastal and Estuarine Study No.41. American Geophysical Union, Washington, DC, pp. 225–250.

Das, M. 2009. Impact of Commercial Coastal Fishing on the Environment of Sundarbans for Sustainable Development. Asian Fisheries Science, volume 22: p157-167

Graaf, D. and Xuan, 1997. A generic plant functional attribute set and grammar for dynamic vegetation description and analysis. Functional Ecology, 11(3).

Erondu, E.S.,1990. The diet of wild and pond-cultured catfish (Chrysichthys nigrodigitatus) Bagridae, in mangrove swamps of the Niger Delta, Nigeria. J. Afr. Zool. 104(5), 367–374.

FAO,1999. Global Characterization of Inland Fishery Enhancements and Associated Environmental Impacts. FAO Inland Water Resources and Aquaculture Service, Fishery Resource Division, FAO Fisheries Circular 945, 89 pp.

Fielder, D.S., Bardsley, W.J. and Allan, G.L.,1999. Enhancement of Mulloway (Argyrosomus japonicus) in Intermittently Opening Lagoons. Fisheries Research and Development Corporation Project No 95/148. New South Wales Fisheries Final Report Series 14, 61 pp.

Fisheries Benchmark Status Report on Sundarbans Cluster by WorldFish Center, 2009.

Gear List of Sundarbans: Integrated Protected Area Co-management (IPAC)-Sundarbans by world fish center, 2010

Gillson, A.N., 1997. A generic plant functional attribute set and grammar for dynamic vegetation description and analysis. Functional Ecology, 11(3).

Gittins, S. P., 1981. A survey of the primates of Bangladesh. Unpublished report. Fauna Preservation Society, London. 64 pp.

Gopal and Junk, 2001. Mangroves of the Sundarbans. Volume 2: Bangladesh. World Conservation Union, Gland, 257 pp.

Grimes, C.B., 1998. Marine stock enhancement: sound management or techno-arrogance? Fisheries 23, 18–23.

Gundermann, N. And popper D.M., 1984. Notes on the Indo-Pacific mangal fishes and on mangrove related fisheries. In: POR, D. and I. DOR. ed., Hydrobiology of the Mangal. P.201-206.

Hamilton and Snedaker, 1984. Mangroves of the Sundarbans Bangladesh., Vol 2.

Hendrichs, H., 1975. The status of the tiger Panthera tigris (Linne, 1758) in the Sundarbansmangrove forest (Bay of Bengal). Saugetierkundliche Mtteilungen 23 : 16 1 - 199.

Hendricks, M.L., 1995. The contribution of hatchery fish to the restoration of American shad in the Susquehanna River. Am. Fish. Soc. Symp. 15, 329–336.

Hilborn, R.,1998. The economic performance of marine stock enhancement projects. Bull. Mar. Sci. 62, 661–674.

Hong, P.N. and San, H.T., 1993 Mangroves of Vietnam. IUCN the World Conservation Union. Bangkok, Thailand. 173 pp.

Hoq, M. E.,2008. Sundarbans Mangrove: Fish and Fisheries Ecology, Resources, Productivity and Management Perspectives. Graphic Media, Dhaka, Bangladesh. 271p.

Hoq, M. E. ,2008. Sundarbans Mangrove: Fish and Fisheries Ecology, Resources, Productivity and Management Perspectives. Graphic Media, Dhaka, Bangladesh.

Hoq, M. Enamul., 2007. An analysis of fisheries exploitation and management practices in Sundarbans mangrove ecosystem, Bangladesh. Ocean & Coastal Management, 50(5-6): 411-427.

Hoq, M.E., Islam, M.N., Kamal, M. and Wahab, M.A., 2001. Abundance and seasonal distribution of Penaeus monodon postlarvae in the Sundarbans mangrove, Bangladesh. Hydrobiologia 457, 97–104.

Huq, K. A. Alam, M. M. Mohsin, A.B.M. Islam, M.S. and Hossain, M.A.R., 2004. A review on the causes destruction of the sundarban mangrove fisheries of Bangladesh. Progress. Agric. 15(2) : 113-122

Huq, K.A. Islam, M.S. and Hossain, M.A.R., 2001. A review on importance of sundarban mangrove fisheries of Bangladesh, Bangladesh J. Fish. Vol. 24(1-2): 73-85.

Huq, S., Karim Z., Asaduzzaman M. and Mahtab F. , 1999. Vulnerability and Adaptation to Climate Change for Bangladesh, Kluwer Academic Publishers, Dordrecht, The Netherlands, 147 pp

Hussain, K.Z. and Acharya, G. ,1994. Mangroves of the Sundarbans, Vol 2, Bangladesh. IUCN, Bangkok, Thailand.

Hussain, Z. and Acharya G., 1994. Mangroves of the Sundarbans. Volume 2: Bangladesh. World Conservation Union, Gland, 257 pp.

Iftekhar M. S., Islam M. R., 2004. Degeneration of Bangladesh's Sundarban mangroves: a management issue. The Int For Rev 2:123-135.

Information on Revenue collection Rate for SRF, Integrated Protected Area Co-management (IPAC)-Sundarbans, 2010

Islam, M. S., Wahab M. A., 2005. A review on the present status and management of mangrove wetland habitat resources in Bangladesh with emphasis on mangrove fisheries and aquaculture. Hydrobiologia 542:165-190.

Islam, M.S. and Haque, M., 2005. The mangrove-based coastal and nearshore fisheries of Bangladesh: ecology, exploitation and management. Reviews in Fish Biology and Fisheries (2004) 14: 153–180

Islam, M.S., 2003. Perspectives of the coastal and marine fisheries of the Bay of Bengal, Bangladesh, Ocean Coast. Manage. 46(8), 763–796.

Islam, M.S. and Wahab, M.A. ,2004. A reviews on the present status and management of mangrove wetland habitat resources in Bangladesh with emphasis on mangrove fisheries and aquaculture.

Islam, N. D. K. M. , 2010. A study of the principal marketed value chains derived from the sundarbans reserve forest, Integrated protected area co-management (IPAC).

Ismail, M., 1990. Environment and ecology of the forested wetlands of the Sundarbans of Bangladesh. In: A. E. Lugo, M. Brinson and S. Brown (eds.), Ecosystems of the World, 15: Forested Wetlands. Elsevier, Amsterdam, pp. 357–386.

IUCN-BD, 2002a. Molluskan Biodiversity of Sundarban – Final report. IUCN-Bangladesh, Dhaka.

IUCN-BD, 2002b. Draft Report on the Orchid and Lichen of the Sundarbans. IUCN-Bangladesh, Dhaka.

IUCN-BD, 2002c. Draft Interim Report on Ornithological Study of Sundarban,. IUCN-Bangladesh, Dhaka.

IUCN, 1997. Sundarban Wildslife Sactuaries (Bangladesh): World Heritage Nomination – IUCN Technical Evaluation. http:// whc.unesco.org/archive/advisory_body_evaluation/798.pdf 12 pp.

IUCN, 1994. Mangroves of the Sundarbans. Vol. 2: Bangladesh. The IUCN Wetlands Programme. IUCN, Gland, Switzerland.

Jhingran, V.G., 1977. Fish and Fisheries of India. Hindustan Publ., Delhi Ch. Xv pp 954

Kamal, D. and Rabbani, A. G., 1998. Mangrove fisheries of the Sundarbans. National seminar on fisheries resources of Bangladesh with particular references to southwest region and the role of khulna university in its development. Khulna university. p.4-9

Kamal, M., 2000 Assistance to Fisheries Research Institute – A Report Prepared for the ‘‘Assistance to Fisheries Research Institute’’. Consultancy report on Marine Fisheries Resource Management. BGD/89/012. FRI-GOB/UNDP/FAO.

Kamal, M., 1999. Assistance to Fisheries Research Institute – A Report Prepared for the ‘‘Assistance to Fisheries Research Institute’’. Consultancy report on Marine Fisheries Resource Management. BGD/89/012. FRI-GOB/UNDP/FAO.

Kathiresan, and Bingham, 2001. Mangrove forests and aquatic productivity. Pp. 129-136.

Kathiresan, Kapetsky, J.M., 1994. Mangrove forests and aquatic productivity. Pp. 129-136.

Khan, M. A. R., 1986. Wildlife in Bangladesh mangrove ecosystem. Journal of the Bombay Natural History Society 83: 32-48.

Khan, M.G., Islam, M.S., Mustafa, M.G., Sada, M.N.U. and Chowdhury, Z.A., 1994. Bio-socioeconomic assessment of the effect of the estuarine set bag net on the marine fishes of Bangladesh. Bay of Bengal Programmed, Madras, India. BOBP/WP/94, 28 pp.

Lowe-Mcconnell, R.H., 1975. Fish communities in tropical freshwaters, their distribution, ecology and evolution. xvii+337. Longman, London.

Lugo, A.E. and Snedaker, S.C., 1974. The ecology of mangroves. 5: 39-64.

Macintosh, D.J., 1982 Fisheries and aquaculture significance of mangrove swamps, with special reference to the Indo-West Pacific region. In: Muir, J.F. and Roberts, R.J. (eds.), Recent Advances in Aquaculture. Croom Helm, England, pp. 4–85.

Macnae, W., 1974. Mangrove Forest and Fisheries. FAO, Rome IOFC:DEV:74:34, 35 pp.

Mahmood,N., 1985. OnFishery significance of the mangroves of Bangladesh. Paper presented at the Workshop on ‘‘Coastal Aquaculture and Environmental Management’’ held during 25–28 April, 1995 at Cox’s Bazar, organized and sponsored by Institute of Marine Science, Chittagong University (IMS, CU).

Matthes, H. and Kapetsky, J.M., 1988. Worldwide Compendium of Mangrove-Associated Aquatic Species of Economic Importance. FAO, Rome FAO Fishery Circular No. 814,

May, R.M., 1974. Stability and complexity in model ecosystems.. Princeton University Press, Princeton, NJ. Ch.Vii p265

Mohan, 1997. Forestry Master Plan, Main Plan 1993-2013, Volume I, Ministry of Environment of Forests, Asian Development Bank (TA No. 1355-BAN). Government of Bangladesh.

Molony, B.W., 2001. Environmental requirements and tolerances of rainbow trout (Oncorhynchus mykiss) and brown trout (Salmo trutta).with special reference to Western Australia: a review. Department of Fisheries, Western Australia Fisheries Research Report 130, 28 pp.

Morton, R.M., 1990. Community structure, density and standing crop of fishes in a subtropical Australian mangrove area. Mar. Biol. 105, 385–394.

Nickerson, D.J., 1999. Trade-offs of mangrove area development in the Philippines. Ecol. Econ. 28, 279–298.

Noss, R.F., 1990. .Indicator for monitoring biodiversity: a hierarchical approach. Conservation Biology 4, 355-369.

Oag, T.M., 1939. Report on the River Hooghly and its headwaters. Commissioner for the port of Calcutta. Calcutta, India.

Odum, W.E. and Heald, E.J., 1975. Mangrove forests and aquatic productivity. Pp. 129-136.

Pauly, D. and Ingles, J., 1986. The relationship between shrimp yields and intertidal (mangrove) areas: a reassessment. In: IOC:FAO Workshop on Recruitment in Tropical Coastal Demersal Communities. IOC, UNESCO, Paris, pp. 227–284.

Pauly, D., 1985 Ecology of coastal and estuarine fishes in southeast Asia: a Philippine case study. In: Yanez-Arancibia, A. (ed.), Fish Community Ecology in Estuaries and Coastal Lagoons, Towards an Ecosystem Integration, UNAM Press, Mexico, pp. 499–535.

Pearson, D.L., 1994. Selecting indicator taxa for the quantitative assessment of biodiversity. Philosophical Transaction of the royal Society of London: Biological Science, 345:75-79.

Pillay, T.V.R., 1967. Estuarine fisheries of the Indian Ocean coastal zone. Pp. 647-657. In: G.H. Lauft (Ed.). Estuaries. American Association for the Advancement of Science, Publ. 83, Washington, D.C.

Presler, F. A., 1991. Forest Management in the Sundarbans, 1875–1952. In: J. Seidensticker, R. Kurin, and A. K. Townsend (eds.), The Commons in South Asia: Societal Pressures and Environmental Integrity in the Sundarbans. The International Center, Smithsonian Institution, Washington, D.C.

Primavera, J.H., 1997. Fish predation on mangrove-associated penaeids: the role of structures and substrate. J. Exp. Mar. Biol. Ecol. 215, 205–216.

Primavera, J.H., 1996. Stable carbon and nitrogen isotope ratios of penaeid juveniles and primary producers in a riverine mangrove in Guimaras, Philippines. Bull. Mar. Sci. 58, 675–683.

Rabbani and Sarker, 1997. Status and distribution of birds of the Sundarbans, Bangladesh.

Rahman, M.M., Rahman, M.M. and Islam, K. S., 2010. The causes of deterioration of Sundarban mangrove forest ecosystem of Bangladesh: conservation and sustainable management issues. AACL Bioflux, Volume 3, Issue 2. http://www.bioflux.com.ro/aacl

Rahman, M.S., 2010 Ecology and management of Sundarban: A Rich Biodiversity of the Largest Mangrove Ecosystem. [http://srmilan.tripod.com]

Ramesh, M.X. and Kathiresan, K., 1992. Mangrove cholesterol in the diet of penaeid prawn Penaeus indicus. Ind. J. Mar. Sci. 21(2), 164–166.

Roberts, C.M., Bohnsack, J.A., Gell, F., Hawkins, J.P. and Goodridge, R., 2001. Effects of Marine Reserves on Adjacent Fisheries. Science 294, 1920–1923.

Robertson, A.I. and Blaber, S.J.M., 1992. Plankton, epibenthos and fish communities. In: Robertson, A.I., Alongi, D.M. (eds.), Tropical Mangrove Ecosystems. Coastal and Estuarine Studies No. 41. American Geophysical Union, Washington, DC, pp. 173–224.

Rouf, M. A. and Jensen, K.R., 2001.Coastal Fisheries Management and Community Livelihood. Possible Strategy for the Sundarbans, Bangladesh. ITCZM Monograph No. 04

Salter, R.E., 1987. Birds of prey and their conservation in the Sundarbans mangrove forests, Khulna, Bangladesh.

Sarkar, D., G. N. Chattopadhyay and K. R. Naskar., 1999. Nature and properties of coastal saline soils of Sundarbans with relation to mangrove vegetation. In: D. N. Guha Bakshi, P. Sanyal and K. R. Naskar (eds.),. Sundarbans Mangal. Naya Prokash, Calcutta¸ pp. 199– 204.

Sarker, S. U., 1985a. Ecological observation on the endangered whitebellied sea eagle Haliaeetus leucogaster (Gmelin) in the Sundarbans, Bangladesh. In: Symposium on endangered marine animals and marine parks. Vol. 4. Endangered and/or vulnerable other marine invertebrates and vertebrates. Paper No. 58. Marine Biological Association of India, Cochin.

Sarker, S. U., 1985b. Density, productivity and biomass of raptorial birds of the Sundarbans, Bangladesh. Proceedings of SAARC Seminar on Biomass Production, 15 April 1985, Dhaka. Pp. 84-92.

Sarker, S. U. and Sarker , N. J., 1985. Birds of prey and their conservation in the Sundarbans mangrove forests, Khulna, Bangladesh. ICBP Technical Publication No. 5. Pp. 205-209.

Sarker, S. U. and Sarker, N. J., 1986. Status and distribution of birds of the Sundarbans, Bangladesh. The Journal of Noami 3: 19-33.

Sasekumar, A., Chong, V.C., Lim, K.H. and Singh, H.R., 1994. The fish community of Matang mangrove waters, Malaysia. In: Sudara, S., Wilkinson, C.R. and Chou, L.M.

(eds), Proc. 3rd ASEAN-Australia Symposium on Living Coastal Resources, Vol. 2: Research Papers. Chulalongkorn University, Bangkok, Thailand, pp. 457–464.

Schlich, W., 1875. Remarks on the Sundarban. Indian Forester 1: 9–11.

Seidensticker, J. and Hai, 1983. The Sundarbans Wildlife Management Plan. Conservation in the Bangladesh Coastal Zone. IUCN, Gland, 120 pp.

Seidensticker, J., 1991. The Bangladesh Sundarbans as Wildlife Habitat: A Look Ahead. In: J. Seidensticker, R. Kurin, and A. K. Townsend (eds.), The Commons in South Asia: Societal Pressures and Environmental Integrity in the Sundarbans. The International Center, Smithsonian Institution, Washington, D.C.

Siddiqi, N.A., Islam, M.R., Khan, M.A.M.and Shahidullah, M. (1993) Mangrove nurseries in Bangladesh. Mangrove Ecosystems Occasional Papers 1. ISME, Okinawa, 14 pp.

Singh, H.R., Chong, V.C., Sasekumar, A. and Lim, K.H., 1994. Value of mangroves as nursery and feeding grounds. In: Wilkinson, C.R., Suraphol, S. and Chou, L.M. (eds.), mStatus Reviews. Proceedings of the Third ASEAN-Australia Symposium on Living Coastal Resources, Vol. 1. Chulalongkorn University, Bangkok, pp. 105–122.

Sinha, M., 1998. Fisheries in Coastal Areas of West Bengal and Required Conservation. CIFRI, Barrackpore, India.

Staples, D.J., Vance, D.J. and Heales, D.S., 1985. Habitat requirements of juvenile penaeid prawns and their relationship to offshore fisheries. In: Rothlisberg, P.C., Hill, B.J. and Staples, D.J. (eds.), Second Australian National Prawn Seminar. CSIRO, Cleveland, pp. 47–54.

Stark, H., 1978. Man, tropical forests and the biological life of soil. Biotropica 10: 1-10.

Tabb, D.C., Heald, E.J., Beardsley, G.L., Roessler, M.A., and Alexander, T.E., 1976. Vegetation. Pp. 197-226.

Travis, J., Coleman, F.C., Grimes, C.B., Conover, D., Bert, T.M. and Tringali, M., 1998. Critically assessing stock enhancement: an introduction to the Mote Symposium. Bull. Mar. Sci. 62, 305–311.

Turnar, S.J., 1995. Scale, observation and measurement: critical choices for biodiversity research.

Twilley, J.K., 1996. Towards more rigorous assessment of biodiversity. In: Bachman, P., Khol, M. and Paivinen, R. (eds) Assessment of biodiversity for improve forest planning. European Forestry Institute Proceedings No.18.

United Nations Environment Programme,1992. Convention on biological diversity. UNEP, Naibari, Na. 92-7807.

Vance, J.K., 1996. Towards more rigorous assessment of biodiversity. In: Bachman, P., Khol, M. and Paivinen, R. (eds) Assessment of biodiversity for improve forest planning. European Forestry Institute Proceedings No.18. Kluwer Academic Publishers, Dordrecht, Netherlands. Pp211- 232.

WCMC. 1996. Assessing Biodiversity Status and Sustainability. WCMC Biodiversity Series No.5.Groombridge,B.and Jenkins,M.D.(Eds),World Conservation Press,Cambridge,UK.140p

Welcomme, R.L. and Bartley, D.M., 1998. An evaluation of present techniques for the enhancement of fisheries. FAO Fish. Tech. Pap. 374, 1–35.

Wiley, R.W., 1999. Fish hatcheries are a powerful tool of fisheries management. Fisheries 24, 24–26.

YADAVA, Y.S., 2003. Exploring deep sea avenue. The Hindu Survey of Indian Agriculture 2004. p 91-95

Yanez-Arancibia, A., Soberon-Chavez, G. and Sanchez-Gil, P., 1985. Ecology of control mechanisms of natural fish production in the coastal zone. In: Yanez-Arancibia, A. (ed.), Fish Community Ecology in Estuaries and Coastal Lagoons, Towards an Ecosystem Integration. UNAM Press, Mexico, pp. 571–595.