

An analysis of fisheries exploitation and management practices in Sundarbans mangrove ecosystem, Bangladesh

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Abstract

Sundarbans mangrove of Bangladesh—a World Heritage Site has been providing a wide array of fisheries activities for a large number of coastal people. Over-fishing, particularly collecting *Penaeus monodon* postlarvae from mangrove and near-shore waters, due to increasing demand from shrimp farming, and over exploitation of plant and wildlife species are exerting increasing amount of stresses on the viability of this delicate ecosystem. A number of regulations have been enacted for the conservation of the resources and ecosystem, but yet to rigorously enforced. The initiative to institute a comprehensive fisheries management system by the recent Asian Development Bank supported “Sundarbans Biodiversity Conservation Project”, therefore, marks the beginning of a new era for sustainability of aquatic resources in the Sundarbans.

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1. Introduction

The Sundarbans, the largest single block of mangrove ecosystem in the world, is located in the estuary of the river Ganges, spanning an area of about 1 million hectares in Bangladesh and India. The Sundarbans in Bangladesh cover an area of 6017 km² along its southwestern part sharing 4143 km² of land and 1874 km² of water body. The ecological succession of West Bengal area of the Sundarbans in India is quite different from that of the Bangladesh’s Sundarbans. Unlike most mangrove forest of the world, the tree vegetation of Sundarbans is not dominated by the members of the family Rhizophoraceae

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[1]. The existence of Sundarbans, forming an ideal mangrove ecosystem, supports a large groups of fish, shrimp, edible crab and also supplies food and cash to the coastal communities. One-third of the country's population is dependent on Sundarbans [2]. With over 3.5 million people from the surrounding areas depend directly or indirectly on the Sundarbans for their livelihood, the forest has been reducing alarmingly day by day.

The Sundarbans mangrove forest was declared as “Reserve Forest” in 1875–76 under the first “Forest Act” of the British India. As a reserve forest, control of fishing within Sundarbans is exercised by the Forest Department (FD) and the output from the fishery being regarded as “minor forest products” [3]. As with other forest products, FD exercises their control by issuing of boat/transportation and fishing permits. Activities of the FD on fisheries are exclusively focused on revenue collection. The fisheries resources are exploited on the basis of maximum sustainable yield (MSY), which is not ideal for sustainable management for the fisheries resources of Sundarbans [4]. The UNESCO has declared the Sundarbans as a World Heritage Site in 1999. No comprehensive fisheries management system has ever been existed in the Sundarbans, although currently Asian Development Bank is supporting a project “Biodiversity conservation in the Sundarbans” and some management options are in the process of implementation [5]. The present report aimed at evaluating the fisheries structure and management practices in Sundarbans Reserve Forest (SRF) and, to some extent, the coastal shrimp farming in Bangladesh.

2. Resource exploitation in SRF

The Sundarbans water supports 208 species of fish and crustaceans belonging to 84 families [3], a higher total than that of other tropical mangroves [6]. The mean fish biomass is 39 kg/ha [7], which is comparable to the *Rhizophora*-dominated forests of Malaysia [8]. Table 1 represents the commercial landings of major fisheries group, as recorded by FD from 1985–86 to 1999–2000. Landing of white fish, which represents major share of Sundarbans fisheries, is gradually declining. Marketable shrimp landings is also in a decreasing trend. Landing of *Tenulosa ilisha* and production of dried fish are fluctuating. *Penaeus monodon* fry collection was in peak during 1993–94 to 1996–97, but started to reduce from 1998 to 2000. Harvest of *Scylla serrata* increased from 1993 to 1994, but also reduced during the year 1998–2000.

The magnitude of stock of fishery resources in Sundarbans water has not been assessed systematically and there is very little information on their quality. The production figure assessed by the FD shows sharp fluctuations from year to year and cannot be used to correctly guess the possible availability of stock. The total annual fisheries landing, including the offshore catch in Sundarbans, may be as high as 75,000 MT [9]. Estimation of yield, exploitation rate and MSY of major shell- and finfish species in SRF are presented in Table 2. The fishery of *T. ilisha*, *Pangasius pangasius*, *Plotossus* spp., *S. serrata* was found to be over-exploited at $E = 0.36–0.42$. The exploitation of *Lates calcarifer* has been estimated to be at its optimum at present with a yield of about 150 MT. The fishing of *Johinius argentus* is nearly fully exploited. The current *Macrobrachium rosenbergii* harvest is far from the optimum. The exploitation of gastropod and oyster seems to be underutilized. The IUCN [10] listed some species of Sundarbans as threatened which are presented in Table 3. Abundance of riverine catfish *Pangasius pangasius* and *Plotosus canius* in the SRF is very low and in the verge of extinction.

Table 1
Fish production (1000 MT) from Sundarbans Reserve Forest (SRF)

Year	Group-wise production							
	White fish	Marketable shrimp	Undersized shrimp	<i>T. ilisha</i>	<i>S. serrata</i>	Crab and shrimp residues	Dry fish	<i>P. monodon</i> fry l(million)
1985–86	NA	0.46	0.57	0.66	NA	NA	NA	NA
1986–87	NA	0.48	0.32	0.62	NA	NA	NA	NA
1987–88	3.86	0.54	0.26	0.97	0.02	0.004	0.58	14.10
1988–89	3.75	0.51	0.14	0.53	0.01	0.01	0.37	30.43
1989–90	3.15	0.37	0.18	0.90	0.04	0.01	0.45	40.34
1990–91	2.95	0.33	0.17	0.65	0.12	0.02	0.61	72.69
1991–92	2.82	0.32	0.18	0.55	0.27	0.03	0.53	110.32
1992–93	3.09	0.31	0.18	0.50	0.49	0.11	0.79	126.97
1993–94	2.53	0.27	0.19	0.59	0.53	0.19	0.86	209.64
1994–95	2.58	0.28	0.20	0.45	0.70	0.35	0.59	263.41
1995–96	2.53	0.28	0.13	0.54	0.64	0.36	0.65	253.07
1996–97	2.53	0.26	0.08	0.39	1.00	0.25	0.74	142.22
1997–98	2.50	0.24	0.10	0.41	0.82	0.36	0.65	127.90
1998–99	1.95	0.20	0.13	0.33	0.42	0.32	0.52	87.97
1999–2000	1.92	0.21	0.10	0.46	0.37	0.05	0.25	57.22

Table 2
Yield, exploitation rate and MSY of fisheries resources in the Sundarbans [4,12]

Species	Yield (tons)	Exploitation rate	MSY (tons)	Remarks
<i>Tenualosa ilisha</i>	762	0.41	523	Over exploited
<i>Lates calcarifer</i>	150	0.35	160	Fully exploited
<i>Pomadasys hasta</i>	232	0.40	457	Optimum
<i>Johnius argentus</i>	548	0.47	593	Optimum
<i>Pangasius pangasius</i>	135	0.42	92	Over exploited
<i>Plotossus canius</i>	141	0.36	92	Over exploited
<i>M. rosenbergii</i>	274	0.30	711	Optimum
<i>Penaeus monodon</i>	180	—	226	Optimum
<i>Scylla serrata</i>	375	—	283	Over exploited
Oyster	3000	—	6000	Under exploited
Gastropod	35	—	113	Under exploited
<i>P. monodon</i> fry	1453 millions	—	672 millions	Over exploited

2.1. Status of major fishery in SRF

Hilsa (*T. ilisha*) still represents about 15% of the total fish production of Bangladesh even after showing a declining trend over the past few years [11]. Out of annual landing of 200,000 MT, nearly 400 MT comes from the Sundarbans. Hilsa landing in SRF has been reduced by 56% in recent years compared to that in 10 years back. The size of hilsa catch in SRF is probably dependent on the size of the stock in the northern Bay of Bengal and controlled by multiple factors which include the pattern of spawning migration. Long-term

Table 3
Threatened fish species of the Sundarbans (modified from IUCN [10])

Family	Species	Status	Global status
Ambassidae	<i>Pseudambassis baculis</i>	VU	—
	<i>P. ranga</i>	VU	—
Anguillidae	<i>Anguilla bengalensis</i>	VU	—
Carcharhinae	<i>Carcharhinus limbatus</i>	—	VU
	<i>Glyphis gangeticus</i>	—	CR
Eleotridae	<i>Butis butis</i>	NO	LR
Plotosidae	<i>Plotosus canius</i>	VU	—
Pristidae	<i>Pristis microdon</i>	—	EN
Scatophagidae	<i>Scatophagus argus</i>	EN	—
Schilbeidae	<i>Pangasius pangasius</i>	CR	—
	<i>Silonia silonia</i>	EN	—
Syngnathidae	<i>Hippocampus kuda</i>	—	VU
	<i>Microphis deocata</i>	EN	—

CR, critically endangered; EN, endangered; LR, lower risk; NO, not threatened; VU, vulnerable.

changes in biological behavior, particularly in spawning and migratory habits as a result of changes in the morphology and hydrology of the major river systems of Bangladesh, may be one of the reasons behind this phenomenon. The capture of juvenile hilsa (*jatka*) is also believed to be highly detrimental to the hilsa stock. It is probable that fishing mortality on the Sundarban's hilsa stock has little impact on recruitment of the main hilsa stock of the country.

Giant prawn *M. rosenbergii* is the most valuable crustacean in Sundarbans water. It is not clear whether *M. rosenbergii* is being overexploited or not [4,12]. However, a large number of juveniles (<3 cm carapace length) are being harvested. The mud crab (*S. serrata*) is harvested on an increasing scale from the Sundarbans and has become into an export oriented lucrative business commodity. The crab fishery has been come under heavy fishing pressure in recent years and considered to be overexploited. There is a significant price variation of this species in the market, which promoting some selectivity of the capture: berried females are more valuable than female without eggs, while males are of least value. Females without egg are sold for fattening in ponds which then export as berried females. Mud crab fishing takes place round the year throughout the SRF of which 30% are berried females. The potential of crab fishery seems to be vast and the prospects of its culture, just as with shrimp, need to be explored. During shrimp fry collection, crab seed are indiscriminately destroyed. The presence of a high abundance of crab megalopa in Sundarbans water would allow for a new mud crab aquaculture grow-out industry to develop the current small-scale crab fattening practices.

2.2. Over-exploitation of fisheries resources in SRF

A prominent feature of the SRF fishery is that its size has been gradually expanding. The present production is about 12,000 MT, almost double of them in 10 years back. A 4-year forecasting on yield of Sundarbans fisheries (based on landed data) shows a marked decline of white fish, *S. serrata*, shrimp and crab residuals and *Penaeus monodon* fry catch [13]. Near-shore fisheries of Sundarbans ecosystem is also believed to be over-exploited.

The extensive use of destructive set bag nets is responsible for this in the estuarine and neritic waters. This expansion needs to be controlled if shell- and finfish stocks are to be conserved. Without control, over-fishing will continue and stock of the currently most heavily exploited species will crash. Fishermen will then turn to less desirable species, and under increased fishing pressure, those population will crash too.

A long-term fisheries data may contain facts reflecting extreme situation and then define the upper and lower limits for predictions of yield and stock size [14]. Catch control is based on determining the MSY of a fish stock and then setting a total allowable catch. The total allowable catch size can be adjusted from year to year based on the status of the stock in relation to MSY. Thus, if the stock is depressed, a relatively low target would be set out to allow the stock to recover. Environmental and biological factors, in addition to the conventional socioeconomic factor, also contribute in determining allowable catch.

2.3. Loss of biodiversity

Coastal shrimp farming in Bangladesh largely relies on the supply of wild *Penaeus monodon* fry, although sizable number of hatcheries are producing postlarvae (PL) [15]. However, the quality of PL produced could not ensure the maximum production benefits. Though shrimp fry collection practice has offered a good source of income for coastal people, this practice brings substantial negative impacts on estuarine and marine fish and shrimp stocks. Mass shrimp fry collection is a threat to the coastal ecosystem, causing damage to the nursery grounds of many species, and to newly planted mangroves as well as to reserve forest [16]. During the past 10 years, availability of most desired *Penaeus monodon* PL has been gradually declined [15,17–20] with the increased level of colossal loss in the coastal rivers as shown in Table 4.

The recruitment of other finfishes and shrimps, and macro-zooplanktons which act as a component of food chain for other groups of aquatic animals, is severely damaged as a consequence of extensive *Penaeus monodon* shrimp fry harvesting from the Sundarbans waters. It is essential for the shrimp fry to reach the small creeks and brackishwater of the estuaries to find shelter and food. The actual stock recruitment of shrimp in the deep sea is directly dependent on the survival of the juvenile in the mangrove nursery grounds and their return to sea. However, if the nursery grounds are destroyed or the juveniles are captured, the chance for the juveniles to return to the sea will obviously be reduced leading to the scarcity of mature mother stock. This will result their less availability in the sea and in the estuary for breeding. A ban on shrimp fry collection came into order in September

Table 4
Losses (%) of shell- and finfish for collecting *Penaeus monodon* PL in coastal water of Bangladesh

Year	<i>P. monodon</i>	Other shrimps	Finfishes	Macrozooplanktons	References
1990	1.20	21.5	30.79	46.5	[17]
1992	0.64	16.02	9.97	73.37	[18]
1995	0.49	13.16	3.19	83.16	[19]
1996	0.17	7.6	2.11	90.12	[20]
1999	0.17	17.2	7.19	75.44	[15]

2000 as an effect of it, the fisheries and biodiversity was increased. However, it will be very difficult to enforce the law because of the large number of fry collectors do not have viable alternative employment opportunity [21]. It is also often the only source of income for thousands of coastal rural women.

3. Population involved in fishing activities

For the local population in the Sundarbans, artisanal fishery is the predominate type of fishing. Artisanal fisheries are labor intensive, capital extensive, traditional in nature, and pursued for subsistence purposes, commercial profits or for both. Inshore, estuarine and coastal fisheries of Sundarbans provide a major source of livelihood for about 200,000 fishermen operating daily in the Sundarbans water. An estimated 14% of people (225,000) living inside a 10 km border around the Sundarbans, participate in *Penaeus monodon* fry collection (Table 5) [9]. They include both males and females from all age groups. Another 20,000 who operate as primary and secondary traders must be added to this, who carry fry from the primary collection points to the shrimp farms in one, two or three stages. Population involvement in hilsa fishing and dried fish production is also high, but in this two activities, people from outside Sundarbans region are engaged as part time employment. *Penaeus monodon* fry collecting gears are generally operated in the rivers of upper part of the SRF. Number of fry collectors are found to be increased considerably during the past 10 years with corresponding increase in fishing effort, whereas the volume of fry catch has been declined (Fig. 1) [22].

Table 5
Denudation of the Sundarbans due to shrimp farming (modified from Shahid and Islam [23])

Study area	Forest area (ha)		Denuded area (ha)	Cause	Present use	Impact	Remark
	1975	1998					
(i) Area-1 Gorikhali	36	—	108	Shrimp farming	Shrimp farming	Loss of habitat for wildlife	Denudation started before 1975
(ii) Area-2 Jangalkanda	Non-forest area	Non-forest area	No denudation of forest	—	Shrimp farming	Increasing salinity in buffer zone	Outside the Sundarbans
(iii) Area-3 Kalabogi	Non-forest area	Non-forest area	No denudation of forest	—	Rice and shrimp culture alternatively	Increasing salinity in buffer zone	Outside the Sundarbans
(iv) Area-4 Kailasganj	Non-forest area	Non-forest area	No denudation of forest	—	Shrimp farming	Increasing salinity in buffer zone	Outside the Sundarbans
(v) Area-5 Khajuria	Non-forest area	Non-forest area	No denudation of forest	—	Rice and shrimp culture alternatively	Increasing salinity in buffer zone	Outside the Sundarbans
(vi) Area-6 Dhangmari	Non-forest area	Non-forest area	No denudation of forest	—	Agriculture	—	Outside the Sundarbans

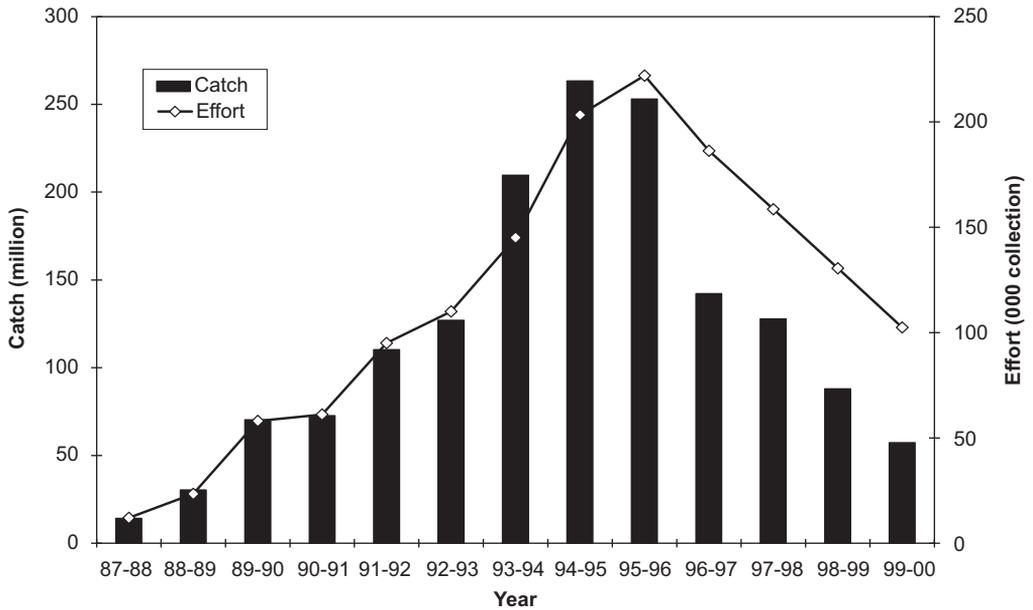


Fig. 1. Relationship between population engaged in *Penaeus monodon* PL collection and effort during 1987–88 to 1999–2000 (modified from Bernacsek and Haque [22]).

4. Mangrove destruction

4.1. Impacts of shrimp farming on the Sundarbans buffer zone

Though there is negligible denudation of the Sundarbans mangrove forest due to shrimp farming in the southwestern region, the unregulated encroachment of shrimp farming facilities into the inland fertile rice growing fields in the buffer zone of the Sundarbans has been causing increase in salinity of soils due to salt water seepage (Table 6). The saline water brought into the fields within the embankments increases salinity of the soil and destroys the nutrient balance through accumulation of sodium chloride. As a result, the soil of the area is gradually becoming sterile and thereby reducing its fertility for other agricultural crop production. Increase in salinity in the buffer zone and over extraction of resources are also creating serious threat to the Sundarbans mangrove forest.

Shrimp farming from January to September along the southwestern coastal region of Bangladesh has been seriously hampering rice cultivation. Because, the cultivation of the major rice crop delayed from its usual time of transplantation in June–July and thus there is decrease in rice production. A survey of the *aman* rice growing areas of 1987 and 2000 using NOAA (AVHRR) satellite indicate that the *aman* rice growing land was decreasing from 1987 to 2000 [23].

4.2. Destruction of mangrove trees during fishing

Desperate attitude of the fishermen contributes to the degradation of both wood and non-wood resources in SRF. About 90% of the boats that regularly enter the forest are

Table 6
Estimates of population involved (%) in exploiting SRF resources [9]

SRF resource exploitation	Participation rate (km)		Nos. of persons (1000) involved in exploitation (km)		
	0–10	10–20	0–10	10–20	0–20
1. Any resource	16.2	—	155.0	81.0	236.0
Wood	2.1	—	20.1	—	20.1
<i>Nypa</i> 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	0.04	0.002	0.4	—	0.4
Turtle	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

small boats which require anchor posts. The FD permits boat owners to have one set of the anchor posts per year on payment of royalty. In practice, however, fishermen use more anchor ports than permitted. Normally they cut the mother trees of *gewa* (*Excoecaria agallocha*) and/or *sundri* (*Heritiera fomes*). The larger boats do not require anchor posts, but do require poles for balancing their boats and vertical posts for tying up their cargo. Generally, winter fishermen temporarily stay inside the forest for sea fishing and fish drying in the islands of southern Sundarbans and use wood resources to build jetties, drying beds, shelters and also for cooking purposes.

5. Management practices in SRF

5.1. Role of FD

Scientific management of forest resources was first initiated in the Sundarbans in the 1870s when a Forest Management Division was established exclusively for the management of Sundarbans in the Gangetic Delta. The FD exercises its control on fisheries resources in SRF through collection of tolls, taxes and revenue from fishing boats, fishermen and fishery products. Every fishing unit/party needs to get a license at the rate of Tk 1500, which is renewable each year at Tk 750 (1 US\$ = Tk 68.5). Failure of renewal of license within 2 years of issuing license, a new license must have to be taken. At the time of issuing permits from the forest stations, tax for fishing and staying in the forest is determined at the rate of Tk 3/person/week for fishing and Tk 0.25/person/week for staying in the forest. In failure to come back with the designated time, a penalty of Tk 3/person/week is charged. Fishing is permitted for 3 weeks in a month. After fishing, the fishermen return through the same forest station they enter and pay tax for their catch.

The fisheries status and management of SRF was scientifically studied in 1994 through a FAO-assisted project (BGD/84/056) [12], from which fisheries structure of Sundarbans was

understood, although Rabanal [24] under another FAO-assisted project (FO:TCP/BGD/2309) observed some basic fisheries of SRF. In depth study on fisheries of Sundarbans was first conducted by Chantarasri [12], where description and MSY of major fisheries resources of Sundarbans were estimated and some management issues were addressed. The data produced by that study were very comprehensive 1-year data and after that no long-term data collection was done, which could provide more information and ensure the sustainable exploitation of the resources. In Sundarbans, the major problem for fisheries management is the absence of fishery experts with overall responsibility of fisheries in SRF.

To sustainable yield management of mangroves for coastal fisheries, the mangroves are kept for providing nutrients, breeding grounds and nursery grounds as permanent habitat. Mangrove forest management is based on the sciences and skills of geology, pedology, climatology, hydrology, botany, ecology, silviculture, forest technology and economics—in the selection and treatment of both wood and non-wood resource [25]. About 46% of the mangrove forests of the world are in Asia [26]. Many Asian countries have established many tools that can provide better baseline information which include remote sensing, GIS and environment impact assessment studies. Sundarbans is still lagging behind in using such techniques.

5.2. Regulations on Sundarbans fishery

The management aspect of fisheries in SRF only covers revenue collection, although some Acts/Regulations exist (Table 7). 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 [12]. Closed season and wildlife sanctuary regulations were introduced recently. Management measures taken are not used at the present time 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 system are outlined in Fig. 2 [5]. Proposed new management regulations for the 17 fisheries of the Sundarbans [5] are summarized below:

- *Pangasius pangasius* and *L. 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, and of *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.

- The only legal mesh size for all gill nets, lift nets, shore seines and set bag nets is 5 cm. No other mesh sizes (smaller or larger) are permitted.
- Caste nets are not permitted for commercial fishing, but may be used for subsistence fishing by non-fishermen only (i.e. wood cutters and honey gatherers).
- Sport fishing using angling gear is only permitted on a catch and release basis.
- Capture of wildlife, sea snakes, large sharks, large rays, large sawfish and very large *L. calcarifer* and *Pangasius pangsius* is strictly prohibited.

Table 7
Existing and proposed fisheries management and conservation rules in SRF

Legislation	Summary of regulations	Implementing agencies
Indian Forest Act, 1878	<ul style="list-style-type: none"> ● 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	<ul style="list-style-type: none"> ● A fishing permit is required to fish in reserved or protected forests ● Royalty may be levied on fish caught in tidal waters of reserved and protected forests ● 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	<ul style="list-style-type: none"> ● <i>Khal Closure Regulation (1989)</i>: closes 18 <i>khals</i> permanently for fishing to ensure natural fish breeding ● <i>Collection & Export of Live Crab Regulation (1995)</i>: closes the entire SRF for crab fishing from December to February to ensure crab breeding ● <i>Closed Season Regulation (2000)</i>: closes fishing in the entire SRF for five species (<i>P. pangasius</i>, <i>P. canius</i>, <i>L. calcarifer</i>, <i>M. rosenbergii</i>, <i>S. serrata</i>) during 1st May to 30th June to ensure natural breeding 	Forest Department
Wildlife Sanctuary Regulations, 1999	<ul style="list-style-type: none"> ● Fishing is permanently prohibited in the three wildlife sanctuaries of SRF 	Forest Department
Other Regulations for Fisheries in SRF	<ul style="list-style-type: none"> ● It is illegal to place nets across a <i>khal</i> and thereby completely block it ● It is illegal to sting a rope transversely across a <i>khal</i> 	Forest Department
<i>Proposed regulations</i> Proposed by FAO through its project (BGD/84/056) in 1994	<ul style="list-style-type: none"> ● Introduction of closed season ● Introduction of protected zones i.e fish sanctuaries 	Some of the FAO proposal have been

Table 7 (continued)

Legislation	Summary of regulations	Implementing agencies
Proposed by World Bank through its project in 1998	<ul style="list-style-type: none"> ● Introduction of minimum size limit of two species—30 cm for <i>L. calcarifer</i> and 10 cm for <i>J. argentatus</i> ● Restriction on number of gillnets ● Maintenance of exploitation rates for commercial species at current levels except <i>P. monodon</i> fry ● Coordination of regulatory powers of Forest Department and Department of Fisheries for life-cycle management of migratory fish stocks i.e. <i>T. ilisha</i> and <i>L. calcarifer</i> ● Closure of small <i>khals</i> (less than 30 m wide) for 12 months within 5 km radius of Forest Stations in SRF, in alternating years ● Permanent closure for wildlife sanctuaries and any other protected areas ● Maintenance of records of permits issued and catch for individual fishermen ● Maintenance of annual harvest limit for various species, initially <i>T. ilisha</i>, all catfishes and mud crab ● Issuance of catch quota to individual fishermen based on a share of the total allowable catch (TAC) ● Restriction of shrimp fry catch to boundary rivers only ● Release of small fishes back to the water caught in shrimp fry collection nets ● Prohibition on harvesting of brood crabs or female crabs with egg ● Maintenance of minimum harvesting weight of 200 g for male and 120 g for female crabs ● Enforcement of National Fish Act to maintain minimum harvesting size limits and closed seasons ● 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 	<p>implemented by Forest Department</p> <p>Some of the regulations have been implemented and implementation of others are questionable</p>

Khals: branches of rivers i.e. canals.

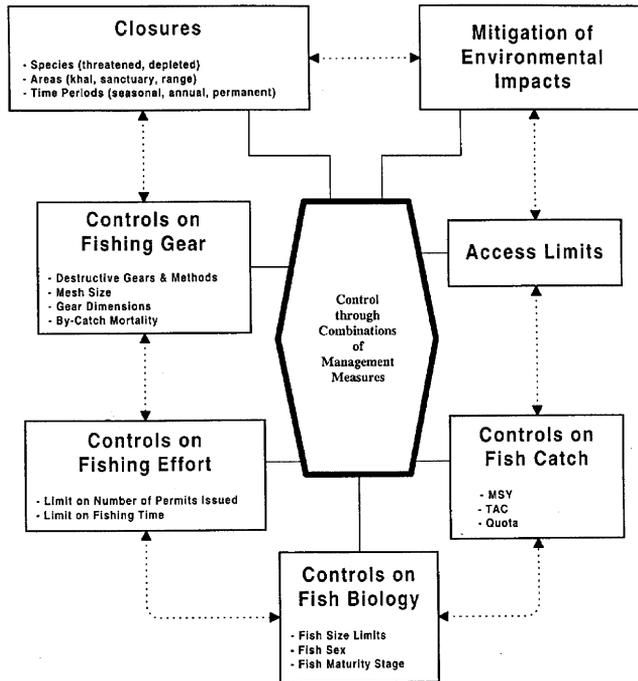


Fig. 2. Control regimes under new Sundarbans fisheries management system [5].

6. Legal regime in relation to SRF and its fishery

6.1. Access right by local community

Sundarbans mangrove forest and water bodies are controlled by the state government through FD. Traditional right of access to Sundarbans is through membership in village community dominated by local elite. These rights are not formally regulated, but are the birthright of the community. Common property and access rights are no longer recognized in this tenural system [27]. The privatizing of public lands including mangrove forests, evolved through the leasing authority of government. Thus, multiple use of common resources are transferred to single use private control. Because of the poverty and political weakness of coastal people, external capital has generally been used to extract resources or develop coastal lands. Consequently, most of the benefits of development flow are away from such communities to the inventors. Mitra [28] described in some details the history of traditional management of the Sundarbans before it was subsumed by rent taking. As commercial demand increased, common property values declined and the traditional rules governing access weakened to the point of ineffectiveness. Concurrently, the elites, whose main interest had been in controlling access to the forest, shifted to rent taking from the new resource extractors. The extractors increasingly came from areas far remote from the forest [28]. At the beginning of the 21st century, impoverishment of communities that depends upon the Sundarbans is accompanied by increased exploitation and powerlessness.

6.2. Laws and policies

The National Fishery Policy promulgated in 1998 includes measures to promote and manage shrimp farming in coastal lands. The establishment of shrimp culture zones is foreseen, but information on implementation mechanisms are not available. Measures are included to mitigate some of the negative effects of uncontrolled shrimp aquaculture. The policy directs that shrimp farm sites should be selected in consultation with the Ministry of Environment and Forests to ensure that they will maintain ecological balance. The policy is new and effective implementation awaits future development. The ground situations, however, quite complex and local power structure plays a significant role in deciding the actual outcome. Almost none of these policies, which safeguard the interest of the people, are being implemented. Chronological development of different legal base of shrimp culture are highlighted in Table 8.

Table 8
Different National Policy related to shrimp cultivation and environment protection

Policy	Summary of major issues
Private Fisheries Protection Act, 1889	Oldest fisheries regulation. Protection of private fisheries and the rights of landowners who do not like to lend their land for shrimp farming, but is in conflict with the Shrimp <i>Mohal</i> Policy which authorizes the government to declare an area as shrimp <i>jolmohal</i>
Forest Act, 1927	Allocation of fisheries management responsibilities to the Forest Department in mangrove areas. This implies duplication of the tasks and responsibilities of Department of Fisheries, with special relevance to fisheries management in the Sundarbans
The Protection and Conservation of Fish Act, 1950	Allowing the government to frame rules for protection and conservation of fish and fisheries
The Government Fisheries Protection Ordinance, 1959	Protection of government owned water bodies against unauthorized fishing
The Marine Fisheries Ordinance, 1983. Amended Rule 28, 2000	Protection of mother shrimps in marine waters. The government has declared four places in the Bay of Bengal in the territorial waters of Bangladesh to be marine protected areas with a view to ensure breeding of fish and shrimps
The Protection and Conservation of Fish Rules, 1985. Amended Rule 8 (IA), 2000	Regulations of licensing, gears and areas of fishing in marine water. Jurisdiction is limited from the 18.29 m depth line to the limit of territorial waters. This thus excludes shallow waters where shrimp fry catching occurs. The ordinance prescribes mesh sizes for different gears, defines the need for fishing licenses when not registered under any other law (as most ships are registered with the Department of Shipping, this rule is by-passed) and facilitates the declaration of marine protected areas
The Protection and Conservation of Fish Rules, 1985. Amended Rule 8 (IA), 2000	Ban on catching of fish, shrimp and prawn fry or post larvae. During last amendment in 2000 when rule 8 (IA) was added, it conflicts with National Fish Policy, 1998. This also conflict with the Embankment and

Table 8 (continued)

Policy	Summary of major issues
The Shrimp Cultivation Tax Act, 1992	Drainage Act, 1952, which needs to modify the provision that “construction of boundaries, dams and embankments in or across the rivers, canals, floodplains are prohibited in general and can only be constructed for irrigation, flood control or drainage”. Should include the purpose of “water supply in shrimp farms” Establishes rules for pay tax on land used for shrimp cultivation within polders of Water Development Board
The Environmental Conservation Act, 1995 and Elaborated Environment Protection Rules, 1995	Provision for environmental clearance. Revision is needed to avoid ship-breaking industry which is relaxed under the guise of re-rolling mills
Fish and Fish Products (Inspection and Quality Control) Rules, 1997	Lay down detailed procedures for inspection and quality control of fish and fish products during transportation, processing and export as well as empower officers to implement the rules
Shrimp <i>Mohal</i> Management Policy, 1992 National Environment Policy, 1995	According to the National Environment Policy, the salinity in land cannot be increased. The Shrimp <i>Mohal</i> Management Policy declares suitable land for shrimp cultivation as shrimp <i>mohal</i> , thereby challenging the National Environment Policy
National Environment Policy, 1995 Export Policy, 1997–2002	An expansion of traditional/semi-intensive cultivation of shrimp, as targeted in the Export Policy, could lead to an increase in salinity, which is not allowed under the provisions laid down in the Environment Policy
National Water Policy, 1998 Agriculture Policy, 1999	The environmental issues against impact of the use of agro-chemicals on soil, water bodies, fisheries and overall biodiversity are not included in the Agriculture Policy. Emphasis are given to use of water only in Agricultural Policy, while, the National Water Policy strongly recommends the integration of uses of water taking into consideration the interest of all users
National Land Use Policy, 2001	Zoning in the coastal areas on the basis of land topography, tidal inundation, water salinity, soil quality and other environmental factors, with the active participation of local people

Mohal: Land owned by the Government, often leased out for fisheries, irrigation and other purposes.

Jalmohal: A large water body, owned by the Government, often leased out for fisheries.

7. Conclusions and policy recommendations

There is a National Policy to protect the area and provide for sustainable use of the Sundarbans resources. Also a land use zoning framework for the World Heritage Site is in place for protected areas, buffer zone, commercial zone for sustainable harvesting and subsistence living area. The FD is bound by mandate to conserve all aquatic resources inside the Sundarbans. To achieve the policy objectives, the following issues need to be addressed:

- Wood and non-wood (i.e. fisheries resources) extraction on sustainable basis.
- Management of shrimp and other aquaculture by means of zonation, improved production practices and enforcement to protect wild stock.
- Participation and knowledge available to all stakeholders.

The management practice within the SRF should consider the concern of the local people, as so far, the traditional and cultural wisdom of the local people who have sustained the ecosystem for generations. The traditional management regime has been replaced by state monopoly and control, which has led to total commercialization of resource extraction. In the beginning of the 1980s the commercial shrimp industry entered into Bangladesh coast. Shrimp farms were established in the adjacent areas of the Sundarbans, and at present is the major activity of the buffer zone (0–20 km around the SRF). The proposed management system under “Sundarbans Biodiversity Conservation Project” has no policy guidelines regarding the shrimp industry and also has no regulation on shrimp fry collection in the buffer zone.

There are concerns over the loss of aquatic biodiversity in Sundarbans as well as in coastal water and encompasses adverse effects of the resources. The ban on fishing in the sanctuaries closes off 23% of the Sundarbans area. This leaves the rest of the SRF as fishing grounds (except the small *khals* where fishing will be banned every other year). For sustainable exploitation, fish stock assessment in the Sundarbans water could be made from the catch data of commercial fisheries rather than project-based survey data. Regulation of size at first capture and mesh size should enforced by regular surveillance. The size of the fishery could also be controlled by limiting the number of weekly gear licenses issued by the FD. The ban on wild shrimp fry collection has not yet been effected because of the concern expressed and objection raised from different corners including donors. Conflict between conservation and fisher folk arises when local communities are excluded from reserve forests. When no alternative income sources are available, poaching and a general breakdown of any management scheme are encouraged.

The fisheries policy situation in Bangladesh has some experience of development projects which focus on the process of development, the importance of stakeholder participation and the possibilities for adapting existing political and institutional structures. A good example is the CBFM (Community-Based Fisheries Management) project in inland waters of Bangladesh managed by the WorldFish Centre and Department of Fisheries. To facilitate fisheries development in Sundarbans, similar arrangement should be needed to demonstrate that GO–NGO (non-government organization) partnerships can be mutually beneficial.

Implementation of the New Management System under SBCP is a new approach to the improved management of Sundarbans fishery. We cannot say at this stage with certainty that the new management system in its present form is the best. The proposed plan appended with the policy further provides institutional direction for multi-sectoral action. It is essential to identify the policies and legislative or regulatory issues that are responsible for destruction or act as hindrances to Sundarbans conservation or sustainable use. Unless the issues are identified, it would be difficult to propose practicable recommendations. Specific needs or weaknesses should be identified before proposing their strengthening. In the light of emerging policy directives, the prevailing sectoral policies need reorientation, and new policies on land and water use, and human settlements should be adopted to ensure institutional coordination. Legislation is needed to regulate all impacting activities

and to establish protective standards, mitigation, monitoring and enforcement. Healthy mangrove systems in Bangladesh not only support the economic needs of up to 30% of the total population of the country, but also protect against cyclones and could serve to mitigate the effects of sea-level rise, certainly over the next 50 years.

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