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RESEARCH ARTICLE

AVAILABILITY OF FISHES IN SUNDARBAN ESTUARY AND DEPENDENCE OF LOCAL PEOPLE ON FISHING FOR THEIR LIVELIHOOD

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ABSTRACT

Sundarban is a mangrove area in the delta formed by the confluence of the Gangas, Brahmaputra and Meghna Rivers in Bay of Bengal stretches from Hoogly River in West Bengal, India to Baleswar river in Bangladesh. It consists of closed and open mangrove forests, agricultural lands, mudflats and barren lands. It is intersected by multiple tidal streams and channels. Sundarbans are enlisted as UNESCO World Heritage Site. The area is rich in biodiversity having 445-faunal wildlife, including 163 Aves, 22 Condrichthyes, 154 Osteichthyes, 40 Mammals, 58 Reptiles and 8 Amphibians. The estuarine system with intricate network of canals and creeks of Sundarbans fringed with thick mangrove foliage, offer excellent nursery ground for most of the brackishwater finfish and shellfish. Millions of tiny larvae, post-larvae or juveniles of several species enter into the ecosystem along with high tides. Mangrove forests in estuaries are rich in many resources, sustaining the livelihoods of individuals residing in and around these ecosystems. Mangroves serve as a protective barrier against cyclones, storms, and tidal surges, safeguarding the local population and their livelihoods. Mangrove forests provide fuel-wood, fodder and small-timber but mangrove wetlands harbour fishes, crabs and other edible invertebrates. The Finfish, shellfish, and other food sources obtained from mangroves are essential for the food security of coastal people. Being motivated with regular income, poor population of Sundarbans has accepted the profession of collection of fish-seeds as an important source of earning. Thus economically, mangroves support livelihood opportunities for coastal communities through fisheries and ecotourism.

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INTRODUCTION

Sundarbans is the largest prograding delta formed at the estuarine phase of the Ganges and Bramhaputra river system. islands. They form a characteristic dense, evergreen and impenetrable mass of trees with numerous arched branching roots. The mangrove belt occupies a strip of low-lying muddy ground, subject to periodical inundation by tides. The Entire delta is formed by the action of the river Ganges-mangrove vegetation is of a transitory nature and represents Bramhaputra, bringing down fine silts from Himalayas. The only a seral type, condition of growth change with the progress mangroves of Indian part of the Sundarbans are estimated at 4263km^2 covering about 61% of the total Indian mangroves. This ecosystem is the reservoir of very rich and diverse animal communities. These communities include both residential and migratory animals, which either live exclusively on mangroves or utilize mangrove habitats temporarily for food and shelter and as breeding and nursery ground. The initial conservation initiative for the Sundarbans commenced with a comprehensive conservation strategy through the declaration of siltation and elevation of the land from sea level. The species occurring in mangroves exhibit certain pronounced characteristics for their peculiar manner of growth and possess remarkable specialized adaptations which enable them to exist in such habitats. Mangroves are found globally in tropical and subtropical regions, primarily between latitudes 25° N and 25° S. The major mangrove regions are distributed in the Old World Tropics, i.e. Indo-West Pacific regions (South Asia, South-East Asia and Australasia); but a few completely of Project Tiger, designating the eastern Sundarbans (2585 km^2) as a Tiger Reserve in 1973, encompassing a core area of 1330 km^2. The term 'Mangrove' applies to a specially adapted vegetation of the littoral region of the World which is confined mainly to the tropics and in favorable localities extends into the subtropical zone. Mangrove forests cover extensive tracts of swampy land along the tropical seas, always fringing muddy salt water creeks, lagoons and estuary of rivers and on low different species of mangroves are also present in the New World Tropics, i.e. Atlantic region (North and South American continents and West African Coast). Mangroves form a highly specialized forest ecosystem along the land-sea interface of the estuary zone in tropical and sub-tropical countries. One of the important features of this area is the regular flooding by tidal water twice daily. The tidal water passing through the creeks inundate the lower part of the vegetation. This very dynamic

eco-system provides a unique opportunity of interaction among plants, soils, adjoining water and aquatic living resources and helps them to exchange different chemical indices and energy contents among themselves. Situated at the boundary between land and sea, mangroves play a crucial role in safeguarding coastal regions from various natural perils, including cyclones and tsunamis (Danielsen *et al*., 2005). The leaves of mangroves fall into the estuarine water and after microbial decomposition turns into detritus, reaching prawn and fish larvae through inshore and tidal currents by the detritus food chain. Thus, Mangrove is a natural nursery. Many of the estuaries in the tropical regions have mangrove ecosystem where the detritus forms the basis of food chain for detritivor benthic animals and the benthic microphytes and phytoplankton of adjacent aquatic ecosystem provide food for many benthic grazers as well as for the pelagic and nektonic primary consumers. These are highly productive ecosystems with productivity about 20 times that of the average oceanic ecosystem. The detritus supplied by this ecosystem triggers the growth of planktonic community in the water. This is then fed upon by zooplaktons and juveniles of finfish and shellfish.
Mangroves ecosystem is the reservoir of very rich and diverse animal communities.

A total of 1434 animal species have been reported from the Indian part of Sundarbans (Anon., 1995) from terrestrial, intertidal and aquatic environments. These animals comprise 989 species of invertebrates and 445 species of vertebrates. Out of 445 vertebrates, 22 species of Chondrichthyes, 154 species of Osteichthyes, 8 species of Amphibia, 58 species of Reptilia, 163 species of Aves and 40 species of Mammals (Chaudhuri and Choudhury,1994; Anon.,1995; Das and Nandi, 1999). Amongst 40 species of mammals, 5 species of dolphins and porpoises are aquatic and the rest are terrestrial. Tiger (*Panthera tigris*) is the key stone species of the tract, the supreme predator and the most faithful guard of the ecosystem. Spotted Deer (*Axis axis*), Wild Boar (*Sus scrofa*) and Rhesus Macque (*Macaca mullata*) are quite abundant so also the rodents. Out of 163 species of birds, 110 are migratory and 53 are residential. The reptilian fauna is represented by one species of saltwater crocodile (*Crocodilus porosus*), 3 species of monitor lizards, 12 species of turtles and terrapins and 40 species of snakes and lizards.

The tidal flats and estuaries of the Sundarbans with its rivers, channels and creeks support large number of fish species about 100 of which are having commercial importance. Zooplanktons comprise diverse taxonomic groups mainly consisting of copepods, amphipods, ostracods, chaetognaths, mysids and hydromedusae. Amongst these, copepods are most dominant representing usually >60% of the total zooplankton population. Moreover, benthic animals produce millions of planktonic larvae, which constitute staple food of mangrove associated fishes. Poor people in developing countries depend heavily on forests and wetlands for their livelihood because of lack of other alternative means to support their subsistence (Ngomela, 2007). For a variety of products, including food, building materials, fire wood, and medications, the local population depends on forest resources. While the contribution of environmental goods and services to rural livelihoods are widely documented (Chhetri *et al*., 2015), their significance within forest-dependent communities remains insufficiently explored although mangrove forests are considered to contribute significantly to the local economy of the people living both near and far of it. Present study is undertaken to assess the availability of fishes in Sundarban estuary around Sundarban Tiger Reserve and dependence of local people on fishing for their livelihood.

STUDY AREA AND METHODOLOGY

Study Area: The Sundarbans are situated inside the delta created by meeting of the Ganges, Brahmaputra and Meghna rivers in the Bay of Bengal. The landform is comprised of a complex system of mudflats and islands formed by the accumulation of silt carried by rivers from their Himalayan origins. These sediment loads are divided by anastomotic channels and tidal waterways. The tidal amplitude seen in estuaries ranges from 3.5 to 4 meters, exhibiting seasonal fluctuations ranging from 2 to 6 meters. The Sundarbans, situated between the latitudes of 21°32′ to 22°40′N and the longitude of 88°05′ to 89°51′E, has an estimated expanse of 10,000 km^2. Notably, 60% of this region is located within Bangladesh, while the remaining 40% is situated in India. This vast expanse represents the most extensive contiguous mangrove forest globally. The geographical area exhibits a tropical climate, featuring a dry season spanning from November to April, followed by a wet monsoonal period throughout the remaining months of the year. The yearly precipitation ranges from 1500 to 2000 mm. The region has frequent occurrences of tropical cyclones and lesser tidal events throughout the monsoon season, resulting in significant flooding and wind-related destruction. The average minimum and maximum temperatures during different seasons range from 12°C to 24°C and 25°C to 35°C, respectively. In the present study, we focused our attention on Sundarban Tiger Reserve area (2585 km^2 of which core area-1330 km^2 and buffer area-1255km^2) spanning between Raimangal river in the east and Matla river in the west in Indian part of Sundarbans.

Fish& Crab Survey and Data Collection: A large portion of local people residing in the fringe areas of Sundarban Tiger Reserve (STR) are involved in catching fishes for their livelihood. They generally go for fishing in rivers and creeks by country boats with 3-5 persons per boat after collecting permits (called BLC) from the Forest Department for a week. The fishermen are allowed to catch fish in the buffer areas (1255 km^2) of Sundarban Tiger Reserve (STR) and in big rivers (viz. Matla, Bidyadhari, Harinbhanga, Jhila, Gosaba, Saptamukhi, Kalindi, Raimangal, etc) from July to March. Collection of finfish and shellfish seed is confined round the year with peak period from April-June. That's why the collection of seeds of finfish and shellfish remain closedfrom April-June. After coming back from fishing, the fishermen sale the fishes and crabs to the Khotis (*'Khoti' is a Bengali term that refers to a wholesale fish shop. It's a place where fish and other seafood are bought and sold, often in large quantities. The term "Arot "generally means a warehouse or depot where goods are stored and traded. Fish wholesalers buy fish and seafood in bulk and then sell it to retailers, restaurants, or other businesses from these Khotis*) situated on the northern and western fringes of the Tiger Reserve. All the Khotis are identified and the fishes and crabs brought to Khotis are enumerated by the surveyor everyday from each Khoti for 4-months (February, March, July and August). There are 10 Khotis identified in the fringes of STR viz. Kalitola, Kumirmari, Lahiripur, Satjelia, Gosaba, Gadkhali, Jharkhali Samabay, Jharkhali Balikhal, Jharkhali Bazar and Canning. Fish and crab data are collected by the surveyor from each Khotieveryday for four months (February, March, July and

August) and recorded as fishing remain stopped in Sundarbans from April to June due to rowdy weather and rolling in rivers during summer and peak period of finfish & shellfish seed availability to protect their diversity.

RESULTS

The raw data of fish and crab collected everyday from the Khotis for 4-months is tabulated species-wise and calculated month-wise and analyzed. The number of fishermen associated with this fishing is also recorded. The results are depicted in the following tables (Table-1 to 7).

Brackishwater Fish Availability in Indian Sundarban Estuary: The first ever study on fishes of Sundarban wetlands came through the monumental work of Hamilton in1822. He described 71 species of fishes from the estuaries of the Ganges and majority of them occurred in Sundarban. Mandal and Nandi (1989) documented 139 species under 101 genera in estuarine waters of Indian Sundarban. Chaudhuri and Choudhury (1994) reported 250 species of fishes belonging to 96 genera from this region available both in freshwater and brackishwater. Das and Nandi (1999) enumerated 22 Chondrichthes (cartilaginous fishes) and 154 Osteichthyes (bony fishes) from Sundarban. Mandal *et al*. (2013) reported 267 fin fish species from the Indian Sundarban estuarine ecosystem belonging to 81 families and 17 orders both in freshwater and brackish water. The aquatic heterotrophs are rich in zooplankton wherein copepods dominate; important commercial nektons are the larvae of tiger prawn, larvae of mullet fishes (*Liza sp*.), milk- fishes (*Chanos chanos)*, seabass (*Lates calcarifer*), hilsa (*Hilsa ilisha*) and megalopa larval stage of edible crab *Schylla serrata*. The commercially important fauna of mangroves mainly includes fin-fishes (Osteichthyes) and shell-fishes (Crustaceans and Molluscs). Present study shows that 17 species belonging to class-Chondrichthyes (14 species of sharks, 2 guitar fish and 1 stingray) (Table-1), 114 numbers of finfishes belonging to Osteichthyes (Table-2) and 20 edible species of shell-fishes (Crustaceans: 8 species of Prawns, 7 species of Crabs and 5 species of Mollusca) (Table-3) are available in the brackish-water estuary in Indian part of Sundarbans.

Table-2 shows the list of finfishes available in Indian part of Sundarban estuary especially in the eastern part of Indian Sundarbans between Malta and Raimangal rivers where Sundarban Tiger Reserve is situated. It is worthwhile to mention that almost all the fishes are edible and commercially important. Several edible fishes are not listed in the table due to their rareness, smaller size and seasonal occurrence and fewer in number. Some of the listed fishes are available abundantly while availability of some of the fishes is moderate. Present survey has recorded 114 numbers of finfishes in the brackishwater estuary in Indian part of Sundarban. Table-3 provides the list of shellfishes available in Indian Sundarban mangroves which include 20edible species of Crustaceans (8 species of Prawns, 7 species of Crabs and 5 species of Mollusca). Giant mud crabs are large in size, profuse in number and delicious in taste, which is available in this region. There are a few more crustacean representatives, viz. spiny lobsters and squillas, which contribute to fish meal industries in this region.

Fish and Crab Survey and Data Recording at Khotis: Fishing was allowed in the buffer zone (1255 km^2) provided that the fishing boats were registered with the Forest Directorate on payment of usual registration fees plus royalty for dry fire wood to be consumed in each fishing trip. Since creation of Sundarban Tiger Reserve fishing is not allowed in the core area (1330 km^2).

Buffer zone except Sajnekhali Wildlife Sanctuary is opened for fishing in case of registered permit-holders. However, a number of fishermen and crab collectors illegally enter the core and Sanctuary area for fish and crab catching. When fishermen come back after catching fish and crabs, they sell those to the Khotis. All the 10-Khotis (fish and crab collection and selling center) situated at the fringes of Sundarban Tiger Reserve are selected for collection of fish and crab data daily for four months. The data of all the important Khotis are presented in the following Tables (Table- 4 to 8).

It is seen from the Table- 4 to 7 that distribution of all fishes is not equal in all the season. Some fishes, e.g. Bogo (*Strongylura strongulura*), Bagda (*Penaeus monodon*), Kucho Chingri (*Metapenaeus brevicornis*), Chamne Chingri (*Metapenaeus brevicornis*), Aar Tangra (*Sperata aor*), Chanda (*Leiognathus blochii*), Dumba (*Euthynnus offinis*), Gagra Tangra(*Arius gagora*), Kotila (*Sadinella albella*), Pankhaki (*Toxotes chatareus*), Haluya (*Parastromateus niger*), Khayra (*Anodontostoma chacunda*), Nihare (*Nemipterus japonicus*), Sardin (*Escualosathor acata*), Tere (*Eleutheronema tetradactylum*), Gang Telapia (*Lobotes surinamensis*) are more available in February- March rather than July –August. On the contrary, Bhetki (*Lates calcarifer*), Baspata (*Silonia silondia*), Cheta Bele (*Grammoplites scaber*), Kan Mach (*Plotosus canius*), Gang Mouti (*Escualosathor acata*), Gule (*Pseudapocryptes lanceolatus*), Katkoi (*Terapon jarbura*), Kotila (*Sadinella albella*), Topse (*Polynemus paradiseus*), Tul Bele (*Sillaginopsis panijus*) are more available in July- August than February-March. The other fishes surveyed and recorded in the above tables (Table- 4 to 7) are available in both the seasons.

The survey data reveals that total fishes caught in 4 months is 190567 kg and total crabs caught in 4 months is 202361 kg. Hence, the quantity of fishes and crabs recorded in between Matla and Raimangal River (western and eastern boundary of Sundarban Tiger Reserve) in 4-months is 392928 kg. By extrapolating the quantity, it will be 1178784 kg per year in the buffer zone of Sundarban Tiger Reserve. This will be approximately15% of the fishes and crabs caught in Indian part of Sundarbans between Raimangal and Hoogly Rivers. The number of fishermen involved in fishing in these areas is 68805 recorded in 4 months. Hence, it will come to 206415 per year. For the entire Indian part of Sundarban, the number of fishermen family involved in fishing will also be increased accordingly. A significant portion of the Sundarban population, particularly those living below the poverty line, relies on fishing for their sustenance.

Livelihood of the Local People in Sundarbans

Fishing and Crab collection: Fishing and crab collection (Figure-1) are important activities in coastal mangrove areas, with 40-50% of the local inhabitants in Myanmar and India are dependent on this activity.

Table 1. Common Shark species (Class: Chondrichthyes) found in Sundarbans

Sl. No	Scientific Name	Common Name	Family	Order
1	*Carcharhinus dussumieri*	White cheeked Shark	Carcharhinidae	Carcharhiiformes
2	*Carcharhinus limbatus*	Blacktip Shark	Carcharhinidae	Carcharhiiformes
3	*Carcharhinus leucus*	Bull Shark	Carcharhinidae	Carcharhiiformes
4	*Carcharhinus sorrah*	Spottail Shark	Carcharhinidae	Carcharhiiformes
5	*Dasyatis pastinaca*	Sting Rays	Dasyatididae	Myliobatiformes
6	*Glaucostegus granulatus*	Sharpnose Guitar Fish	Glaucostegidae	Rhinobatiformes
7	*Glyphis gangeticus*	Ganges River Shark	Carcharhinidae	Carcharhiiformes
8	*Glyphis glyphis*	Sharpteeth Shark	Carcharhinidae	Carcharhiiformes
9	*Glyphis siamensis*	Irrawady river shark	Carcharhinidae	Carcharhiiformes
10	*Galeocerdo cuvier*	Tiger shark	Galeocerdonidae	Carcharhiiformes
11	*Lamiopsis temmincki*	Broadfin shark	Carcharhinidae	Carcharhiiformes
12	*Scoliodon laticaudus*	Indian Dog/Spadenose Shark	Carcharhinidae	Carcharhiiformes
13	*Sphryna blochii*	Arrow headed shark	Sphyrinidae	Carcharhiiformes
14	*Sphryna zygaena*	Hammer headed shark	Sphyrinidae	Carcharhiiformes
15	*Stegostoma fasciatum*	Zebra Shark	Stegosmatidae	Orectolobiformes
16	*Rhinobatos annandalei*	Guitar Fish	Rhinobatidae	Rhinopristiformes
17	*Rhizoprionodon acutus*	Milk Shark	Carcharhinidae	Carcharhiiformes

Table 2. Bony Saltwater Fin-Fishes (Class: Osteichthyes) found in Sundarbans

Sl.No	Scientific Name	Local Name	Common Name	Family	Order
1	*Acanthopagrus berda*	River/SeaBream	Goldsilk Seabream	Sparidae	Acanthuriformes
2	*Acanthopagrus laeus*	Datne	Yellowfin Seabream	Sparidae	Acanthuriformes
3	*Acentrogobius cyanomos*	Mangrove goby	Threadfin blue goby	Gobiidae	Gobiiformes
4	*Aetomylaeus nichofii*	Shankhachil	Banded Eagle ray/Stingray	Myliobatidae	Myliobabatiformes
5	*Ailia coila*	Kajli	Kajoli/Kajli	Ailiidae	Siluriformes
6	*Ambassis dussumieri*	NamChanda	Asiatic Glassfish	Ambassidae	Perciformes
7	*Amblypharyngodon mola*	Gang Mourala	Indian Carplet	Danionidae	Cypriniformes
8	*Anguilla bengalensis*	Baan mach	Long finned eel	Anguillidae	Anguilliformes
9	*Anodontostoma chacunda*	Khaira	Chacunda gizzard Shad	Dorosomatidae	Clupeiformes
10	*Arius arius*	Simul Tangra	Threadfin Sea Catfish	Ariidae	Siluriformes
11	*Arius gagora*	Gagra Tangra	Gagora Catfish	Ariidae	Siluriformes
12	*Arius jella*	KantaTangra	Blackfin Sea Catfish	Ariidae	Siluriformes
13	*Arius thalassinus*	Kotua	Giant Sea Catfish	Ariidae	Siluriformes
14	*Arius sumatranus*	Mochon	Goat/Marine Catfish	Ariidae	Siluriformes
15	*Boleophthalmu sboddarti*	Mudskipper	Boddart's goggle-eyed goby	Gobiidae	Gobiiformes
16	*Bathygobius orbicularis*	Bokobaru	Orbicular Batfish	Gobiidae	Gobiiformes
17	*Batrachocephalus mino*	Kata Bukha	Beardless Sea Catfish	Ariidae	Siluriformes
18	*Chanos chanos*	Chenoch/Milkfish	Asiatic Milk fish	Chanidae	Gonorhynchiformes
19	*Chelonodontops patoca*	SasaphotaPotka	Gangetic Pufferfish	Tetraodontidae	Tetraodontiformes
20	*Chirocentrus dorab*	Samudrik Chela	Dorab wolf-herring	Chirocentidae	Clupeiformes
21	*Chrysochir aureus*	Bhola	Goldbelly Croaker	Sciaenidae	Acanthuriformes
22	*Clarias batrachus*	Kan Magur	Walking Catfish	Clariidae	Siluriformes
23	*Coilia dussumieri*	Ruli Mach	Gold-spotted anchovy	Engraulidae	Clupeiformes
24	*Coilia reynaldi*	Amudi	Reynald's Grenadier Anchovy	Engraulidae	Clupeiformes
25	*Corica soborna*	Kachki	Ganges River Sprat	Clupeidae	Clupeiformes
26	*Cynoglossus lingua*	Kukurjibha	Long tongue sole (Flat Fish)	Cynoglossidae	Pleuronectiformes
27	*Cynoglossus bilineatus*	Pata Mach	Fourlined tongue sole	Cynoglossidae	Pleuronectiformes
28	*Dayscinaena albida*	Lal Bhola	Bengal Corvina	Sciaenidae	Cypriniformes
29	*Drepane punctata*	Guti Pan Mach	Spotted sicklefish/butterfish	Drepaneidae	Acanthuriformes
30	*Eleutheronema tetradactylum*	Gurjali /Tere	Indian Salmon	Polynemidae	Carangiformes
31	*Epinephelus bleekeri*	ChandiBaul	Bleeker's Rockcod	Serranidae	Perciformes
32	*Escualosa thoracata*	Gang Mouti	White sardine	Dorosomatidae	Clupeformes
33	*Euthynnus offinis*	Dumba	Mackerel Tuna	Scombridae	Scombriformes
34	*Gazza minuta*	Gang Chanda	Toothed Pony fish	Leiognathidae	Acanthuriformes
35	*Glossogobius giuris*	Bele	Bar-eyed Goby/Tank Goby	Gobiidae	Gobiiformes
36	*Grammoplites scaber*	Cheta/Mur Bele	Rough Flathead	Platycephalidae	Scorpaeniformes
37	*Gudusia chapra*	Chapila	Indian Oil Sardin	Clupeidae	Clupeiformes
38	*Gymnothorax tile*	Metka/Eel	Indian Mud Moray	Muraenidae	Anguilliformes
39	*Hilsa/Tenualosa ilisha*	Ilish	Hilsa	Clupeidae	Clupeiformes
40	*Harpadon nehereus*	Lote	Bombay Duck fish	Harpadonidae	Aulopiformes
41	*Ilisha elongata*	Ramgacha	Elongate ilisha	Pristigasteridae	Clupeiformes
42	*Johniusar gentatus*	Rupoli Poa	Silver Croaker	Sciaenidae	Cypriniformes
43	*Johnius dussumieri*	ChotoKalo Poa	Bearded Croaker	Sciaenidae	Cypriniformes
44	*Lates calcarifer*	Bhetki	Giant Seaperch/Seabass	Latidae	Carangiformes
45	*Leiognathus blochii*	Chanda	Bloch's ponyfish	Leiognathidae	Perciformes
46	*Leiognathus equulus*	Tak Chanda	Common ponyfish	Leiognathidae	Perciformes
47	*Lepturacanthus savala*	Sitapati	Small-head ribbon fish	Trichiuridae	Perciformes
48	*Leuciscus waleckii*	Amudi Mach	Golden Anchovy	Engraulidae	Clupeiformes
49	*Liza parsia*	Parse	Goldspot Mullet	Mugilidae	Perciformes
50	*Liza tade*	Bhagone	Rock Mullet	Mugilidae	Mugiliformes

Continue ….

51	*Liza macrolepis*	Bata Parse	Largescale (Grey) Mullet	Mugilidae	Perciformes
52	*Lobotes surinamensis*	Koivol	Triple Tail Fish	Lobotidae	Lobotiformes
53	*Lutjanus fulviflamma*	Laufoli	Dory Snapper	Lutjanidae	Perciformes
54	*Lutjanus johnii*	Koi-bhola	Red/John's Snapper	Lutjanidae	Perciformes
55	*Macrospinosa cuja*	Kuja Bhola	Largespine Croaker	Sciaenidae	Perciformes
56	*Megalaspis cordyla*	Mackerel	Hardtail Scad	Carangidae	Carangiformes
57	*Mugil cephalus*	Bhagon	Grey mullet	Mugilidae	Perciformes
58	*Mystus vittatus*	GathiyaTangra	Striped dwarf Catfish	Bagridae	Siluriformes
59	*Mystus gulio*	Nona Tengra	Long Whiskers Catfish	Bagridae	Siluriformes
60	*Mystus tengara*	CommonTengra	TengaraMystus	Bagridae	Siluriformes
61	*Netuma thalassina*	Khagga	Giant Catfish	Ariidae	Siluriformes
62	*Nemipterus bipunctatus*	LalPari/Chakori	Threadfin Bream	Nemipteridae	Perciformes
63	*Nemipterus japonicus*	Nihare	Indian Threadfin Bream	Nemipteridae	Perciformes
64	*Odontamblyopus rubicundus*	LalGule/Chewa	Eel Goby	Gobiidae	Gobiiformes
65	*Otolithoides pama*	Bhola	IndianJawfish/PamaCroaker	Sciaenidae	Cypriniformes
66	*Otolithoides biauritus*	Poa-bhola	Bronze Croaker	Sciaenidae	Cypriniformes
67	*Otolithes cuvieri*	Dhoma Poa	Lesser Tiger-tooth Croaker	Sciaenidae	Cypriniformes
68	*Osteogeneiosus militaris*	Gadi-Tangra	Soldier Catfish	Ariidae	Siluriformes
69	*Pampus argenteus*	Pomfret	Silver Pomfret	Stromateidae	Scombriformes
70	*Pampus chinensis*	Pamplate	Chinese Silver Pomfret	Stromateidae	Scombriformes
71	*Pangasius pangasius*	Pangas Tangra	Pangas Catfish	Pangasiidae	Siluriformes
72	*Pangasius bocourti*	Bacha Mach	River Cobbler/BasaFish	Pangasiidae	Siluriformes
73	*Parastromateus niger*	Halwa/Baul	Black Pomfret	Carangidae	Carangiformes
74	*Parambassis ranga*	Ranga Chanda	Indian Glassy fish	Ambassidae	Mugiliformes
75	*Planiliza macrolepis*	Parse	Largescale Mullet	Mugilidae	Mugiliformes
76	*Pellona ditchela*	Choukka Mach	Toothed Shad/IndianPellona	Pristigasteridae	Clupeiformes
77	*Platycephalus indicus*	ChetaBele	Bartail Flathead	Platycephalidae	Scorpaeniformes
78	*Plotosus canius*	KanMagur	Eel-tail Catfish	Plotosidae	Siluriformes
79	*Polynemus paradiseus*	Topse	Paradise threadfin	Polynemidae	Perciformes
80	*Polydactylus indicus*	Sele/Dara	Indian threadfin	Polynemidae	Perciformes
81	*Pomadasys argenteus*	Rupali Datina	Silver Grunter	Haemulidae	Perciformes
82	*Pomadasys furcatus*	DorakataDatina	Banded/Grey Grunter	Haemulidae	Perciformes
83	*Protonibea diacanthus*	KalaDatina/Poa	Black-spotted Croaker	Sciaenidae	Acanthuriformes
84	*Pseudapocryptes lanceolatus*	Gule	Pointed-tailed Goby	Gobiidae	Gobiiformes
85	*Pterotolithus maculatus*	Madhu Bhola	Blotched tiger-toothed Croaker	Sciaenidae	Perciformes
86	*Rhabdosargus sarba*	Silver Bream	GoldlinedSeabream	Sparidae	Acanthuriformes
87	*Rhinomugil corsula*	Khorsula	Corsula mullet	Mugilidae	Mugiliformes
88	*Sadinella albella*	Kotila	Sardines	Clupeidae	Clupeiformes
89	*Scatophagus argus*	Pairachanda	Spotted Scat/butterfish	Scatophagidae	Perciformes
90	*Scomberomorus guttatus*	Laufoli	Spotted Seer Fish	Scombridae	Scombriformes
91	*Setipinna phasa*	Phasa	Gangetic Hairfin anchovy	Engraulididae	Clupeiformes
92	*Setipinna taty*	TeliPhasa	Scaly Hairfin anchovy	Engraulidae	Clupeiformes
93	*Setipinna tenuifilis*	Chokdhela	Common Hairfin anchovy	Engraulidae	Clupeiformes
94	*Sillago sihama*	ChhotoBele	Silver whiting	Sillaginidae	Perciformes
95	*Sillago soringa*	SundariBele	Soringa whiting	Sillaginidae	Perciformes
96	*Sillaginopsis panijus*	TulBele	Gangetic whiting	Sillaginidae	Perciformes
97	*Silonia silondia*	Baspati	Silond Catfish	Schilbeidae	Siluriformes
98	*Sperata aor*	Aar Mach	Long-whiskered Catfish	Bagridae	Siluriformes
99	*Stolephorus baganensis*	Dora Fesha	Spined anchovy	Engraulididae	Clupeiformes
100	*Stolephorus commersonii*	Chapta Mola	Commerson's Anchovy	Engraulididae	Clupeiformes
101	*Stromateus chinensis*	Rup Chanda	Chinese Pomfret	Stromateidae	Scombriformes
102	*Strongylura strongulura*	Bogo/Bak	Spot-tailed Needle fish	Belonidae	Beloniformis
103	*Terapon jarbura*	Kat Koi	Tiger- Perch	Teraponidae	Centrarchiformes
104	*Triacanthus hamrur*	TeyKanta	Lunar-tailed Bigeye	Triacanthidae	Acanthuriformes
105	*Thryssa dussumieri*	Pati Fesha	Dessumier'sThryssa	Engraulididae	Clupeiformes
106	*Thryssa hamiltoni*	Ram Phasa	Hemilton'sthryssa	Engraulididae	Clupeiformes
107	*Toxotes chatareus*	Pankhaki	Common Archer Fish	Toxotidae	Carangiformes
108	*Trichiurus lepturus*	Sitapati	Large head Ribbon fish	Trichiuridae	Perciformes
109	*Trichiurus gangeticus*	Chhuri	Gangetic Ribbon fish	Trichiuridae	Perciformes
110	*Tylosurus crocodilus*	Todak	Hound Needle/Sword Fish	Belonidae	Beloniformes
111	*Uropterygius concolor*	Boro-Baan	Brown Moray-eel	Muraenidae	Anguilliformes
112	*Valamugil seheli*	Ram Parse	Blue-spot Mullet	Mugilidae	Mugiliformes
113	*Zenarchopterus ectuntio*	EkthukiKakila	Halfbeaks	Hemiramphidae	Cyprinodontiformes
114	*Zenarchopterus striga*	Kankley	Hoogly Halfbeaks	Hemiramphidae	Cyprinodontiformes

The abundance and diversity of fish in the Sundarbans surpass adjacent freshwater and marine ecosystems in Bangladesh, making it a critical area for aquatic biodiversity (Uddin *et al*., 2021). Fishermen enter into the mangrove areas for fishing after taking permits from the nearest forest office. Sometimes they enter the forests without permission. These permits are given for a specific time and area which is mentioned in the permits.These permits are issued against registered Boat License Certificates (BLCs). In the Sundarban Tiger Reserve there are about 923 Boat Licence Certificates or Fishing Permits, out of which 75% are active and 25%are lying inactive due to various administrative and technical reasons. However, some irregularities have been noticed like the fishermen usually extending their period of stay in the forest area after expiry of permit times and trying to enter non-permitted areas.

Shrimp Collection: Shrimp collection in the Sundarban involves collecting tiger prawn seedlings from the riverbanks during low tide using hand-pulled nets. These tiny seeds are sold to shrimp farms for cultivation, with collectors earning a meager daily income despite spending long hours in harse, saline conditions. Tiger prawn shrimp (*Penaeus monodon*) collection (Figure 2) was one of the popular livelihood activities in mangrove areas of the Sundarbans as they are the nursery grounds.

Table 3. Prawns and Crabs (Shellfish, Class: Crustacea) found in Sundarbans

Sl.No	Scientific Name	Local Name	Common Name	Family	Order
	Prawns				
1	*Acetes indicus*	Jawala Chingri	Salted Small Prawn	Sergestidae	Decapoda
2	*Acetes erythraeus*	Varta Chingri	Tsivakihini Paste Shrimp	Sergestidae	Decapoda
3	*Palaemon styliferus*	Gura Chingri	Roshna Prawn	Palaemonidae	Decapoda
4	*Penaeus monodon*	Bagda Chingri	Tiger Prawn	Penaeidae	Decapoda
5	*Penaeus indicus*	Chabra Chingri	Indian/White Shrimp	Penaeidae	Decapoda
6	*Parapenaeopsi ssculptilis*	Lal Chingri	Red Prawn	Penaeidae	Decapoda
7	*Metapenaeus brevicornis*	Chamne Chingri	Yellow/PinkShrimp	Penaeidae	Decapoda
8	*Metapenaeus monoceros*	Horina Chingri	Brown Shrimp	Penaeidae	Decapoda
	Crabs				
1	*Charybdis cruciata*	Samudra Kakra	Swimming Crab	Portunidae	Decapoda
2	*Matuta lunaris*	Lajjabati Kakra	Moon Crab	Matutidae	Decapoda
3	*Ocypoda macrocera*	Lal Kankra	Harmit Crab	Ocypodidae	Decapoda
4	*Scylla serrata*	Nona Kankra	Giant Mud-Crab	Portunidae	Decapoda
5	*Sesarma tetragonum*	Gecho Kakra	Tree-climbing Crab	Sesarmidae	Decapoda
6	*Uca acuta*	BeuleKankra	Fiddler Crab	Ocypodidae	Decapoda
7	*Varuna litterata*	CittiKankra	River Swimming Crab	Grapsidae	Decapoda
	Mollusca				
1	*Anadara granosa*	DaityaChilon	Blood Cockle	Arcidae	Arcida
2	*Magallana gryphoides*	Kosturi/Chilon	Giant Oyster	Ostreidae	Ostreoida
3	*Saceostrea cuculata*	ChhotoKosturi	Rock/Hooded Oyster	Ostreidae	Ostreoida
4	*Meretrix meretrix*	Zhinuk/Chilon	Asiatic Hard Clam	Veneridae	Venerida
5	*Dosinia subrosea*	Shamuk/Jhinuk	Fine dosinia/Clam	Veneridae	Venerida

Table 4. Name of Khoti (Fish & Crab Collection Centre) -Jharkhali (Samabay+Balikhal)

Name of Fish/Crab	Scientific Name	Quantity of Fish and Crab (in Kg) Captured Month-wise			
		February	**March**	**July**	**August**
1 Chingri		559	963	1327	2086
2 Lal Chingri	*Parapenaeopsis sculptilis*	56	34	252	55
3 ChabraChingri	*Penaeus indicus*	177	260	501	716
4 KuchoChingri	*Metapenaeus brevicornis*	26	169	576	564
5 Bagda	*Penaeus monodon*	340	279	992	493
6 Bhetki	*Lates calcarifer*	526	362	679	278
7 JabaBhetki		88	96	250	92
8 Bhola	*Otolithoides pama*	529	543	1104	402
9 Bogo	*Strongylura strongulura*	11	30	127	41
10Bhagon	*Mugil cephalus*	19	52	87	34
11 Chokdhela	*Setipinna tenuifilis*	27	14	249	253
12 Mud Crab	*Scylla serrata*	9516	7916	35084	33725
13 Chela	*Chirocentrus dorab*	68	34	102	40
14Amudi	*Coilia reynaldi*	429	107	277	71
15Datne	*Acanthopa gruslaeus*	650	431	273	456
16Ilish	*Hilsa/Tenualosa ilisha*	72	109	231	225
17Fesha	*Setipinna phasa*	29	70	266	93
18Gule	*Pseudapocryptes lanceolatus*	54	93	129	169
19Gurjali	*Eleutheronema tetradactylum*	19	27	248	39
20 Gagra Tangra	*Arius gagora*	87	164	221	173
21Tangra	*Mystus tengara*	88	36	240	163
22PagasTangra	*Pangasius pangasius*	136	179	214	96
23Kanmagur	*Plotosus canius*	102	193	324	134
24Kan Mach	*Plotosus canius*	39	122	410	335
25Khaira	*Anodontostoma chacunda*	326	249	279	185
26Katkoi	*Terapon jarbura*	19	14	63	89
27Kotila	*Sadinella albella*	15	6	55	34
28Laufoli	*Lutjanus fulviflamma*	107	209	325	174
29Lote	*Harpadon nehereus*	42	81	275	84
30Mochon	*Arius sumatranus*	379	562	568	469
31Nihare	*Nemipterus japonicus*	220	207	242	274
32 Parse	*Liza parsia*	256	132	339	229
33Pyratoli	*Scatophagus argus*	101	137	306	227
34 Pomfret	*Pampus argenteus*	27	46	122	158
35Pankhaki	*Toxotes chatareus*	43	20		
36Sele	*Polydactylus indicus*	83	633	773	97
37Sitapati	*Trichiurus lepturus*	37	42	46	12
38Tere	*Eleutheronema tetradactylum*	28	18	12	34
39Topse	*Polynemus paradiseus*	18	47	86	36
40 Gang Telapia	*Lobotes surinamensis*	30	45		
41 Gang Mouti	*Escualosathor acata*			21	18
42ChetaBele	*Grammoplites scaber*			35	19
Total Fishes		**5862**	**6814**	**12643**	**9176**
Total Crab	Only *Scylla serrata*	**9516**	**7916**	**35084**	**33725**
Total Fish+Crab		**15378**	**14730**	**47628**	**42901**
No. of Fishermen family involved		**6058**	**5394**	**11742**	**8120**

Table 5. Name of Khoti (Fish & Crab Collection Centre): Kalitala,Hingalganj

Name of Fish/Crab	Scientific Name	Quantity of Fish and Crab (in Kg) Captured Month-wise			
		February	March	July	August
1 Chingri		1444	784	463	216
2 ChabraChingri	*Penaeus indicus*	1055	905	621	458
3 ChamneChingri	*Metapenaeus brevicornis*	1241	676	666	317
4 KuchoChingri	*Metapenaeus brevicornis*	561	100		
5Bagda	*Penaeus monodon*	150	141	111	106
6Bhetki	*Lates calcarifer*	69	34	138	114
7JabaBhetki		73	48	64	252
8Bele	*Glossogobius giuris*	158	172	125	130
9 Bhola	*Otolithoides pama*	80	70	293	321
10 Bogo	*Strongylura strongulura*	136	108	94	132
11Bhagon	*Mugil cephalus*	147	201	86	163
12 Mud Crab	*Scylla serrata*	5631	4278	9872	8269
13Datne	*Acanthopa gruslaeus*	359	142	975	640
14Amudi	*Coilia reynaldi*	169	38	115	40
15Fesha	*Setipinna phasa*	57	87	69	93
16 Kan Magur	*Plotosus canius*	18	23	73	25
17Lote	*Harpadon nehereus*	49	76	78	67
18Nihare	*Nemipterus japonicus*	30	73		
19 Parse	*Liza parsia*	87	145	250	52
20Payratali	*Scatophagus argus*	346	110	286	39
21Pankhagi	*Toxotes chatareus*	13	39		
22Sele	*Polydactylus indicus*	21	20	115	145
23Topse	*Polynemus paradiseus*	37	76	42	81
24TulBele	*Sillaginopsis panijus*	10	22	13	17
Total Fish +Crab		**11684**	**8358**	**14549**	**11677**
Total Fishes		**6053**	**4080**	**4667**	**3408**
Total Crab		**5631**	**4278**	**9872**	**8269**
No. of Fishermen family involved		**4076**	**2784**	**5244**	**1848**

Figure 1. Fishing in rivers (above) and Crab collection (below) in Sundarban areas

Figure 2. Tiger Prawn Shrimp collection by netting in Raimangal River in Sundarbans

Table 6. Name of Khoti (Fish & Crab Collection Centre): Canning

Local Name of Fish/Crab	Scientific Name	Quantity of Fish and Crab (in Kg) Captured Month-wise			
		February	March	July	August
1 Lal Chingri	*Parapenaeopsis sculptilis*	1013	585	335	473
2 ChabraChingri	*Penaeus indicus*	5236	5182	2722	1998
3 SadaChingri	*Penaeus indicus*	922	841	436	323
4 HorinaChingri	*Metapenaeus monoceros*	305	162	72	592
5 KuchoChingri	*Metapenaeus brevicornis*	483	352	175	112
6 Bagda	*Penaeus monodon*	233	114		
7Bhetki	*Lates calcarifer*	1580	151	918	844
8JabaBhetki		1929	3609	2470	282
9 Bhola	*Otolithoides pama*	377	887	1626	891
10 Lal Bhola	*Chrysochir aureus*	128	54	51	67
11 Bogo	*Strongylura strongulura*	288	167	211	173
12Bhagon	*Mugil cephalus*	275	273	151	16
13Bele	*Glossogobius giuris*	163	177	127	30
14TulBele	*Sillaginopsis panijus*	85	90	13	29
15Mud Crab	*Scylla serrata*	3361	4340	4212	6223
16 Chela	*Chirocentrus dorab*	365	115		89
17Dumba	*Euthynnus offinis*	1730	863	437	998
18 Dante	*Acanthopa gruslaeus*	339	302	161	67
19 Amudi	*Coilia reynaldi*	2389	572	644	858
20 ELISH	*Hilsa/Tenualosa ilisha*	445	131	381	719
21Fesha	*Setipinna phasa*	734	682	257	163
22PagasTangra	*Pangasius pangasius*	585	125	285	1198
23 Simul Tangra	*Arius arius*	1785	3382	2253	90
24 Aar Tangra	*Sperata aor*	360	467	45	23
25 Gagra Tangra	*Arius gagora*	230	106		
26Gurjali	*Eleutheronema tetradactylum*	384	677	67	48
27Gule	*Pseudapocryptes lanceolatus*		24	52	43
28 Gang Chuno	*Amblypharyngodon mola*	575	167	38	15
29 Gang Mouti	*Escualosathor acata*	264	85		
30Haluya	*Parastromateus niger*	35	62		
31Katkoi	*Terapon jarbura*	860	142	125	177
32Kaivol	*Lutjanus johnii*	22	95	46	57
33Kotila	*Sadinella albella*	282	280	171	163
34Khayra	*Anodontostoma chacunda*	141	123		
35 Kan Magur	*Plotosus canius*	279	237	154	46
36KukurGiba	*Cynoglossus lingua*	12	18	17	13
37Laufoli	*Lutjanus fulviflamma*	560	431	354	223
38Lote	*Harpadon nehereus*	112	88	196	47
39Nihare	*Nemipterus japonicus*	1560	56	927	3665
40 Pomfret	*Pampus argenteus*	54	85	183	230
41Payratali	*Scatophagus argus*	670	559	589	246
42Pankhagi	*Toxotes chatareus*	120	42	58	18
43 Parse	*Liza parsia*	2133	563	427	215
44Pata Mach	*Cynoglossus bilineatus*		34		
45Sele	*Polydactylus indicus*	1085	1274	1397	101
46Sitapati	*Trichiurus lepturus*	199	95	381	110
47Sardin	*Escualosa thoracata*	70	88		
48 Tara/Tere	*Eleutheronema tetradactylum*	247	200	216	91
49Topse	*Polynemus paradiseus*	95	79	57	33
50Baspata	*Silonia silondia*			12	16
Total Fish+Crab		**35099**	**29363**	**23447**	**28204**
Total Fishes		**31738**	**25023**	**19225**	**22181**
Total Crab	Only *Scylla serrata*	**3361**	**4340**	**4212**	**6223**
No. of Fishermen family involved		**1810**	**1532**	**1417**	**1506**

This activity was mostly carried out by women and was a grave threat as many were attacked by crocodiles. It also had a negative impact on the aquatic biodiversity as the tiger prawn collection resulted in the destruction of at-least 50other species of finfish and shellfish. In the absence of any tiger prawn hatchery in the West Bengal, wild caught seed is exclusively used for stocking coastal wetlands (bheries) in the State.This livelihood activity has been heavily discouraged now after the formation of Joint Forest Management Committee due to its negative impact on the ecosystem and biodiversity. Presently only a handful of people are involved in this activity.

Honey Collection: Rock bees (*Apis dorsata*) from the Himalayas visit the Sundarbans forest every year. Most of the mangrove flowers are highly nectar bearing. This attracts the rock bee to visit Sundarbans during summer months which is the main flowering season of mangroves. Flowering starts with the bloom of *Aegiceras corniculatum* from March and is followed by the flowering of *Acanthus ilicifolius, Avicennia* spp*., Sonneratia apetala* and *Rhizophora* spp. This continues for two months during April and May. The density of honey depends on the number of salt - excretory glands available on the tree. *Aegiceras corniculatum* having 19 glands.

Table 7. Name of Khoti (Fish & Crab Collection Centre): Gosaba

Name of Fish/Crab	Scientific Name	Quantity of Fish and Crab (in Kg) Captured Month-wise			
		February	**March**	**July**	**August**
1 Chingri		858	591	1415	1244
2 Kucho Chingri	*Metapenaeus brevicornis*	72	78		
3 Chabra Chingri	*Penaeus indicus*	135	527	223	250
4 Lal Chingri	*Parapenaeopsis sculptilis*	195	233	135	112
5 Sada Chingri	*Penaeus indicus*	96	166		
6 Mud Crab	*Scylla serrata*	152	135	208	164
7 Amudi	*Coilia reynaldi*	1131	267	469	392
8 Ruli	*Coilia dussumieri*	58	17	13	28
9 Bhetki	*Lates calcarifer*	288	132	319	109
10JabaBhetki		60	63	137	85
11 Bogo	*Strongylura strongulura*	28	35	20	32
12 Bhola	*Otolithoides pama*	324	48	775	587
13Bhagon	*Mugil cephalus*	48	31	22	53
14 Bele	*Glossogobius giuris*	125	22	133	34
15 Baspata	*Silonia silondia*		32	40	58
16 Chanda	*Leiognathus blochii*	175	196		
17 ChetaBele	*Grammoplites scaber*			61	78
18 Chapela	*Gudusia chapra*			80	40
19 Dante	*Acanthopagrus laeus*	45	195	342	136
20 Dumba	*Euthynnus offinis*			144	40
21 Elish	*Hilsa/Tenualosa ilisha*			200	94
22 Fesha	*Setipinna phasa*	576	225	501	1000
23 Gang Mouti	*Escualosathor acata*	116	57	43	477
24 Gule	*Pseudapocryptes lanceolatus*			24	43
25 Laufoli	*Lutjanus fulviflamma*	55	55	43	72
26 Lote	*Harpadon nehereus*	26	57	1397	2867
27 Tangra	*Mystus tengara*	109	13	110	117
28 Gagra Tangra	*Arius gagora*	28	24		
29 Kata Tangra	*Arius jella*	78	31	463	124
30 PagasTangra	*Pangasius pangasius*	13	23		
31 MochanTangra	*Arius sumatranus*	17	26	52	35
32 Simul Tangra	*Arius arius*			18	
33 Khayra	*Anodontostoma chacunda*	194	113	66	89
34 Kan Magur	*Plotosus canius*	79	73	77	30
35 Kotila	*Sadinella albella*			250	171
36 Katkoi	*Terapon jarbura*			80	230
37 Nihare	*Nemipterus japonicus*	12	10	138	189
38 Parse	*Liza parsia*	280	55	266	184
39 Payratali	*Scatophagus argus*	185	199	227	235
40 Pomfret	*Pampus argenteus*	15	12	78	143
41 Pankhagi	*Toxotes chatareus*			23	38
42 Sardin	*Escualosathor acata*			340	42
43 Sitapati	*Trichiurus lepturus*	200	134	292	127
44 Sele	*Polydactylus indicus*	35	26	33	18
45 Tere	*Eleutheronema tetradactylum*	66	53	75	80
46 Topse	*Polynemus paradiseus*	15	47	31	12
47 Tul Bele	*Sillaginopsis panijus*			64	192
Total Fish+Crab		**5889**	**3934**	**10094**	**10157**
Total Fish		**5737**	**3799**	**9886**	**9993**
Total Crab		**152**	**135**	**208**	**164**
No. of Fishermen family involved		**886**	**485**	**1287**	**1301**

Table 8. Name of Khotis (Small): Lahiripur, Kumirmari, Satjelia, Gadkhali

Name of Fish/Crab	Scientific Name	Quantity of Fish and Crab (in Kg) Captured Month-wise			
		February	March	July	August
1. Misc.Fishes		3868	2802	1730	1882
2. Mud Crabs		6384	5548	22940	34403
Total Fish+Crab		10252	8350	24670	36285
No. of Fishermen family involved		2744	2355	3104	5112

per sq mm. gives the best honey. As rock-bees are migratory so the experiment of setting up apiaries with rock-bees has failed. The best mangrove species to produce honey comb are *Excoecaria agallocha* (39%) followed by Bain (*Avicennia* spp.) 16%, Goran (*Ceriops* spp.) 11%, Garjan (*Rhizophora* spp.) 10%, Keora (*Sonneratia* spp.) 10% and others bear only 14%. The ideal site for construction of hive would be *Exoecaria* and *Phoenix* combination of forests. Honey collection teams require permits from the Forest Department to move on to the mangrove forests (Figure 3).

Ondetecting a honey comb the honey collectors' smoke out the bees using torches of *Phoenix* leaves called as 'Bolen' (bunch of leaves). They take care not to damage the eggs, larva etc found in the comb. The honey collectors come back to the same comb after fifteen days and again cut them. The second time the yield is normally 60% that of the first time. One of the drawbacks of Sundarban honey is that it contains more moisture than honey obtained from other areas due to which it ferments quickly.

Figure 3. Wild Honey Collection Team in Sundarbans (Left: -Team is moving out to Forests and Right: -Team returned after collection of Honey)

Aquaculture: Prawn and fish farming in brackish water ponds is emerging as an alternative to traditional fishing in Sundarbans. Aquaculture, including both freshwater and brackish water systems, is a vital livelihood for many communities in the Sundarbans, contributing to the local economy. Various government and non-government organizations are working to promote sustainable aquaculture practices. Aquaculture in the Sundaban areas, particularly shrimp farming, is a significant economic activity but also poses challenges to the mangrove ecosystem. While it provides livelihoods and contributes to national economies, the expansion of aquaculture, especially shrimp farming, has led to the conversion of agricultural land and potential mangrove destruction. Aquaculture in Sundarbans involves a significant growing shift from agriculture to shrimp farming driven by market demand but this growth is often unchecked and poses threats to the fragile mangrove ecosystem through habitat destruction.

DISCUSSION

Socio-economic Profile of Villages in Sundarbans: Many poor people in developing countries depend heavily on forests and wetlands for their livelihood because of lack of other alternative means to support their subsistence (Ngomela, 2007). For a variety of products, including food, building materials, fire wood, and medications, the local population depends on forest resources. While the contribution of environmental goods and services to rural livelihoods are widely documented (Chhetri *et al*., 2015),their significance within forest-dependent communities remains insufficiently explored although mangrove forests are considered to contribute significantly to the local economy of the people living both near and far of it. In general, the villages in and around mangroves have a high percentage of socially disadvantaged groups. The level of literacy as well as per capita income is much lower than in other parts of the country. The infrastructure in the villages is poorly developed with hardly any metaled roads making it difficult to pass in heavy rains. The main mode of transport and communication is mainly by boat. Electricity is patchy, primary health center and schools are also inadequate. In the absence of any major industry in the area, the vocation can broadly be divided as cultivators 26.5%, agricultural labour 47%, household worker 1.5% and others 25% which include fishermen, crab collectors, honey collectors etc. Almost 50% of the agricultural workers are also fishermen and crab collectors in lean periods of agriculture. The majority of farmers fall under the category of small and marginal groups. The rich people in the village mainly invest in agricultural land and commercial fishing by engaging the poor fishermen to earn high profits. Moneylenders also abound in the villages. They give advances to fishermen and honey collectors in return of which they take all the fish caught and honey collected, respectively for a pittance. Most of the villagers also have a cattle population, which are reared not for milk supply but to fulfill their protein requirements. The majority of the people's livelihoods in mangrove areas were at a subsistence level (Wai *et al.*, 2019). They heavily depended on natural resources for their livelihoods. The income for the local poor communities living in rural areas of developing countries was less than US$ 1 per day and they rely on the ecosystem services (Barbier, 2012). Their income (43% to total household income) was generated by selling forest products collected from the mangrove forest such as fishes, crabs and prawn. So, half of the respondents were engaged in mangrove based occupations because they are poor and predominantly live in the delta region.

Role of Mangrove Associated Fauna in Sundarbans Ecosystem: The fauna connected with mangroves has an enormous role in the Sundarbans' ecological and economic frontiers. Not only that, this ecosystem is a vital resource in terms of wood and wood products but also that shellfishes and finfishes occurring in this ecosystem as adults and/or juveniles as well as honey bee have a direct impact on the socio-economy of the people of this region. The Sundarbans ecosystem also harbor heterogeneous assemblage of innumerable invertebrates, which are collectively called zooplankton. These communities play a significant role in trophic structure and energy transfer. Taxonomically, diverse benthic animals which mostly occupy littoral and sub-littoral zones of this ecosystem are also ecologically and economically very significant. Some of these benthic communities belonging to Mollusca and Crustacea (prawns and crabs) comprise shellfishes which are having direct economic importance. Benthic animals produce millions of planktonic larvae to support fish population.

Animals of these category, more particularly sea anemones, polychaetes, gastropods, bivalves, decapods, holothurians, and hemicordates create a wide variety of bioturbation structures, which are very significant for trapping sediments and mangrove seeds (Chaudhuri and Choudhury,1994). Moreover, benthos also maintains the equilibrium of the ecosystem as grazers, scavengers, burrowers and borers. These burrowers by making innumerable burrows provide suitable microhabitats for the sustenance of other animal species in the ecosystem and at the same time facilitate air and water to get entry into the soil. The nektonic forms which mainly comprise fishes have considerable commercial importance. A diversified group of invertebrates belonging to ciliated protozoa, tanaids, amphipods, decapods larvae, nematods, and polychaetes in association with bacteria, yeast and fungi cause biodegradation of mangrove litters to particulate organic matter and to fine detritus, which support pelagic and benthic communities of mangroves and its adjacent ecosystems (Das and Nandi,1999). Mangroves are ecologically diversified and highly productive ecosystems (Hogarth, 2007) that play crucial roles in the functioning of the environment (Nagelkerken *et al*., 2008). Mangroves possess significant economic value due to their provision of collective ecological services (Costanza *et al*., 2014; Salem and Mercer, 2012).

Dependence of Local People on Coastal Resources: In Sundarban areas, the primary sources of livelihood are agriculture, fishing, and animal husbandry. Additionally, honey collection, tourism, and the extraction of non-timber forest products also contribute to the local economy. Most of the present day's coastal populations are very poor and they have to depend on the sea fishes and coastal resources. Almost 14.33% of the Sundarbans population is dependent on fishing as their primary occupation. However, a large % of population, 76% considers fishing a secondary occupation. Additionally, over 2 million people depend on the Sundarbans directly or indirectly for their livelihood, with many relying on fishing for subsistence indicating its importance to the local economy. Agriculture is viewed by 78% of the people as their primary source of income. Large scale fish and prawn seed collections from river water are now posing serious threat to the aquatic ecosystem in the river water of the Sundarbans and other coastal areas. By their ever increasing interferences on these forest resources, the mangrove forests are becoming thinner and thinner and natural regeneration process of these mangrove plants are hampered due to damage of the seed and seedlings in the nursery beds. More than 1000 families are now engaged for honey collections from the Sundarban mangrove forests and more than 100,000 fishermen are engaged in collecting prawn (*P. monodon*), other fishes like *Liza parsia, Liza tade*, *Lates calcarifer* and *Mugil cephalus* seeds, fishing and forestry activities, taking risk of lives from tiger and crocodiles (Naskar,1999). But money lenders forced them to these forestry activities for making profit out of these rural people's hard work. However, the declaration of Sundarban Tiger Reserve has restricted the damage and destruction of Mangroves in the eastern part of Indian Sundarbans.

Human Activities hampering the Estuarine Diversity: The removal of wetlands in the Sundarban estuary has caused a reduction in the diversity and intricacy of the estuarine environment, leading to significant decreases in the populations of certain frequently encountered fish species. Furthermore, fish and other aquatic wildlife in the Sundarbans region are in grave danger due to the infiltration of saltwater and the sudden increase in salinity pushed on by climate change and human activity (Joshi and Ghose, 2014).The study of Biswas *et al.* (1999) has shown that there is a declining trend in the availability of shellfish and finfish seeds with the passage of time. It seems that the overexploitation of fish seeds resources is being reflected by the decline in the number of fish seeds. Human interactions in these natural forests and reclaimed forest lands for the development of agriculture, fisheries and human inhabitation have inhibited the natural regeneration process of these very sensitive mangrove ecosystems (Naskar,1999). Large scale fish and prawn seed collections from the river water are now posing serious threat to the aquatic ecosystem in the river water of the Sundarbans and other coastal areas.

CONCLUSION

Man is the highest biotope in any environment and they would cause diverse damage by the artificial ecological changes, but man can rebuild the environment in its true perspectives. For keeping the nature in balance and for getting maximum benefit from these wetland ecosystems, planned measures are required to undertake for protecting it in such estuarine lands on an urgent basis. Any developmental work on the coastal intertidal area will affect the mangrove ecosystems. The development of fisheries, agriculture, forestry, ecotourism and industrial set up may have direct conflict because each can claim the mangrove forests ecology as under their own control and administrative domain. Now-a-days Sundarbans have attracted much attention, particularly to the prawn farmers, for having unique potentialities of exportable qualities prawn, *Penaeus monodon* (Bagda)*, P. indicus and Macrobrachium rossenbergii* (Galda). For increasing the export potentialities and having the ideal habitat for estuarine prawn, *P. monodon and P. indicus,* since the last centuries, these vast areas have been included under prawn culture. For these potential prawn farming and development of fisheries, the mangrove forest areas have been neglected and cleared in several parts of the Sundarbans mangal and converted these to brackishwater prawn farm without following the natural laws and rules of the mangal succession and/or sustainable productivities of the natural ecosystem.

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