International Journal of Trend in Scientific Research and Development (IJTSRD)
International Open Access Journal
ISSN No: 2456 - 6470 | www.ijtsrd.com | Volume - 2 | Issue – 4

Mangroves of Indian Sunderbans Depleting Alarmingly Over the Past Few Decades

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ABSTRACT
Indian Sundarbans is tidal halophytic mangrove forest in the world. It is intersected by a complex network of tidal waterways, mudflats, and small islands of salt-tolerant mangrove forests. A variety of habitats have developed to accommodate the wildlife, including beaches, estuaries, permanent and semi-permanent swamps, tidal flats, tidal creeks, coastal dunes, back dunes and levees (Shapiro and Ari 2016). Besides a high number of mangrove tree species, additional plant species can be found here. The forest cover of the study area also provide a vital buffer against cyclones that are common in that part of the world and has been called "a natural safeguard for people (Wikipedia, the free encyclopedia 2017). The lives of the study area residents are frequently affected by human-animal conflicts; a few tiger and crocodile attacks every year are common. Because of issues such as deaths and injuries due to human-animal conflict, over-fishing and deforestation, the state imposed several restrictions on livelihood strategies. The state forest department have tried to reduce the local people's dependency on the forest for their livelihood by taking several management practices on infrastructure development projects such as building roads and jetties, excavating irrigation channels and ponds, providing solar lamps and establishing a few medical facilities (Ghosh and Priyanka 2015). Studies have shown that majority of population understand and support the conservation of mangroves and it ecosystems. However, perceived socio-demographic factors such as severe poverty, lack of political commitment, and absence of community level institutions are often barriers to the successful implementation of conservation policies (Das and Mandal 2016).

Keywords: *halophytic mangrove forest, deforestation, livelihood strategies, management practices*

1.0 INTRODUCTION

The Indian Sundarbans, a world heritage site, consists of an area of about 6312.768 sq. km (2012) out of which 2122.421 sq. km is covered by mangrove forests. The total forest cover of the Indian Sundarban, as assessed by Remote Sensing studies for the year 1986, was about 2246.839 sq. km, which gradually declined to 2201.41 sq. km in 1996, to 2168.914 sq. km in 2001 and to 2122.421 sq. km in 2012 (Samanta and Hazra, 2017). There has been a loss of 124 sq. km of mangrove forest cover. Thus a study is undertaken in Indian Sundarbans to explore the feasibility of forest management with respect to prevailing forest conservation measures in order to provide opportunities for improvement of forest cover in a sustained way.

2.0. AIMS & OBJECTIVES

- To evaluate the existing vegetation cover of the study area
- To evaluate the causes of the shrinkage of forest cover of the study area
- To explore the mitigation strategies for mangrove forest maintenance

3.0. METHODOLOGY

Reviewed and analyzed secondary data, information and literature that are available in the public domain, including information available on official websites of several Governmental and Non-Governmental agencies, scientific data and reports are used for the purpose of writing this paper.

4.0. STUDY AREA

4.1. Location: The study area lies between 21◦30'N to 22◦38'N latitudes and 88◦05'E to 88◦28'E longitudes and is bounded on the west from Bhagirathi or Hooghly to River Kalindi on the east and from Kalindi River to the confluence of River Meghna (Bangladesh), on the north by the Dampier Hodges Line to the south by Bay of Bengal. The study area covers 4264 sq. km (Bera *et al*. 2016) (Fig. 4.1).

4.2. Relief/Topography: The lands of the study area are plain with a network of canals, rivers and surrounded by estuaries. The process of land building through sedimentation by the Ganga and its distributaries is still active in this area. The average elevation of the lands in the study area is ~5m above mean sea level with a very gentle slope.

4.3. Geology: The area is the result of extensive fluvio-marine deposits of the river Ganges and the Bay of Bengal and the character of the sediment is silty clay. The dominant association of kaolinite with subordinate amount of quartz, illite and chlorite in the clay minerals in the Sundarban mangrove core sediment (Rajkumar *et al.* 2012). The adsorption capabilities result from a net negative charge on the structure of minerals, high surface area and high porosity (Alkan *et al.* 2004).

4.4. Geomorphology: The whole study area is under alluvial tract. Mainly seven gemorphic units are considered in the study area namely creeks, river channel, mud flat, alluvial plain, sand flat, mangrove swamp and estuary (Ganguly *et al.* 2006).

4.5. Drainage: The study area is criss-crossed with the rivers; among them majors are namely Matla, Ajmalmari, Kankalmari, Thakuran, Moni, Piyali, Raidighi, Mridangabhanga, Bidyadhari, Saptamukhi, Haribhanga, Kalindi etc.

4.6. Geohydrology: Generally aquifers occur in the confined condition in the depths range of 76-360 m with numerous alterations of clay and sandy clay beds of varying thickness. Ground water from unconfined aquifer is generally neutral to mildly alkaline with pH ranging from 7.2-8.1. It has low electrical conductivity (523-1463 mhos/cm at 250C), low chloride 14-188 ppm, and concentration of calcium; magnesium bicarbonate and iron vary from 14-76, 11-44, 281-640 and 0.01-3.4 ppm respectively. The deeper groups of aquifers occurring in the depths range 180-360 m contain fresh water. The ground water from deeper confined group is neutral to mildly alkaline with pH ranging from 7.4-8.1. The specific conductance ranges between 714-2692 mhos/cm at 250C and the chloride values range between 14-596 ppm. Concentration of bicarbonate, calcium, magnesium and iron vary respectively from 207-598, 12-68, 11-50, and 0.01-2.01 ppm. Thus it is seen that the quality of ground water both from the unconfined aquifers and from deeper confined group of aquifers in the southern part of the study area is suitable for human consumption (C.G.W.B 2010).

4.7. Climate: The study area is under the typical tropical monsoonal maritime climate. The climate in Sunderbans is generally soothing and pleasant. Ordinarily, the climate in Sunderbans ranges from 34 °C and 20 °C, and the rainfall is extremely high. So the weather is almost always moist and with the humid air from Bay of Bengal blowing constantly carrying 80% humidity.From October to March the North Easterlies blow here. While from March to September, the Westerly prevails. Since the sea is nearby, there is a cool sea breeze during night and thus the temperature is favorable all along the day. During the high tides at sea, there is maximum possibility of Sunderbans Delta being over flooded. But at the same time the sea provides an excellent climatic condition for the vegetation and the animals. Thus the climate in Sunderbans is neither too hot nor too cold (Climates in Sunderbans - Indian Holiday 2018).

4.8. Soil: Soils of the Indian Sundarbans mangrove forest differ from other inland soils in that they are subjected to the effects of salinity and waterlogging, which naturally affect the vegetation. In places soils are semi-solid and poorly consolidated. pH ranges widely from 5.3 to 8.0. Soil is in general medium textured; sandy loam, silt loam or clay loam. The grain size distribution is highly variable. Silt loam is the dominant textural class. A 72-87% silt content in 0-60 cm depth for Indian part of Sundarbans (Ray *et al.* 2014). Porosity is 0.7 (Ray et al. 2014). Sodium and calcium contents of the soil vary from 5.7 to 29.8 meq/100g dry soil, respectively, and are generally low in the eastern region and higher towards the west. Available potassium (K) content of the soil is low, 0.3-1.3 meq/100g dry soil. Organic matter content

varies between 4% and 10% in dry soil. Soil salinity increases from 5 ppt in east (slight to moderate) to 30 ppt in west (highly saline), but the salinity is not uniform from north to south throughout the forest (Soils of Sundarban mangroves 2016).

4.9. Vegetation: Vegetation at the Indian Sunderbans consists mainly of dense mangrove forests. It is the primary vegetation in the Sunderbans Delta. It is a unique tree that can stand in inundated land for a long time. Spikes rise up from their roots and they help in respiration and overall support of the Mangrove Plants (Plate 4.1). In fact this vast delta is referred to as a tidal swamp forest. All the vegetation types at the Sunderbans are evenly distributed. Indian Sunderbans derived its name from the 'Sundari' trees that thrive in great numbers in this region. These mangrove trees can grow very well in a combination of salt water and fresh water. More than 50 varieties of mangrove or sundari trees that grows wild as vegetation at the Indian Sunderbans region. In fact the Indian Sunderbans delta is one of the largest mangrove forests in the world. Mangrove plants thrive very well in muddy, wet soil and marshy areas in tropical tidal waters. The mangrove vegetation at the Indian Sunderbans can be categorized into shrubs, trees, ground ferns or palms depending upon the ratio of salt water and fresh water that the roots intake (Vegetation in Sunderbans 2018).

5.0. RESULT & DISCUSSION

5.1. Existing Vegetation Cover in the Study Area

The Indian Sundarbans flora is characterised by the abundance of Sundari (Heritiera fomes), Gewa (Excoecaria agallocha), Goran (Ceriops decandra) and Keora (Sonneratia apetala) all of which occur prominently throughout the area. New forest accretions are often conspicuously dominated by Keora (Sonneratia apetala) and tidal forests. It is an indicator species for newly accreted mud banks and is an important species for wildlife, especially spotted deer (Axis axis). There is abundance of Dhundul or Passur (Xylocarpus granatum) and Kankra(Bruguiera gymnorhiza) though distribution is discontinuous. Among palms, Poresia coaractata, Myriostachya wightiana and Golpata (Nypa fruticans), and among grasses spear grass (Imperata cylindrica) and Khagra (Phragmites karka) are well distributed. The varieties of the forests that exist in Sundarbans include mangrove scrub, littoral forest, saltwater mixed forest, brackish water mixed forest and swamp forest. Besides the forest, there are extensive areas of brackish water and freshwater marshes, intertidal mudflats, sand flats, sand dunes with typical dune vegetation, open grassland on sandy soils and raised areas supporting a variety of terrestrial shrubs and trees (Wikipedia, the free encyclopedia 2018).

Fig. 4.1 Study Area

Except these mangrove vegetation (Plate 5.1), the varieties of trees are found in the homestead land, majors are Terminalia arjuna (Arjun), Acacia nilotica (Babla), Albizzia lebbeck (Shiris), Eucalyptus globulus (Eucalyptus), Lagerstroemia speciosa (Jarul), Swietenia mahagonij (Mahagoni), Shorea robusta (Sal), Tectona grandis (Segun), fruit trees like Mangifera indica (Aam), Syzygium cumini (Jamun), Artocarpus heterophyllus (Jackfruit), Psidium juajava (Guava), Carica papaya (Papaya), Cocos nucifera (Coconut), Areca catechu (Supari), Ficus glomerata (Jogya dumur), flower trees like Michelia champaca (Chanpa), Ixora coccinea (Rangan), Hibiscus rosa\ sinensis (Jaba) etc (Nath Bhadra and Khan 2015).

A check list of some existing vegetation in the study area is given below (Nath Bhadra and Khan 2015) (Table 5.1 & 5.2).

Table 5.1: Mangrove Forest Vegetation

Sl. No.	*Scientific names*	Local names	Names of Families	Types of plant
1	*Avicennia alba Blume*	Paira Baen	Avicenniaceae	Tree
2	*Avicennia marina (Forsk.) Vierh.*	Kala Baen	Avicenniaceae	Tree
3	*Avicennia officinalis L.*	Jat Baen	Avicenniaceae	Tree
4	*Aglaia domestica Pellegrin.*	Amur	Meliaceae	Tree
5	*Bruguiera cylindrical (L.)*	Bakul	Rhizophoraceae	Tree
6	*Bruguiera gymnorrhiza (L.) Lam.*	Kankra	Rhizophoraceae	Tree
7	*Bruguiera sexangula Poir.*	Kankra	Rhizophoraceae	Tree
8	*Bruguiera parviflora (Roxb.) Wight and Arn. Ex Griff.*	Bakul	Rhizophoraceae	Tree
9	*Cerbera manghas Geartn.*	Dakor	Apocynaceae	Tree
10	*Ceriops tagal (Perr.) C.B. Robins.*	Math Goran	Rhizophoraceae	Tree
11	*Cynometra iripa Kostel.*	Singra	Caesalpiniaceae	Tree
12	*Excoecaria agallocha L.*	Genwa	Euphorbiaceae	Tree
13	*Heritiera fomes Buch.-Ham.*	Sundari	Sterculiaceae	Tree
14	*Hibiscus tiliaceus L.*	Bhola	Malvaceae	Tree
15	*Kandelia candel (L.) Druce*	Garia	Rhizophoraceae	Tree
16	*Lumnitzera racemosa Willd.*	Kripe	Combretaceae	Tree
17	*Nypa fruticans Wurmb.*	Golpata	Palmae	Tree
18	*Phoenix paludosa Roxb.*	Hental	Palmae	Tree
19	*Pandanus odoratissimus L. f.*	Keya	Pandanaceae	Tree

20	*Rhizophora apiculata Blume*	Garjan	Rhizophoraceae	Tree
21	*Rhizophora mucronata Lam.*	Garjan	Rhizophoraceae	Tree
22	*Sonneratia apetala Buch.-Ham.*	Keora	Sonneratiaceae	Tree
23	*Sonneratia caseolaris (L.) Engl.*	Ora	Sonneratiaceae	Tree
24	*Sonneratia griffithii Kurz.*	Ora	Sonneratiaceae	Tree
25	*Sonneratia alba J. Smith*	Ora	Sonneratiaceae	Tree
26	*Thespesia populnea (L.) Sol.ex. Cerrea*	Paras	Malvaceae	Tree
27	*Tamarix troupii Hole*	Nona Jhau	Tamaricaceae	Tree
28	*Tamarix dioica Roxb.*	Nona Jhau	Tamaricaceae	Tree
29	*Xylocarpus granatum Koenig*	Dhundul	Meliaceae	Tree
30	*Xylocarpus mekongensis Pierre. (Syn. Xylocarpus gangeticus Prain)*	Passur	Meliaceae	Tree
31	*Avicennia officinalis L.*	Jat Bani/Jat Baine	Avicenniaceae	Tree
32	*Avicennia alba Bl.*	Kalo Bani/ Kalo Baine	Avicenniaceae	Tree
33	*Avicennia marine (Forsk.) Vierh.*	Peyara Bani/ Peyara Baine	Avicenniaceae	Tree
34	*Fimbristylis ferruginea*	Not Available	Cyperaceae	Herb
35	*Heliotropium curassavicum L.*	Not Available	Boraginaceae	Herb
36	*Suaeda maritima (L.) Dum.*	Giria Shak	Chenopodiaceae	Herb
37	*Suaeda monoeca L.*	Nonaguru	Chenopodiaceae	Herb
38	*Sesuvium portulacastrum L.*	Jadu Palang	Ficoidae	Herb
39	*Scirpus s.l.ittoralis Schrad.*	Chuchura	Cyperaceae	Herb

40	*Acanthus ilicifolius L.*	Harguza	Acanthaceae	Shrub
41	*Aegialitis rotundifolia Roxb.*	Tora	Plumbaginaceae	Shrub
42	*Acrostichum aureum L.*	Hodo	Pteridaceae	Shrub
43	*Brownlowia tersa (L.) Koster.*	Lata Sundari	Tiliaceae	Shrub
44	*Clerodendron inerme L.*	Banjai	Verbenaceac	Shrub
45	*Caesalpinia crista L.*	Nate	Caesalpiniaceae	Shrub
46	*Ceriops decandra (Griff.) Ding Hou.*	Jhamti or Jele Goran	Rhizophoraceae	Shrub
47	*Pluchea indica Less.*	Gagan Tulshi/ Bon Tulshi	Compositae	Shrub
48	*Salacia chinensis L.*	Dimal	Hippocrateaceae	Shrub
49	*Viscum orientale Willd.*	Banda	Viscaceae	Shrub
50	*Salicornea brachiata Roxb.*	Not Available	Chenopodiaceae	Under-shrub
51	*Aegiceras corniculatum (L.) Blanco*	Khalsi	Myrsinaceae	Shrub to small tree
52	*Acanthus volubilis Wall.*	Lata harguza	Acanthaceae	Climber
53	*Dalbergia spinosa Roxb.*	Chandi	Papilionaceae	Climber
54	*Entada phaseoloides (L.) Merr. Nicker bean*	Gila	Mimosaceae	Climber
55	*Finlaysonia obovata L.*	Dudhilata	Asclepiadaceae	Climber
56	*Mukuna gigantean DC*	Not Available	Papilionaceae	Climber
57	*Stichtocardia tidifolia Hallier F.*	Not Available	Manispemaceae	Climber
58	*Derris scandens (Roxb.) Benth.*	Kalilata	Papilionaceae	Woody Climber
59	*Derris D.fritoliata Lour. heterophylla (Willd.) Back. and Bakh.*	Kalilata	Papilionaceae	Woody Climber
60	*Hemithrea compressus L.*	Not Available	Gramineae	Grass

61	*Myriostachya wightiana (Nessex Steud.) Hook f.*	Ghash	Gramineae	Grass
62	*Porterasia coarctata (Roxb.) Tateoca.*	Dhanighash	Gramineae	Grass
63	*Saccharum cylindricum L.*	Ulu	Gramineae	Grass
64	*Stenochlaena palustris Bedd.*	Not Available	Polypodiaceae	Fern

Table 5.2: Vegetation in Settlement Sites

Sl. No.	*Scientific names*	Local names	Names of Families	Habit of plants
1	*Terminalia arjuna (Roxb.exDC.Wight &Arn.)*	Arjun	Combretaceae	Tree (Indigenous)
2	*Acacia nilotica (L.) Delile*	Babla	Mimosaceae	Tree (Indigenous)
3	*Albizia lebbeck Benth.*	Shiris	Mimosaceae	Tree (Indigenous)
4	*Eucalyptus globules Labill.*	Eucalyptus	Myrtaceae	Tree (Introduced)
5	*Lagerstroemia speciosa (L.) Pers*	Jarul	Lythraceae	Tree (Indigenous, Planted)
6	*Swietenia mahagoni Jacq.*	Mahagoni	Meliaceae	Tree (Introduced)
7	*Shorea robusta Roxb. Ex Gaertn.f.*	Sal	Dipterocarpaceae	Tree (Indigenous, Planted)
8	*Tectona grandis L.f.*	Segun	Verbenaceae	Tree (Indigenous, Planted)
9	*Mangifera indica L.*	Mango/ Aam	Anacardiaceae	Tree (Indigenous)
10	*Syzygium cuminii (L.) Skeels*	Blackberry/ Jam	Myrtaceae	Tree (Indigenous)
11	*Artocarpus heterophyllus Lam.*	Jackfruit /Kanthal	Moraceae	Tree (Indigenous)
12	*Psidium juajava L.*	Guava/Peyara	Myrtaceae	Tree (Indigenous)
13	*Cocos nucifera L.*	Coconut/Narkel	Palmae	Tree (Indigenous, Planted)
14	*Areca catechu L.*	Betel nut/Supari	Palmae	Tree (Indigenous Planted))

15	*Ficus glomerata Roxb.*	Jogya dumur	Moraceae	Tree (Indigenous)
16	*Michelia champaca L.*	Chanpa	Magnoliaceae	Tree (Indigenous, Planted)
17	*Erythrina variegate L.*	Palita Mather, Mandar	Papilionaceae	Tree (Indigenous)
18	*Typha elephantine Roxb.*	Hogla	Typhaceae	Herb
19	*Ixora coccinea L.*	Rangan	Rubiaceae	Shrub (Indigenous, Planted)
20	*Hibiscus rosa-sinensis*	Hibiscus/ Jaba	Malvaceae	Shrub (Indigenous, Planted)
21	*Mussaenda frondosa L.*	Mussaenda	Ruliaceae	Shrub (Indigenous, Planted)
22	*Jatropha panduraefolia L.*	Jatropha	Euphorpiaceae	Shrub (Indigenous, Planted)
23	*Lantana amara L.*	Putush	Verbenaceae	Shrub (Planted)
24	*Carica papaya L.*	Papaya	Carieaceae	Shrub to tree (Introduced, Planted)
25	*Tabernaemontana coronaria R.Br.*	Tagar	Apocynaceae	Shrub to Tree (Indigenous, Planted)

26	*Gloriosa superb L.*	Agnisikha	Liliaceae	Climber (Indigenous)
27	*Clitoria ternatea L.*	Aparajita	Papilionaceae	Climber (Indigenous, Planted)
28	*Scindapsus officinales Schott*	Pothos or Money Plant	Araceae	Climber (Planted)
29	*Philodendron sp.*	Philodendron	Araceae	Climber (Planted)
30	*Monstera deliciosa Liebm.*	Monstera	Araceae	Climber (Planted)
31	*Ouisqualis indica L.*	Malati lata Rangoon Creeper	Cornbretaceae	Creeper (Planted)
32	*Vernonia elaeagnifolia*	Vernonia	Compositae	Creeper (Planted)
33	*Jasminum sp.*	Jue	Oleaceae	Creeper (Planted)
34	*Ipomoea aquatic Forsk.*	Kalmi	Conrolvulaceae	Thrnner and (Indigenous)
35	*Bougainvillea glabra Choisy*	Bagan bilas	Nyctaginaceae	Scrambler (Planted)

Source: Compiled from secondary data sources

5.2. Significance of Mangrove Forest in the Study Area

The mangrove forest provides benefits to the local communities in various ways (a) many mangrove trees are of great economic and use value as building materials for rural houses, furniture, making boats and as fuel wood (Government of India (1989), (b) many mangrove herbs have medicinal values (Vannucci 2004), (c) mangrove functions as wind-breaking barrier, minimizing the intensity of cyclonic storms (Bandyopadhyay 1989,

Plate 5.1 Mangrove Vegetation

Plate 4.1 Pneumatophores

Mastaller 1996) and (d) mangrove functions as natural sewage treatment plant and an important carbon dioxide sink. It absorbs pollutants from both air and water. The mangrove plants have high percentage of tannin present in their barks and leaves, which can neutralize some of the industrial pollutants and reduce their detrimental effect (Naskar and Guha Bakshi 1987, Mastaller 1996, Banerjee 1998, Government of West Bengal 2002, Vannucci 2004). The mangrove forest in the study area is an important nursery, breeding, feeding and spawning ground for many brackish water animal species especially fishes of great economic importance. From the beehives in the study area, people collect honey and wax on an average every year. It is the home of a number of endangered and globally threatened species. The mangrove ecosystem in the study area provides scope for interdisciplinary research programme involving natural and social sciences. Mangrove in the study area restoration offers good opportunities for ecotourism, biological research, conservation education and economic benefit to local communities (Nath Bhadra and Khan 2015).

The mangroves of Sunderbans are mainly belonging from Abisiniya and Rizophora families. The breathing roots, stilt roots and tap roots of mangroves protect the inhabitants of Sunderbans from soil erosion, flood and coastal erosion. Actually the root systems of mangroves hold soil consistently during tidal effects. As a result the intensity of soil erosion is thus mitigated during tides. From the geographical perspective the mangroves situate towards the extreme southern part of West Bengal, as a consequence of such location they protect Kolkata with the important districts of south Bengal from destructive tropical cyclones being originated on the Bay of Bengal. Lots of honey is available in the Sunderban Mangrove jungles. Not only, this honey is sold in India and also exported for earning foreign currency, but also the poor people residing at Sunderbans economically depend on such forest products. But nowadays this type of forest dependency is strictly restricted by the Government. The natural vegetation found in the Sunderban jungles has a great economic value (Table 5.3). Except these, to maintain the balance of ecosystem, production of oxygen and also maintain the stability between food chain and food web, the mangroves of Sunderbans play a very vital role. This is why it is called the „Natural Museum". And at last but not the list to control environmental pollution, weather and climate, these mangroves play a very significant role (Bera *et al.* 2016).

Table 5.3 Floral Diversity and its Importance in Indian Sunderbans

(i) Garjan	Rhizophora apiculata	➢ About 33% tannin is found at the barks ➢ It is used for curing the diabetes disease ➢ Wood pieces are being made ➢ The wood of this tree is used to burn bricks and Charcoal is found
(ii) Garjan	R. murcronata	➢ The chemicals from barks stop bleeding ➢ Use to join fractured soft muscles ➢ Use to cure diabetes
(iii) Kankra	Bruoguiera gymnorhiza	➢ 36% tannin is found ➢ Use to cure abdominal diseases and diabetes
(iv) Ban Bakul	B. parviflora	➢ Fruits are used for making eye medicine
(v) Bakul	B. cylindrica	➢ Fruits are used for making eye medicine

(vi) Garan	Ceriops tagal	➢ Extract from barks stop bleeding and useful for diagnosis of Cancer
(vii) Jhampti Garan	C. decandra	➢ Extract from barks stop bleeding
(viii) Gariya	Kandelia Candel	➢ Use to cure diabetes
(ix) Bani	Opuntia delenii	➢ Expectorant from fruits i.e. medicines are made for removing cough from windpipe
(x) Akash Bel	Cassytha filiformis	➢ Medicine for curing dysentery
(xi) Ban Jui	Clerodendrums inerme	➢ Medicines for cough and fever are produced from leaf‟s extracts
(xii) Kaora	Sonreratia apetala	➢ Use to build wooden plank
(xiii) Ganoa	Exceoecaria agallacha	➢ Use to make match sticks ➢ Wooden pieces are made
(xiv) Sundari	Heritiera minor	➢ Use to construct wooden boat
(xv) Pasur	Xylocarpus granatum	➢ Use to make wooden plank
(xvi) Dhundul	Xylocarpus granatum	➢ Use to work in Lathe machine ➢ Use to construct boat
(xvii) Golpata	Nipa fruticans	➢ Alcohols are produced

Source: Gib Bhugol o Paribesh, Bera *et al.* 2016

5.3. Present/Current Status of the Shrinkage of Forest Cover in the Study Area:

Table 5.4 Loss of Forest Cover over the Years

Island **Year**	**1986**	**1996**	**2004**	**2012**
	Area in sq. km			
Indian Sunderbans	2246.839	2201.41	2168.914	2122.421
Gosaba	517.47	517.44	506.71	506.69
Dulibhasani West	180.03	174.78	170.90	163.47
Dalhousie	76.60	72.39	68.09	64.24

Bhangaduni	40.44	35.15	29.55	24.91
Jambudwip	6.09	5.91	5.68	5.003

Source: Mangrove Forest Cover Changes in Indian Sunderban (1986-2012) Using Remote Sensing and GIS, Samanta and Hazra 2017, School of Oceanographic Studies, Jadavpur University & Climate change impact: Sunderbans steadily losing its famed mangroves, Singh 2017

Table 5.5 Shrinkage of Forest Cover

Year	**Indian Sunderbans**	**Island**				
		Gosaba	**Dulibhasani West**	**Dalhousie**	**Bhangaduni**	**Jambudwip**
		% of shrinkage of forest cover				
1986	**2.02**	0.006	2.92	5.50	13.08	2.96
1996	**1.48**	2.07	2.22	5.94	15.93	3.89
2004	**2.14**	0.004	4.35	5.65	15.70	11.92
2012	**5.54**	**2.08**	**9.20**	**16.14**	**38.40**	**17.85**

Source: Formula of determining decreasing rate, i.e. $\frac{\text{Actual/Initial value} - \text{Decreasing Value}}{\text{Actual/Initial value}} \times 100$

The total forest cover of the Indian Sunderbans for the year 1986 was about 2,246.839 sq. km., which gradually declined by 2,201.41 sq. km. in 1996, then down to 2168.914 sq. km in 2004 and to 2122.421 sq. km in 2012. The loss in the mangrove forest in the Indian Sunderbans is about 5.54 %. The loss in mangrove cover at Gosaba has been about 2.08%, down from 517.47 sq. km in 1986 to 506.69 sq. km in 2012. In Dulibhasani West, the loss of mangrove cover has been about 9.20% from 180.03 sq. km. in 1986 to 163.47 sq. km. in 2012. The mangrove forest cover of Dalhousie, another island, has depleted by 16.14%, from 76.60 sq. km. in 1986 to 64.24 in 2012. Bhangaduni has mangrove forest land, from 40.44 sq. km. in 1986 to 24.91 sq. km in 2012, taking the loss to over 38.40%. Jambudwip, one of the smallest uninhabited islands at the mouth of the sea, also has reduced forest cover from 6.09 sq. km. in 1986 to 5.003 sq. km. in 2012, or about 17.85% (Table 5.4 & 5.5) (Fig. 5.1 & 5.2).

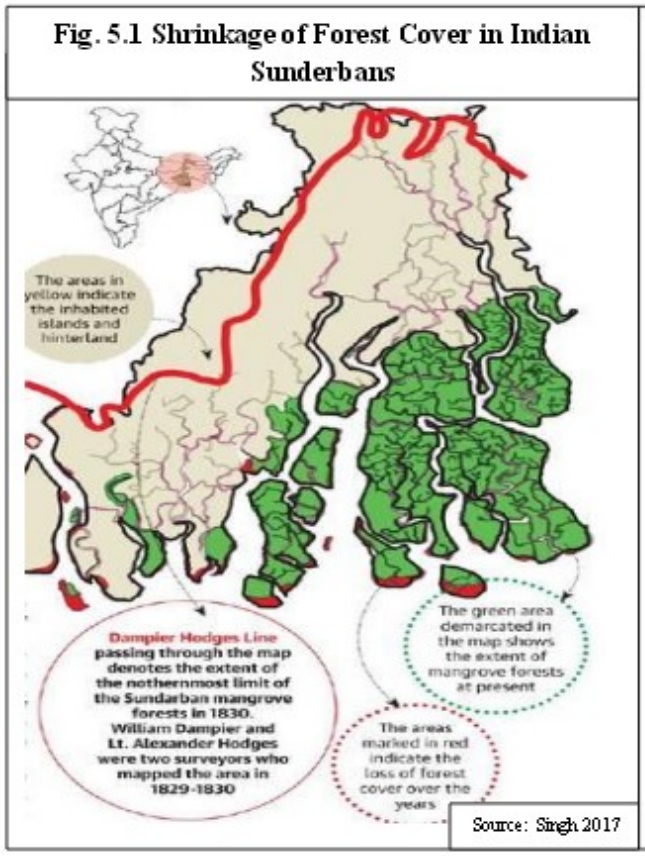

Fig. 5.1 Shrinkage of Forest Cover in Indian Sunderbans

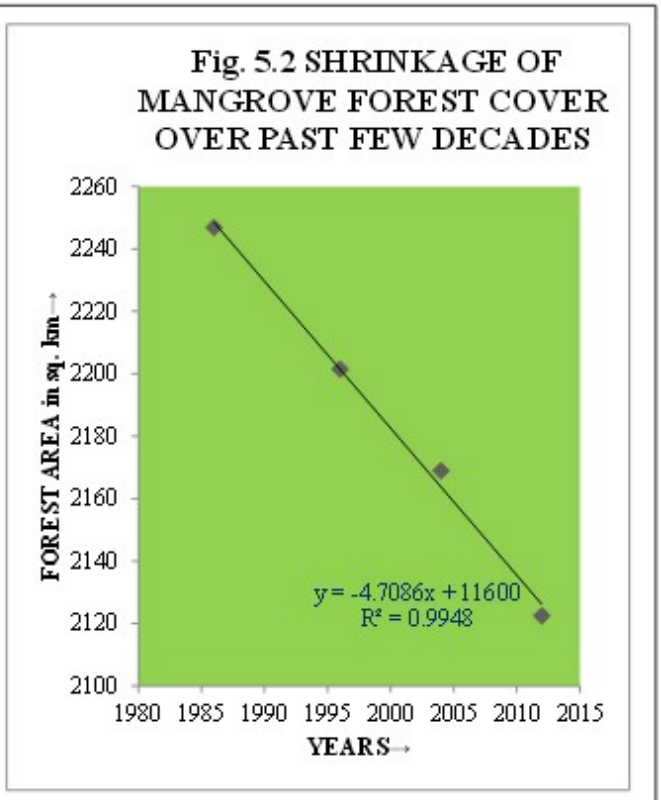

Fig. 5.2 SHRINKAGE OF MANGROVE FOREST COVER OVER PAST FEW DECADES

5.4. Possible Causes of Deforestation in Indian Sunderbans over the Past Few Decades

The balance is fragile between the people living in the study area with their surrounding mangrove forests, upon which they depend for subsistence and livelihood, because excessive exploitation due to lack of supplementary or alternative livelihood and income generation and prevailing poverty can undermine the resource availability. Some of the households directly extract forest resources for their livelihood and the remaining households depended partly on the forest resources, both earning money from either selling or processing these resources. Actually people living in the study area mostly depend on forest resources to satisfy many of their basic needs, such as food, fuel, construction materials for houses, boats, furniture and fishing implements, medicinal herbs and many other items for trade and commerce (Nath Bhadra & Khan 2015).

Moreover, the continuation of this process of depleting forest cover in response to climate change and sea level rise poses a serious threat to the carbon sequestration potential and other ecosystem services of this mangrove forest in future. The mean sea level rise at the Sagar Island Station, measured from 1985 onward till 2010, shows a rise by 2.6-4 mm a year, which can be considered a driving factor for coastal erosion, coastal flooding, and an increase in the number of tidal creeks (Samanta & Hazra 2017, Singh 2017). The climate change and sea level rise has contributed to the phenomenon of losing land, including mangrove forests in the Indian Sundarbans, in the last part of the 21st century. This is because there is less fresh water flow and sediment supply in the western (Indian) part of the delta, so there is starvation of sediment and the rate of sea level rise is higher than sediment supply. Hence Indian Sunderbans are losing land, including mangrove forest (Hazra, the Hindu).

5.5 Management through Improvement of Forestry

Forest management in general can aim at sustainability of forests and forestry, ensuring adequate supplies of forest products, maintenance or expansion of forest cover and species composition, habitat and ecosystem conservation and improved quality of products and improved efficiency of production and distribution systems, as a basis for improved value of forests and forestry (including but not limited to economic revenue). Management of mangrove habitats and dependent communities has an even broader, multi-disciplinary scope. The following aspects have been identified as relevant for the study area, with the explicit aim of sustainable resource

utilization, to the benefit of future generations as well as present ones.

5.5.1. Contribution of non-timber forest products (NTFPs) in the livelihood: The major NTFPs that are found in the study area include honey, bee wax, tannin, bark and leave (Golpata) etc. It may become one of the essential components of the livelihood of the forest dependent population of the study area. The NTFPs being collected from the forests may contribute in the income generation of the local people. Actually NTFPs as a livelihood asset may help as a "safety net" against the livelihood vulnerability of the study area. Of course not every family of the villages go for NTFPs collection but if, they go for it on the basis of seasonality when there is a lean period in agriculture, high livelihood vulnerability may be reduced.

5.5.2. Work under NREGA: After reconstruction and repairing of the dykes, planting of mangrove species may be a good option for providing work under NRGEA. „Dhani" grass and reeds can be grown on the slopes a fodder (Banerjee 2009).

5.5.3. Agro forestry or pisciculture: Agro forestry or pisciculture can also be tried in the forest. It is a practice to excavate channels in order to make inroads for the river water to enter the forest. Then they plugged the inlet point and used the water for growing fish. Thus, livelihood options for the people could be introduced without disturbing the forest cover in any way (Banerjee 2009).

5.5.4. Social forestry: Social forestry can be useful for eco-restoration of mangrove vegetation through creation of employment opportunities (Bose 2004).

5.5.5. Mangroves and aquaculture: Action has to be taken for reforestation, restoration and development of the mangroves. Promotion of integrated conservation and management systems between mangroves and aquaculture is to be advocated.

6.0. CONCLUSION

The Indian Sundarbans contain the world's largest halophytic mangrove forests and one of the most biologically productive of all natural ecosystems. The forests contain a rich biota which includes the Bengal tiger and many threatened reptiles. The mangrove jungles of Indian Sundarbans are also of great economic importance as a storm barrier, shore stabilizer, nutrient and sediment trap, a source of timber and natural resources, and before cyclone Sider were the most important source of fish and shrimps on the east Indian coast, They are an excellent example of the ecological processes of monsoon rain flooding, delta formation, tidal influence and plant colonization. The Indian Sundarbans lie within a WWF Global 200 Eco-region, and are contained by both a Ramsar Wetland and a UNESCO Biosphere Reserve which contains the Tiger Reserve, National Park and three wildlife sanctuaries. Moreover the people worked in the forest, of whom some collected timber and firewood, some collected honey and beeswax (The season for collecting honey and wax is limited to ten weeks from April 1st. Thousands of people, with permits from the Forest Department, enter the forest for nests) and some harvested the natural resources and hunted mainly deer, and some were fisherman and shrimp farmers. Today, the area provides a livelihood at some seasons of the year. Local people are also dependent on the forests for charcoal, timber for boats and furniture, poles for house-posts and rafters, nypa, palm thatch for roofing, grass for matting reeds for fencing, shells and reptile skins, with deer, fish, crabs and shrimps taken for food. Therefore, from these aforesaid significant values, the mangroves of Indian Sundarbans must be conserved through proper implementation of Government and Non-Government various initiatives considering the infrastructural development of the study area and people"s cooperation and willingly participation.

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