

Dwindling Indian Sundarban Mangrove: The Way Out

ABSTRACT : Euphony of Sundarban mangrove lies in its picturesque beauty. Keeping aside Bangladesh part, Indian Sundarban mangrove forest alone have been dwindled about 58%, from 10,000 km² to 4226.6 km². By this time it has witnessed to the extinction of five important mammalian species along with ecosystems existing around them. In the array many others seem threatened. Nevertheless, the biological diversity is very much rich; so are enriched ecosystem services and economic benefits harnessed from this mangrove forest in the purpose of livelihood. The Indian Sundarban mangrove forest is the largest one in view of both area coverage and floral diversity as assessed 62% and 90% respectively, amongst other mangrove forests in India. The ecosystem services of the forest renders are noteworthy that includes nutrient release, increasing soil and water fertility, mitigation of other adversities including natural calamities which coastal areas very often encounter. The ecosystem services sustain both terrestrial and aquatic food chain that in turn facilitates economic benefits such as food, fodder, medicines, timbers, etc. upon which local people are dependent. However, a conflict prevails between resources and livelihood that apparently reflects the poor indices of ecofootprint of the Indian Sundarban areas. Some measures, if undertaken, may ensure the protection of Indian Sundarban from further degradation.

“The woods are lovely, dark, and deep”

– Robert Frost

The poet could feel to express such line after being mesmerized to behold the beauty of the forest which had been far distance from Sundarban; however, his ecstasy of feeling anybody may find quite resemblance hitherto to the picturesque of Sundarban mangrove forest.

Euphony of the name ‘Sundarban’ draws three distinct opinions about its genesis: one opinion believes that ‘Sundarban’ had been christened from ‘Sundari’ species (*Heritiera formes*), which had once dominant population in Sundarban forest. Bengali vernacular ‘Sundari’ means beautiful. The second argues that as Sundarban is being situated facing, towards sea so the name had been derived as ‘Samudraban’ which means forest within the sea. The Samudraban later has been modified ‘Sundarban’ after twist of word. The third one simply opines as it is really a beautiful forest, so is the name ‘Sundarban’.

The vegetation of Sundarban mangrove forest appeared during 31750 ±2030 years before past (BP)¹. But the formation of Bengal basin wherein present day Sundarban mangrove forest exists initiated as early as 126 million years BP². Considered as ‘Proto-delta’, the landmass initially experienced a strong regression of sea and the shifting of coastline to southwards during 49.5-10.5 million years BP¹. As a result an incomplete ‘Transitional-delta’ was formed and that later got the present shape of ‘Modern-delta’ during 10.5-4.5 million years BP¹. Situated at the mouth of Ganga-Brahmaputra delta, the united landmass of Sundarban mangrove forest has been the largest single mangrove chunk in the world^{3,4}. After partition of India in 1947, Bangladesh (erstwhile Pakistan) shares about 60% of mangrove forest area and remaining 40% fall in India.

Indian Sundarban presently covers 4266.40 km² though satellite images has recorded only 1434.40 km², based on forest dominated areas. Estimated roughly that Indian Sundarban spread over about 10,000 km² before two centuries back, 42% of which exist now. Evidently, Kolkata city was covered with mangrove vegetation and that saline marine condition extended upto north of Barrackpore, North 24-Parganas (Fig.1) along with occurrence of tidal ingression at the place of present day Dum Dum between 6,000-10,000 years BP^{5,6}. Since then dwindling has been more than half of mangrove forest area; so remain less than 50% today in Indian Sundarban. Such reduction of Indian Sundarban mangrove forest has been similar to the trend of over all forest degradations in general and mangrove forest in particular in view of global perspective; once mangrove forest covered three-fourth of coastlines of the tropical and sub-tropical countries⁷. Considering the importance of mangrove forests in the present context, this article is intended to discuss only Indian Sundarban mangrove forest with regard to its contribution of maintaining biodiversity and rendering ecosystem services to human welfare in one way, and recommendation of some measures for its protection in other.

Biological Diversity: Existing and Lost : An Indubitable Treasures : Sundarban mangrove forests (united landmass of both Bangladesh and India) have been considered as one of the seven most important wetlands globally, based on biological diversity⁸. In this respect Indian Sundarban constitutes the substantial biological

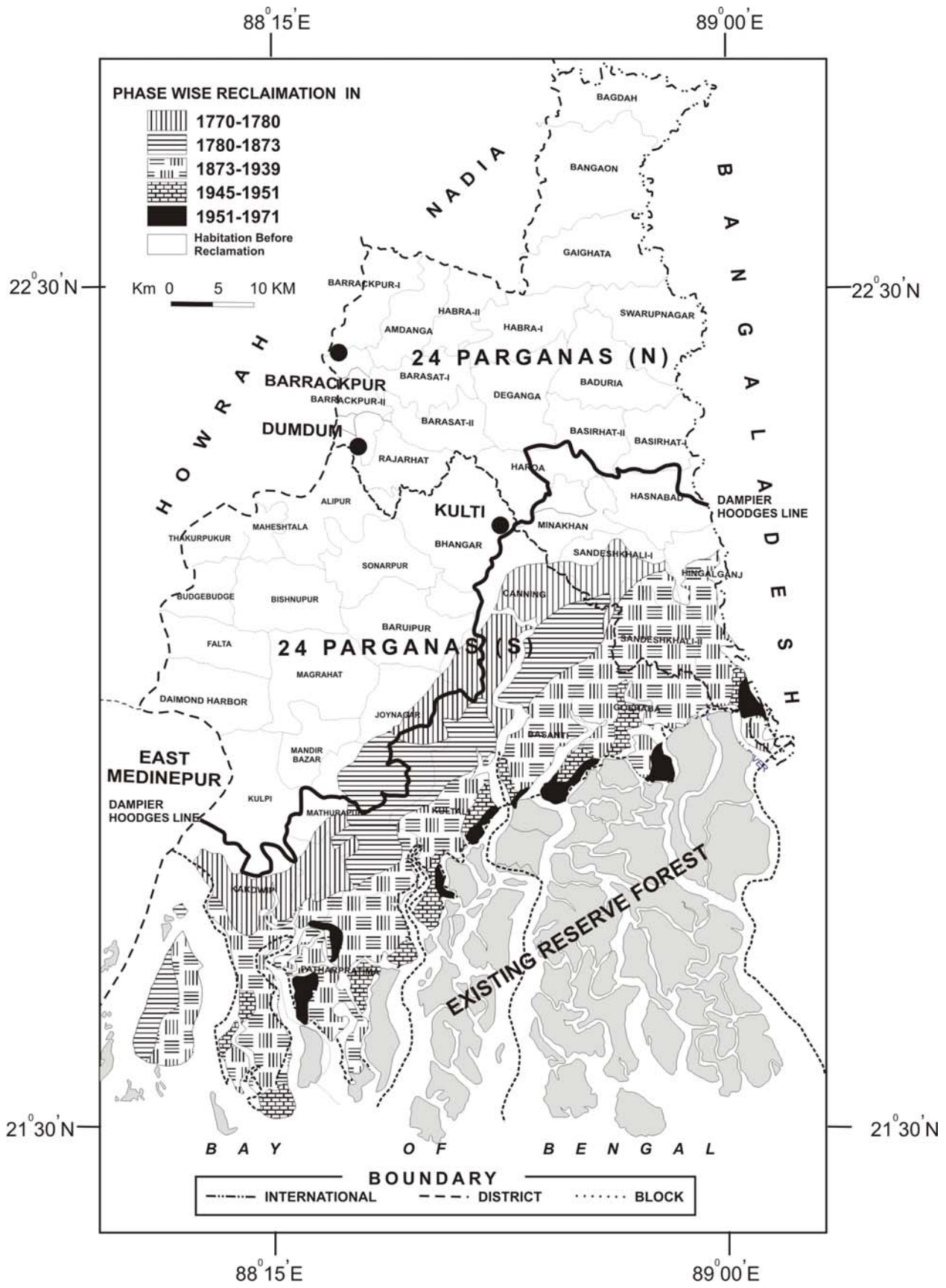


Fig. 1. Map showing reclaimed forest areas and existing forest of Indian Sundarban, along with extended part of mangrove forest recorded from paleontological evidences (see text).

diversity (Table-1), including 69 intertidal plant species. Of which 30 species belong to true mangrove, 20 species mangrove associates and 12 species back mangals⁹. In global perspective the Old World tropics comprising 40 true mangrove and the New World tropics only 8 true mangrove, both together constitute 48 true mangrove species¹⁰. Importantly, Indian Sundarban alone represents 30 true mangrove out of 40 true mangrove reported in the Old World Tropics. In National perspective, Indian Sundarban mangrove covers 62% area about 2,400 Sq.km¹¹, which maintains 90% species diversity, followed by Andaman and Nicobar Island with 76.5% and Bhitarkanika, Orissa with 72.3% (Fig. 2a & b) in respect of existing major mangrove diversity⁹.

TABLE 1 Floral and faunal diversity of Indian Sundarban mangrove (ref. 3,4)

SPECIES	NUMBERS
Plant	
Bacterial stain	24
Lichens	04
Algae	80
Fungi	22
Bryophytes	04
Pteridophytes	03
Higher species	69
Animal	
<i>Invertebrates</i>	
Protozoa	104
Cnidaria	33
Ctenophora	02
Platyhelminthes	41
Namethelminthes	68
Mollusca	142
Annelida	78
Arthropoda	476
Echinodermata	20
<i>Vertebrates</i>	
Chondisthys	22
Fishes	154
Amphibia	08
Reptilia	58
Aves	163
Mammalia	40

Lost Beyond Retrieval : Unfortunately, Indian Sundarban mangrove forest (also Bangladesh Sundarban) had witnessed to a great loss of precious biological

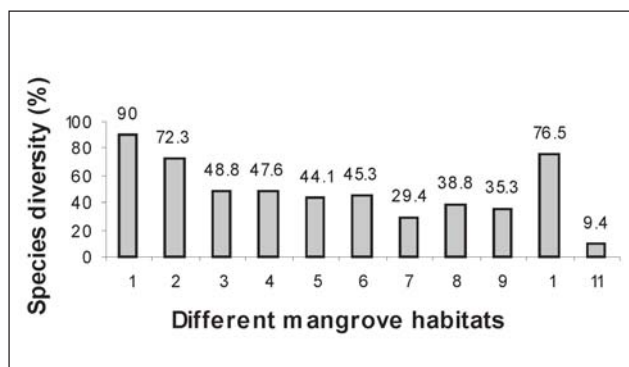
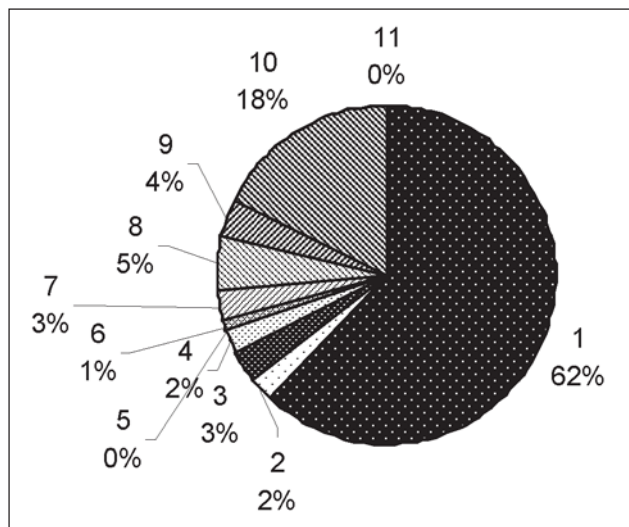


Fig. 2. a & b Percentage of area coverage and diversity of mangrove respectively in India. Different mangrove habitats: 1. Sundarbans, W.B.; 2. Bhitarkanika, Orissa; 3. Godavari & Krishna delta, A.P.; 4. Cauveri estuary, Tamilnadu; 5. Cochin estuary, Kerala; 6. Kundapur & Malpe estuary, Karnataka; 7. Goa estuary, Goa, 8. Bombay estuary, Maharashtra; 9. Bhabnagar estuary, Gujrat; 10. Andaman & Nicobar Islands; and 11. Lakshadweep Atoll.

treasures: Swamp deer (*Cervus duvauceli duvauceli*), Wild buffalo (*Bubalus bubalis*), Javan Rhinoceros (*Rhinoceros sondaicus*), Gharial (*Gariales gangeticus*), and Sweet water turtles (*Chitra indica*), these species were found available even 100 years back¹². Their remains were recorded during excavation of Calcutta Metro Rail or digging of sweet water ponds of Sundarban¹³. It is assessed that 11 species of reptiles, 6 species of birds, and 7 species of mammals are highly endangered; the decreasing number of their population is in an alarming state¹⁴. Depletion of biological diversity may lead to destabilize ecosystem services to human welfare and may limit economic opportunities of future generations¹⁵. The extinction of these five mammalian species has definitely created the gap within the ecosystem services, which has remained unanswerable particularly services they could provide to human beings. These important species could have been source of economic benefit for livelihood of major populace of Indian

Sundarban by dint of eco-tourism via-a-vis wild life conservation. Apart from that, the reasons for which they became extinct are yet unresolved, except the reason indicating changed ecological condition due to neo-tectonic movement. So the loss is irreparable; even around them a tropic food chain existed that possibly jeopardized subsequently. The ecosystem loss is also hardly measurable. For example, around single tree species approximately 300 species of insects and several birds species are dependent¹⁶; a distinct ecosystem exists. That any forest ecosystem renders its services to human beings, if calculated, is unbelievable.

Ecosystem Services : A Staggering Occurrence :

Ecosystem services are defined as services generated due to the interaction and exchange between biotic and abiotic components of an ecosystem, which includes the occurrence of energy flow, cycling of nutrients and other materials considered as production of ecosystem functions through various ways, but that does not include products like food¹⁷. Any ecosystem services may be categorized into two groups such as (a) direct services that are visible apparently to common people, and (b) indirect services that require estimation by experts groups (Table 2).

TABLE 2. Indian Sundarban mangrove forest rendering ecosystem services (ref. 4,7),

(a) Direct services	(b) Indirect services
Mitigation of natural calamities such as cyclone, aila, tsunami, sea surges, strong tidal flow, prevention of coastal erosion, soil accretion resulting in expansion of Islands, etc.	(i) Decomposition of litter, release of nutrients, processing and acquisition of nutrients, increase of soil fertility, retention of soil moisture, prevention of salt encrusted layer through leaching over soil surface, waste assimilation, pollination, biological control, pollution control, regulation of atmospheric gases and composition, regulation of climate and water, wastewater treatment, lowering the biological oxygen demand (BOD), possibly performing bio remediation (ii) Provision of breeding, hatching, spawning, rearing of large number of aquatic organisms, including economically important fishes.

Ecosystem services, however, get setback when destruction of forest continues. The more the forest is reduced, the less the reclaimed areas become fertile. Litter fall from mangrove vegetation, decomposition of litter and thus nutrient release into soil and water, all are cumulative effects of ecosystem services, which diminish with loss of

vegetation. Even maintaining biodiversity requires reasonable analysis and protection of ecosystem services¹⁷. One is integral to another. The mangrove ecosystem alone is quite productive as measured to yielding as 350-500g C/m²/yr¹⁸ that provide a substantial contribution to the food chain that leads to keep sustainability of coastal fisheries⁷. *Avicennia* spp. and *Sonneratia* spp. dominated forest area of Indian Sundarban has been assessed to produce about 212 tons/ha of biomass¹⁹. An estimate has shown that a full grown mangrove stand of 10 years old may add to soil the following amounts of nutrients through litter decomposition: N, 46.6 kg/ha/yr; K, 25.6kg/ha/yr; Ca, 99.3kg/ha/yr; Mg, 34.1kg/ha/yr; and Na, 31.8kg/ha/yr²⁰.

Present Scenario in Inner Estuary : Mangrove can act to metabolize organic waste and have been termed as natural waste treatment works. By utilizing nutrient loads they can increase productivity⁷, but continuous excessive input of nutrients may adversely affect the ecosystem of mangrove²¹. For example, *Sonneratia caseolaris* prefers growing in low saline zone of less than 5ppt at water. Its population is mostly confined in Minakha Kulti area, 24-Parganas (North) of Indian Sundarban. Just 10 years back the population of this species was found luxuriant growth, but now is under serious threat. The total number of population is decreasing rapidly. Though the species is capable of surviving in high polluted area, but continuous excessive sewage discharge push the entire population at high risk of extinction. Pollutants load about 22,900 kg per day discharged from Kolkata metropolis have drained off through Hooghly River and sunk at mangrove estuarine belt²²; until now the amount of waste load has increased many times. Regeneration of *Sonneratia caseolaris* is severely affected because of excessive waste load along with continuous habitats loss mainly due to brackish water aquaculture and brick industry development. Another species, *Nypa fruticans*, locally Known as Golpata, is affected too, but in a different way. The species is sensitive to high salinity; so, the population is found growing at river mouth of freshwater run off. The population are cruelly damaged for harvesting its leaves for thatching.

Nevertheless, in fact large scale habitat loss in Indian Sundarban could not bring complete extinction of any particular flora; for the vegetation constitute considerable number of population of respective species, along with large area coverage. This is evident from past and present survey record of species^{23,24,25,26}. Though, the total number of flora remains unchanged; however, population of certain species is under threat. For example, *Atalantia corea* and *Acanthus volubilis*, which are presently confined

in particular zone with very limited populations²⁷, are now threatened.

Economic Benefit : Plant Resources : Indian Sundarban mangrove forest produces resources that have direct economic benefit for livelihood. These resources include three items: (i) Food, fodder, honey, leafy vegetables, (ii) Tannin, wax, fuel wood, thatching material, timber for construction of house, boat, fence, etc., and (iii) Medicinal plants. Fruits of *Sonneratia apetala* are marketed now and also preferable food items to Rhesus monkeys¹³. Frond of *Acrostechum aurium* is used as leafy vegetables. Most of the mangrove leaves are suitable fodder for the domestic livestock, apart from wild animals like deer, monkey and wild boar. That one of the most economic resources is honey support livelihood substantially among honey collectors living in the fringe villages of Sundarban. A group comprising 10 members in one venture may collect about 10 quintal of honey costing Rs. 4,8000 @ Rs.48.00/kg as per Govt. rate; so that one can earn Rs. 4,800 per trip; whereas in local market one kg of honey cost ranging between Rs. 80-100²⁸. Honey collection from Sundarban forest is a seasonal activity occurring usually in the period of 15th April to 31st May every year.

Resources like tannin, wood, timber, etc., if calculated, will amount to a staggering figure in terms of pecuniary benefit, but local people use these resources as their integral part of daily life without economic botheration. Mangrove flora also provides important medicinal benefits: leaves of *Bruguiera gymnorrhiza* is used for remedy of diarrhea and blood pressure, *Rhizophora mucronata* for angina, *Acanthus ilicifolias* for asthma and rheumatism, *Lumnitzera racemosa* for herpes and itches, *Cynometra ramiflora* and *Excoecaria agallocha* for leprosy^{29,30}.

Faunal Resources : In faunal diversity, about 94 finfishes, 12 shellfishes, 8 crabs, and 5 mollusca, which have high commercial value, are economically important¹⁴. Survey has shown that of seven forest blocks outside Sundarban Tiger Reserve (STR) a total of about 26,500 people, comprising 3,000 people actively engaged in fishing, 5,600 people in fishing associated works, 9000 people employable fishers and 8,500 employed fishers, is recorded from two blocks viz., Kakdwip and Namkhana, 24 Parganas (South). Estimate about 16% and 40% people from these two blocks has been surveyed in respect of their only earning as well as dependence on fishing activity in Indian mangrove forest areas³¹. This glimpse of survey covering only two blocks out of total 22 forest blocks (15 inside tiger reserve area +7 outside tiger reserve area) has importantly revealed the potentiality of economic viability of Indian Sundarban mangrove forest areas.

Conflict : Resource vs. Livelihood : Forest refers to vegetation that is the basis of the whole ecosystem along with biological diversity in a given area. Human survival and economic well being are fully dependent upon biological diversity that encompasses all life forms, ecosystems, and ecological processes, acknowledging the hierarchy at genetic, taxa and ecosystem levels³². The more is the biodiversity the greater is the access to available resources, along with increased net primary production and decreased nutrient loss¹⁶.

In such context, ecofootprint is considered as the indicator of future development of tropics that is estimated from the consumption of resources (production + import – export of a given resources) of nations³³. In Indian Sundarban, the forest area is covered with dark and deep mangrove vegetation, while adjacent reclaimed area is densely populated and also utilized for agriculture crops, brackish water fisheries and brick industry for livelihood. There is a constant chasm in between production of resources and consumption of resources by local inhabitants. Accurate data is not available, but the rate of populations increase and depend on forest resources obviously leads to shortage of resources that results in over exploitation of mangrove forest. Thus dwindling forest areas is inevitable, which reflect apparently the poor indices of ecofootprint of Indian Sundarban as a whole. Usually, livelihood is inversely correlated to both forests and resources, but later two are linearly correlated, being as much vigorous forest yields as more resources (Fig. 3).

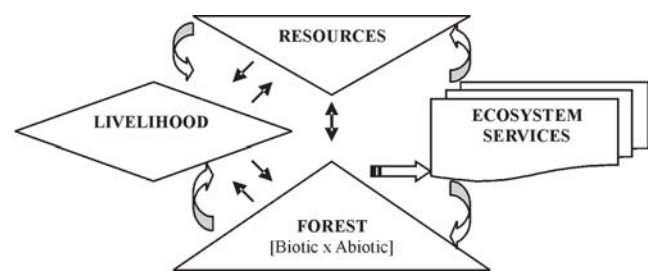


Fig. 3. Correlation among forest, resources and livelihood: forest and resources are linearly correlated, but both are inversely correlated to livelihood. Ecosystem services that are generated due to interaction among biotic and abiotic components of forest sustain further both forest and resources. In the process economic benefits harnessed from forest and resources help livelihood.

Committed Destruction : Such pristine forest had been dwindled because of committed destruction. Degradation of Sundarban mangrove forests started since 1770 during British India. Claude Russel and later Tilmen Henckell initiated to reclaim Sundarban forests, which were then partly utilized for rehabilitation of human population and remaining for rice fields and brackish water fisheries.

A chronological data represents the period of forest destruction along with respective areas, occurring in five phases (Fig. 1). For forest reclamation, most of the labours engaged came from Chhotanagpur, the erstwhile Bihar and later they had been settled in reclaimed areas. In 1947 India witnessed the destiny of her partition. Effect of which engulfed Indian Sundarban too. A huge influx of refugee was settled in reclaimed Indian Sundarban³⁴. Until 1971, the reclamation of forest continued. Since then the need for conservation of mangrove awoke, albeit lately. Nonetheless, degradation of forest was not stopped, rather perpetuated slowly by illegal encroachment because of dense population. The time period from 1951 to 1981, increase of population and dwindling of forest has been just inversely correlated, which is clearly visible (Fig. 4).

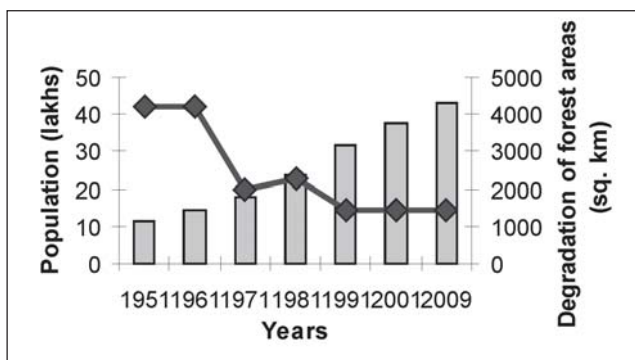


Fig. 4. Correlation between population increase and dwindling forest areas.

Thanks to awareness as well as surveillance from Govt. sectors and NGOs, the rate of degradation of forest area has been checked during late eighty onwards, though population increase has not been stopped.

Geographical Location: Vulnerable to Natural Calamities : Tropical cyclones accompanied by storm surges are common phenomenon in Sundarban areas which being situated at tropical zone is vulnerable to cyclonic effect. The Bay of Bengal is a potentially energetic region for the development of cyclonic storms, accounting for about 7% of the global annual total number of tropical storms³⁵. It is because the entire Bay of Bengal falls under the tropical belt and therefore, receives almost vertical fall of insolation that warms up water surfaces as quick as fast. On the other hand, being shallow depth of it as compared to Arabian Sea, water masses as a whole warm up abruptly resulting in the formation of low pressure centres covering large area. These low pressure centres are in turn akin to form cyclonic storms and most of which move towards onshore land of Bay of Bengal due to South-north polar movement of earth as per Ferrell's law, and severely hit the Sundarban area. The records show

that at every two-three alternate years such type of storm would hit the Sundarban; till date 90 severe storms affected Sundarban. Dense vegetation cover is only capable of mitigating such severity³⁶.

Protection of Indian Sundarban: Some Measures :
Plantation : Local people living in Indian Sundarban are poor indeed, but appear to be intelligent. They are capable of implementing any low coast technology to produce or increase resources for their own, if guided properly. Their problem with regard to livelihood is acute. Most of the people suffer from fuel wood scarcity. For solution of such problem *Avicennia* spp., *Excoecaria* sp. and *Sonneratia* spp. are most preferable ones to be grown in locality through social forestry programme. These species are of multi advantages like fuel, fodder, food, along with litter decomposition and nutrient turn over for fertilizing soil and water in particular.

Strategic Plan : A scientific strategic planning is essential for plantation programme. Each species has specific salinity tolerance and thus succeed in definite pattern (Table 3). If the plantation of different species is undertaken following the succession pattern pertaining to salinity tolerance, regeneration of forest and their survival may be ensured. Moreover, the species, which are threatened, may be also conserved through this strategic plantation programme. Experiment on seed germination and seedling development of *Heritiera fomes* has inferred that lower salinity about <5 ppt is favourable for seed germination and seedlings development of this species³⁷. Indian Sundarban face an unavoidable scarcity of freshwater due to urbanization and expansion of Kolkata metropol, because of blockage between distributaries and main river stream of the Ganga. Now a days Indian mangrove mainly depend upon rainwater only for lowering increased salinity level. If any plant fails to germinate in natural condition due to effect of high salinity; it is suggested that mature seeds are to be collected from forest areas and germinated in artificial bed. Then plantation of seedlings may take place according to salinity tolerance of respective species.

Legal Provisions : The Ministry of Environment and Forests, Govt. of India has notified Coastal Regulatory Zone (CRZ) and classified four categories to regulate various activities in coastal areas. Under these categories, all mangrove forests areas have been demarcated as CRZ-1 that includes an area of 100m² or with buffer zone at least 50m. As per this notification, no developmental activities can take place and a total ban has been imposed on felling of trees⁷. In such case the legal provisions may

TABLE 3 Range of salinity tolerance, tidal range and succession of major mangroves genera (ref. 4,26).

Genera (no. of species)	Tidal zone & range	Salinity toleranc (range in ppt*)	Forest zone
<i>Avicennia</i> spp. (3)	MLWP, 0-1m	9.0-30.0	River flat
<i>Sonneratia</i> spp. (3)	MLWP, 0-1m	4.0-15.0	River flat
<i>Aegiceros</i> sp. (1)	MLWP, 0-1m	10.0-14.0	River flat
<i>Rhizophora</i> spp. (2)	MTLL, 5-6m	9.0-25.0	River slope
<i>Bruguiera</i> spp. (4)	MTLL-ML, 3-6m	6.0-20.0	River flat-slope
<i>Ceriops</i> spp. (2)	ML, 3-5m	6.0-15.0	River flat
<i>Kandelia</i> sp. (1)	MTLL-ML, 3-6m	10.0-25.0	River slope
<i>Xylocarpus</i> spp.(2)	MLWN, 2-3m	15.0-20.0	Ridge forest
<i>Excoecaria</i> sp. (1)	MLWN, 2-4m	3.0-18.0	River flat
<i>Aegialitis</i> sp. (1)	MLWN, 2-4m	5.0-7.0	River flat
<i>Heritiera</i> sp. (1)	MLWS, 1-2m	5.0-15.0	Ridge forest
<i>Lumnitzera</i> sp. (1)	MLWS, 1-2m	5.0-12.0	Ridge forest
<i>Schyphiphora</i> sp. (1)	MLWS, 1-2m	5.0-9.0	Ridge forest
<i>Nypa</i> sp. (1)	MTLL-ML, 3-6m	5.0-18.0	River mouth
<i>Brownlowia</i> sp. (1)	MLWS, 1-2m	7.0-12.0	Ridge forest

(* Range of salinity of respective genera has been recorded based on tolerance level of mature plant; MLWP=Mean Low Water Spring, MTLL=Mid Tide Lower Limit, ML=Mean Level, MLWN=Mean Low Water Neap, MLWS=Mean Low Water Spring)

be monitored sincerely so as to protect Indian Sundarban mangrove.

Peoples Participation : No development can run smoothly without involvement of local people and also without arrangement of alternative livelihood for them. People of Sundarban are compelled to collect resources from forests. Their major collection includes fuel wood, fishes and timber woods. Their dependence particularly on catching of fishes and crabs is difficult to be stopped. On the other way, reasonably they may be restricted to catch fishes during pre monsoon to peak-monsoon period, when fishes breed and increase their population. Balance of biological diversity is likely to be maintained if the faunal diversity get chance to breed. Alternatively, cottage industries like food processing, handicraft manufactures, poultry farming, piggery, integrated fishery and aquaculture may be adopted instead during the time of restriction of fishing. Moreover, these farming practices may be subsidized, if required, for protection of such precious forest mainly during the off-season when entry into the forest is prohibited.

Government Initiatives : Protecting this sensible and one of the most productive ecosystem zone, Govt. has taken some initiatives by establishing. (i) Sundarban Development Board in 1973, (ii) Sundarban Tiger Reserve

Project in 1973, (iii) Crocodile Breeding and Rearing Project in 1976, (iv) Man and Biosphere Reserve Project in 1989, (v) Olive-ridley rearing project, etc. These are some positive steps to conserve and part of awareness programme for protection of Indian Sundarban mangrove forest.

Conclusion : Indian subcontinent in general and West Bengal and Bangladesh in particular, are fortunate enough to have mangrove forest formed at the mouth of the Ganga-Brahmaputra delta. Conservation of mangrove forest ensures the soil and water fertility by addition of a huge amount of nutrient released through litter decomposition – a unique ecosystem services. On the other hand, dwindling forest area means increase of unproductive landmasses that leads to scarcity of resources, including fish, fauna and agricultural produces. Balanced maintenance of climate and gaseous exchange

definitely depends upon sustenance of mangrove forest vegetation. Its regeneration warrants maintaining food chain of both terrestrial and aquatic systems as part of ecosystem services, apart from other essential services and economic benefits necessary for livelihood. Here science is essentially required in tune with rhythm of culture involving populace as to ‘have promise to keep’ Indian Sundarban mangrove ecosystems protective. □

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