SEAGRASS, SEAWEED AND MANGROVE ECOSYSTEM OF GULF OF MANNAR AND PALK BAY REGION

S.THIRUMALAISELVAN*, M. RAJKUMAR, R. VINOTHKUMAR, L. REMYA AND S.M. SIKKANNDER BATCHA

Mandapam Regional Centre of ICAR-CMFRI, Marine Fisheries Po, Mandapam camp, Ramanathapuram

GULF OF MANNAR

The Gulf of Mannar, a shallow bay, with a coastline of 364.9 km, is known for its coral reefs and sea grass beds which harbour several endangered species. The Gulf-of-Mannar Marine National Park (GOMMNP) declared in 1986, under the Wildlife (Protection) Act, 1972, covers an area of almost 560 sq. km andincludes 21 islands. The 21 islands are distributed in four groups – Mandapam, Keezhakarai, Vembar and Tuticorin groups and located in 3-6 miles distance from the coast and vary in area from 0.25 ha to 130 ha.The Gulf of Mannar, the first Marine Biosphere Reserve (GOMMBR) in the South and South East Asia, covers from Rameswaram to Kanyakumari in Tamil Nadu, India.The GOMMBR encompasses a chain of 21 islands and adjoining coral reefs off the coasts of the Ramanathapuram and the Tuticorin districts forming the core zone; the Marine National Park and the buffer zone includes the surrounding seascape and a 10 km strip of the coastal landscape covering a total area of 10,500 Km^2, in the Ramanathapuram, Tuticorin, Tirunelveli and Kanyakumari Districts with a long coastline of 364.9 Km.

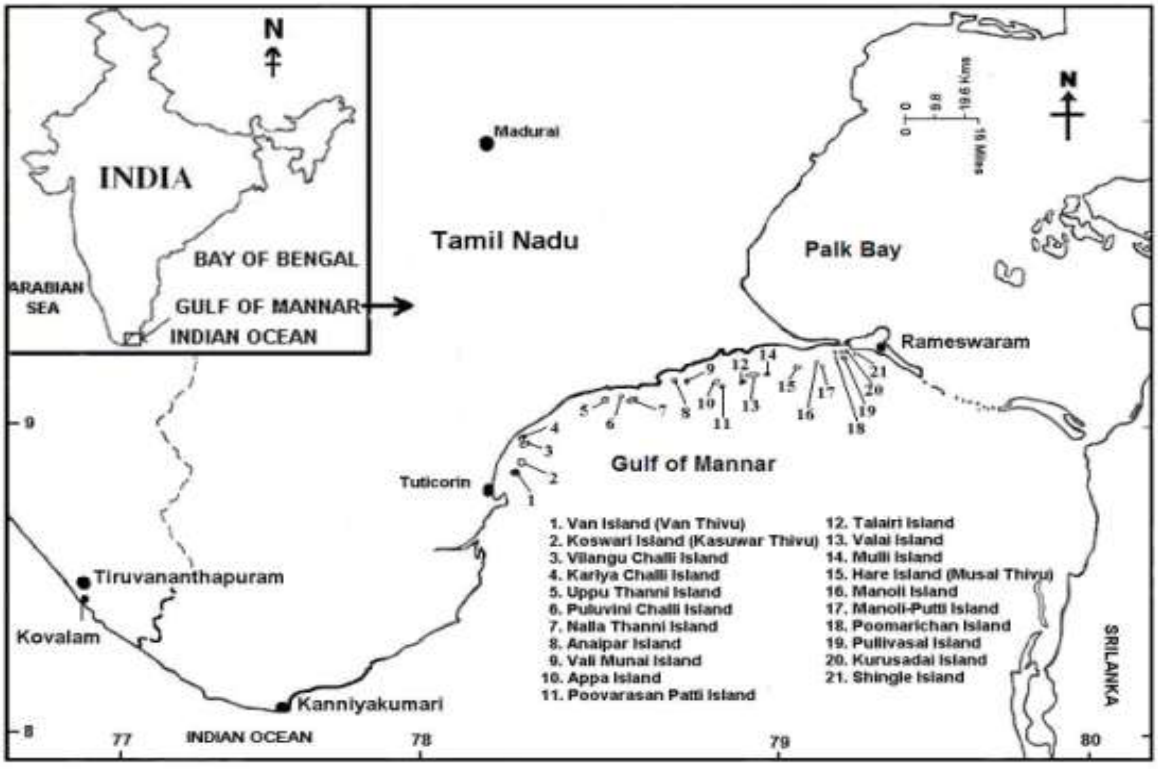


Fig 1: The map of Gulf of Mannar (with 21islands) and Palk bay region

PALK BAY

The Palk Bayis a shallow water area with biodiversity conglomeration nestled between the island nation of Sri Lanka and South East Peninsula India and a coastal length of 250 km on the Indian side. The bay is landlocked with three openings- One big eastern opening into the Bay of Bengal and two narrow openings into the Gulf of Mannar. It borders five coastal districts of Tamil Nadu between Kodiyakarai or Point Calimere in Nagapattinam district to Dhanushkodi in Ramanathapuram district. The width of the bay ranges from 64 – 137 km. The longshore currents from the Bay of Bengal and Gulf of Mannar transport sediments into the Palk Bay adding silt and clay to the shallow sea floor.

SEAWEED RESOURCES

Marine macroalgae or seaweeds are plant like that generally live attached to rocks or other hard substrata in coastal areas. They belong to three different groups based on thallus color, Chlorophyceae, Rhodophyceae and Phaeophyceae. Iyengar (1927) was the firstIndian phycologist to work on Indian marine algae, followed by Boergesen (1933-1938) whocarried out extensive work on the marine algae collected from southIndia, Bombay and Gujarat coast.

Further these resourceswere studied on the distribution, resource assessment, utilization and cultivation of seaweeds of the Indian coast by Krishnamurthy 1985; Krishnamurthy & Untawale 1985;Silas et al. 1986; Chauhan et al. 1990; Kaliaperumal, Kalimuthu 1993; Mairh 1994. Thediversified seaweed assemblages were present in the southeast coast of Tamil Nadu (Mandapamto Kanyakumari, including the islands in the Gulf of Mannar), Gujaratcoast (Okha, Dwarka, Porbandar, Veraval and Diu), Lakshadweep and Andaman – Nicobar Islands.

Table 1: Seaweed Diversity of the Indian Coast

Algae group	Order	Family	Genus	Species
Chlorophyceae	7	19	43	213
Rhodophyceae	16	36	135	431
Phaeophyceae	6	13	37	289
Total	**29**	**68**	**215**	**933**

Source: Kaliaperumal and Kalimuthu, 2004.

The intertidal and shallow subtidal waters, with rocky and coralline substrata of gulf of mannar harbour luxuriant growth of a diverse seaweed flora. The seaweed species of Sargassum, Dictyota, Gracilaria, Gelidium, Cystoseira and Codium mostly inhabit the midlittoral to lower littoral regions of the slope. Upper midlittoral regions are characterized by the occurrence of Ulva, Enteromorpha, Chaetomorpha, Cystoseira and Gelidiella sp.

The important seaweeds collected from the areas around Gulf of mannar are Brown algae-*Gracilaria edulis*(Kanchi pasi), *Gelidiella acerosa*(Marekozhudu), and Red algae - *Sargassamsp*(Kattakorai) and *Turbinaria sp* (Baagoda pasi).These are the native species found in Indian waters. Seaweeds contain different vitamins, minerals, trace elements, protein, iodine, and boiactive substances.The seaweed resources are exclusively utilized for the production of commercially and industrially important phycocolloids such as agar and alginates. While *Gracilaria edulis*and *Gelidiella acerosa*are used in the agar industry and *Gelidiella acerosa* (microbiological quality agar production), *Sargassam sp* and *Turbinaria sp* are used for agarose/alginate industries. The cultured seaweed *Kappaphycus alvarezii* have a quality raw material for carrageenan production.

Table 2: Seaweed Diversity of Gulf of Manner and Palk bay coast

Algae	Genera	Total number of species
Chlorophyta	23	80
Rhodophyta	60	146
Phaeophyta	18	56
Total	101	282

In Mandapam area 180 species of seaweeds are growing, of which about 40 species are economically important. They are the species of *Enteromorpha, Ulva, Caulerpa, Codium* (green algae); *Colpomenia, Hydroclathrus, Cystoseira, Hormophysa, Sargassum, Turbinaria* (brown algae);*Asparagopsis, Gelidiella, Gracilaria, Sarconema, Hypnea, Acanthophora* and *Laurencia* (red algae).

These seaweed resources are available in abundance only in shallow areas around the gulf of mannar islands. *G.edulis* produces edible quality agar and it has grown in any shallow waters on soft substratum such as clay. *Gelidiella acerosa* is available only around corals area of gulf of mannar islands.

Fig 2: Some important seaweed species are listed below.

Ulva lactuca

Ulva reticulata

Caulerpa sp

Caulerpa racemosa

Enteromorpha compressa

Halimedagracilis

Cladophora sp

Padina tetrastromatica

Sargassum wightii

Sargassum ilicifolium

Turbinaria conoides

Kappaphycus alvarezii

Gracilaria verrucosa

Gelidiella acerosa

Gracilaria edulis

Gracilaria salicornia

The major threats faced by seaweeds resources are over-exploitation in and around coral reef areas by local fishers,washed ashore due to strong current & wave action, anthropogenic activities, diseases and climate change. Presently seaweed culture practices carried out by local fishers in Palk bay region mainly *Kappaphycus alvarezii*, some area in *Gracilaria edulis* culture in bamboo pole raft methods.

SEAGRASS RESOURCES

Seagrasses are a mixed group of flowering plants which grow submerged in shallowmarine and estuarine environments worldwide. Structurally, seagrasses are more closelyrelated to terrestrial plants, having specialized tissues that perform specific tasks within eachplant. Seagrasses possess true roots that not only hold plants in place, but also are

specializedfor extracting minerals and other nutrients from the sediment. However, they do not possessthe strong, supportive stems and trunks.

The seagrass beds provide food, habitat, and nursery areas for numerous finfish,shellfish and other marine organisms. The sea bottom areas that are devoid of seagrass are vulnerable to intense wave action from currents and storms. The extensive root system in seagrasses, which extends both vertically and horizontally, helps stabilize the sea bottom in a manner similar to the way land grasses prevent soil erosion.Detritus from bacterial decomposition of dead seagrass plants provides food for worms, sea cucumbers, crabs, and filter feeders such as anemones and ascidians.The seagrass meadows provide an ideal environment for juvenile fish and invertebrates to conceal themselves from predators. Seagrass leaves are also ideal for the attachment of larvae and eggs, including sea squirt and mollusc etc.

The vast seagrass beds were present in Palk bay and Gulf of Mannar between mainland and islands and towards seaward side from the islands. The seagrass species, *Haloduleuninervis*is extensively distributed in Gulf of Mannar and is one of the dominant and primary species in the intertidal belt. It occurs both on sandy and muddy substratum with a thin layer of sand. *H.uninversis*plays an important role both as stabilizers andsediment accumulator and occurs either as a bed of monospecific community or a mixedvegetation with *Cymodocearotundata*, *Cymodocea*serrulata, *Halophila ovalis* and *Enhalusacoroides*. *Cymodoceaserrulata*occurs extensively in most of the islands of Gulf of Mannarand forms a significant browsing ground for the endangered dugong. *Thalassiahemprichii*and *H. uninervis*beds are the important habitat for Holothurians commonly known as seacucumbers.

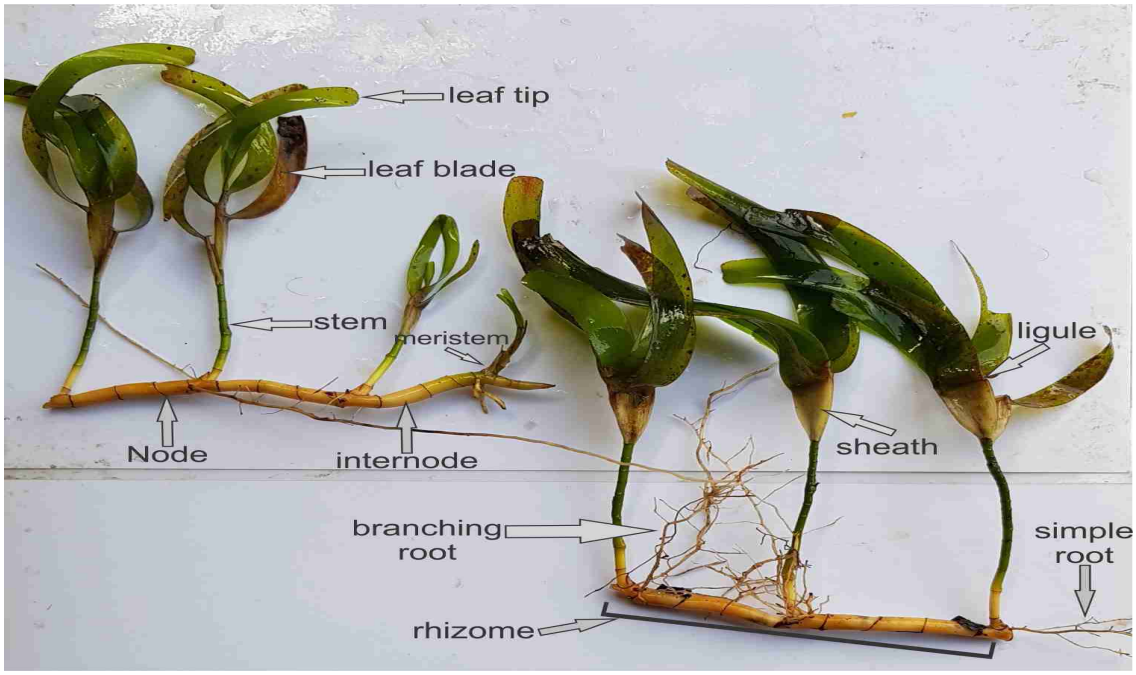


Fig 3: Schematic diagram of seagrass with different parts.

S.No.	Species	Gujarat	Maharashtra	Goa	Karnataka	Kerala	Tamil Nadu			Andhra Pradesh	Orissa	West Bengal	Lakshadweep	Andaman Islands	Nicobar Islands
							Gulf of Mannar	Palk Bay	Other sites						
1.	*Enhalus acoroides*	-	-	-	-	+	+	+	-	-	-	-	+	+	+
2.	*Halophila ovalis*	+	-	+	-	+	+	+	+	+	+	+	+	+	+
3.	*H. ovata*	+	-	-	-	-	+	+	-	+	+	+	+	+	+
4.	*H. decipiens*	-	+	-	-	-	+	+	-	-	-	-	+	+	-
5.	*H. stipulacea*	-	-	-	-	-	+	+	-	-	-	-	-	+	-
6.	*H. beccarii*	+	+	+	+	+	+	+	+	+	+	+	-	-	-
7.	*H. ovalis ramamurthiana*	-	-	-	-	-	-	+	+	+	+	-	-	-	-
8.	*H. minor*	-	-	-	-	-	-	-	-	-	+	-	-	+	-
9.	*Thalassia hemprichii*	+	-	-	-	-	+	+	-	-	-	-	+	+	+
10.	*Syringodium isoetifolium*	-	-	-	-	-	+	+	+	-	-	-	+	+	+
11.	*Cymodocea serrulata*	+	-	-	-	-	+	+	+	-	-	-	+	+	+
12.	*C. rotundata*	-	-	-	-	-	+	+	+	-	-	-	+	+	+
13.	*Halodule pinifolia*	+		-	-	-	+	+	+	+	+	+	+	+	+
14.	*H. uninervis*	+	-	-	-	-	+	+	+	+	+	+	+	+	+
15	*H. wrightii*	-	-	-	-	-	+	+	+	+	-	+	-	-	-
16.	*Rupia maritima*	+	-	-	-	-	+	-	-	-	+	-	-	-	-
Total		8	2	2	1	3	14	14	9	7	8	6	10	12	9

+: present; -: absent.

Table 3: Distribution of seagrasses in various sites of India

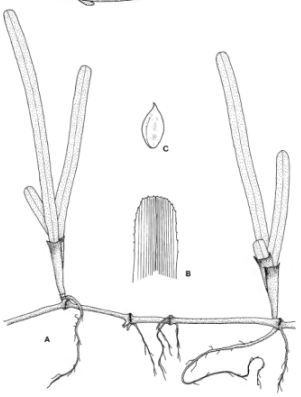
Source: Thangaradjou and Bhatt, 2017.

Fig 4: Some important seagrass species present in Gulf of Mannar and Palk bay waters

Enhalusacoroides

- It has dark green long linear grass like leaves, 1.0-1.5cm wide, 50-170cm long.
- Common in shallow intertidal areas with sandy and muddy substrata but can extend down upto the depth of 6m
- It has the only seagrass species which forms aerial surface pollination

Cymodoceaserrulata



- Cymodoceaserrulata has a smooth, herbaceous rhizome system, which produces short, erect shoots often with fibrous rootlets at each node, each shoot bearing 2-5 leave
- The leaf is narrowed at the base and the leaf tip is bluntly rounded and distinctly serrated.
- This species can quickly recover or return after a disturbance

Syringodiumisoetifolium

- Leaves of 5-10cm long, they can grow to 50cm long. The seagrass has tubular leaves much like a thick noodle &circular in cross-section.
- The leaves have a smooth pointed tip. The rhizomes are slender (1.5mm in dia).
- Shoots emerge from these rhizomes, each shoot with 2-3 leaves, the lower portions encased in a sheath.

Halophila ovalis

- It is a small herbaceous plant.
- The leaves are ovate in outline, appearing on stems that emerge from rhizome beneath the sand
- The roots get upto 80mm long and are covered in fine root hairs.
- It has connected by a series ofinterconnecting rhizomes.

Halodule pinifolia

Halodule uninervis

Halophila beccarii

Halophila decipiens

The present major threat to seagrass meadows in Gulf of Mannar and Palk bay is destructive fishing activitiesparticularly bottom trawling fishing operation, deterioration of water quality, boat anchoring, sedimentation, coastal pollution, dredging operation, Induatrial waste like thermal plant fly-ash waste, strong water current etc.

MANGROVES ECOSYSTEM

Mangroves are trees or large shrubs, including ferns, which normally grow in saline coastal habitats in the tropics and subtropics, in or adjacent to the intertidal zone and which have developed special adaptations in order to survive in this environment.Generally, mangroves are divided into two categories ‘true mangrove species’ (i.e. plants which are found only in tropical intertidal habitats) and ‘mangrove associates’ (i.e. plants which are not exclusive to these habitats)

Table 4: The list of true mangrove species reported by various authors in India.

Species names	Singh & Garge (1993)	Dagar *et al.* (1993)	Naskar (2004)	Selvam *et al.* (2004)	Kathiresan & Rajendran (2005)	Mandal and Naskar (2008)	Kathiresan (2008)
Acanthus ebracteatus	•	•	•		•		•
A. ilicifolius	•	•	•	•	•	•	•
A. volubilis	•	•	•				
Acrostichum aureum				•	•		•
Ac. speciosum					•		•
Aegialitis rotundifolia	•	•	•	•	•	•	•
Aegiceras corniculatum	•	•	•	•	•	•	•
Aglaia cucullata			•	•	•		
Avicennia alba	•	•	•	•	•	•	•
A. marina	•	•	•	•	•	•	•
A. marina var. *acutissima*			•				
A. officinalis	•	•	•	•	•	•	•
Atalantia correae			•				
Brownlowia tersa			•				
Bruguiera cylindrica	•	•	•	•	•	•	•
B. gymnorrhiza	•	•	•	•	•	•	•
B. parviflora	•	•	•	•	•	•	•
B. sexangula	•	•	•	•	•	•	•
Ceriops decandra	•	•	•	•	•	•	•
C. tagal	•	•	•	•	•	•	•
Cynometra iripa		•	•	•			•
Cy. ramiflora		•	•				•
Dalbergia spinosa			•				
Dolichandrone spathacea					•		•
Excoecaria agallocha	•	•	•	•	•	•	•
E. indica					•		•
Heritiera fomes	•	•	•	•	•	•	•
H. littoralis	•	•	•	•	•	•	•
H. kanikensis				•	•		
Kandelia candel	•	•	•	•	•	•	•
Lumnitzera littorea	•	•	•		•	•	•
L. racemosa	•	•	•	•	•	•	•
Nypa fruticans	•	•	•	•	•	•	•
Pemphis acidula				•	•		•
Phoenix paludosa	•	•	•			•	
Rhizophora × *annamalayana*					•		•
R. apiculata	•	•	•	•	•	•	•
R. mucronata	•	•	•	•	•	•	•
R. × *lamarckii*	•	•	•	•	•		•
R. stylosa	•	•	•	•	•	•	•
Sarcolobus carinatus			•				
S. globosus			•				
Scyphiphora hydrophyllacea	•	•	•	•	•	•	•
Sonneratia alba	•	•	•	•	•	•	•
S. apetala	•	•	•	•	•	•	•
S. caseolaris		•	•	•	•	•	•
S. griffithii		•	•	•	•	•	•
Xylocarpus granatum	•	•	•	•	•	•	•
X. moluccensis	•	•	•	•	•		
X. mekongensis	•	•	•	•		•	•
Total number of species reported	32	36	43	35	39	30	39

Source: Ragavan*et al.*,2016(• denotes occurrence.)

Indian mangroves consist of 46 true mangrove species belonging to 14 families and 22 genera, which includes 42 species and 4 natural hybrids. In other words, about 57% of the world's mangrove species are represented in India. The East coast has 40 mangrove species belonging to 14 families and 22 genera. The West coast has 27 species belonging to 11 families and 16 genera and the Andaman and Nicobar Islands (ANI) have 38 species belonging to 13 families and 19 genera. In India, the mangrove forest overall cover is estimated to be 4740 km^2, of which about 58% is along the east coast (Bay of Bengal), 29% along the west coast (Arabian Sea) and the remaining 13% in the Andaman and Nicobar Islands (Forest Survey of India, 2015).

In West Bengal, mangroves are present in the Sundarbans, the large deltaic complex of the riverGanges, shared by Bangladesh (62%) and India (38%). Totally 33 true mangrove species belonging to 21 genera and 14 families have been identified in Indian Sundarbans.

The mangrove cover can be attributed to two reasons in our region

I. The east coast has large estuaries with deltas formed due to runoff and deposition of sediments, whereas the west coast has funnel-shaped estuaries with an absence of deltas and
II. The east coast has gentle slopes with extensive flats for colonization by mangroves, whereas the west coast has steep slopes (Kathiresan, 2010).

The mangroves of Andaman and Nicobar Islands (ANI) are probably the best developed in India in terms of their density and growth. In Tamil Nadu mangroves are confined to Pichavaram, Muthupet, Palk bay and Gulf of Mannar. A total of 17 true mangrove species belonging to 12 genera and 8 families have been recognized from Tamil Nadu. The Gulf of Manner and Palk bay region harbours mangroves with a considerable diversity which supports a variety of biological organisms. It is believed that the region was once covered with thick mangrove forests.

Fig 5: Some of the important mangrove species present in Gulf of Mannar and Palk bay area

Avicenia marina

Pemphis acidula

Ceriops tagal

Rhizophora mucronata

In Gulf of Manner, a total of 11 mangrove species, 17 mangrove associate plants were identified. Mangroves species - *Avicennia marina, Bruguiera cylindrica, B. gymnorrhiza, Ceriops tagal, Excoecaria agallocha, Lumnitzera racemosa, Pemphis acidula, Rhizophora apiculata, R. mucronate and Acanthus ilicifolius*. *Avicennia marina* is the most abundant species followed by *Pemphis acidula*. This is followed in descending order by *Ceriops tagal, Rhizophora mucronata, Bruguiera cylindrica, Lumnitzera racemosa, Excoecaria agallocha and Rhizophora apiculata.*

The state forest department noted that there was overexploitation led to vanishing of mangroves species. As a result, themangrove species such as *Bruguiera gymnorrizha* and *Acanthus ilicifolius*collected earlier in Rameswaram have disappeared in recent years, and similar the cases of Pemphis acidula in Pamban and Acanthus ilicifolius inKrusadai Island. The increase in the extent of salt pans is yet another factor leading to the shrinkage of mangroves particularly around Tuticorin (Kathiresan, 2008)

Importance of mangrove ecosystem

Mangrove ecosystem are biodiversity hotspots extremely productive ecosystems, providing many critical services that benefit all of us. They provide nesting and breeding habitat for fish and shellfish, migratory birds etc. Mangroves are essential to maintaining water quality. With their dense network of roots and surrounding vegetation, they filter and trap sediments, heavy metals, and other pollutants. It has ability to retain sediments flowing from upstream prevents contamination of downstream waterways and protects sensitive habitat like coral reefs and seagrass beds below. Mangroves are the first line of defence for coastal communities. They stabilize shorelines by slowing erosion and provide natural barriers protecting coastal communities from increased storm surge, flooding, and hurricanes. It serves sequestering carbon at a rate of two to four times greater than mature tropical forests and store three to five times more carbon per equivalent area than tropical forests. It has the potential for sustainable revenue-generating initiatives including ecotourism, sport fishing, and other recreational activities.

The major threats faced by mangrove ecosystem are mangrove deforestation, Land reclamation, Industrial occupancy and waste dumping, coastal pollution, shortage/nil of river runoff, diseases etc. Adverse effects on mangroves could lead to serious consequences for the adjoining fragile and important ecosystems such as coral reefs and sea grass beds. Damage to mangroves affects the sediment budget and promotes the coastal erosion.

Reference:

1. Thangaradjou, T. and Bhatt, J. R. 2017. Status of seagrass ecosystems in India. *Ocean Coast. Manag*., 159: 7-15. DOI: 10.1016/j.ocecoaman.2017.11.025.
2. Kathiresan, K. 2010. Importance of mangrove forest of India. *J. Cost. Environ*. 1: 11–26.
3. Kathiresan, K. 2008. Biodiversity of Mangrove Ecosystems. Proceedings of Mangrove Workshop. GEER Foundation, Gujarat, India.
4. Kaliaperumal, N. and Kalimuthu, S. 2004. Commercial exploitation in seaweed in India. *Souvenir, National Symposium and Exposition*. SRUA & CMFRI. pp. 35-38.
5. Kaliaperumal, N. 2007. Present status of marine algal biodiversity in Gulf of Mannar region, Tamil Nadu. *Indian Hydrobiol*., 10(1): 53-62.
6. Database on Gulf of Mannar Biosphere Reserve, 2015. ENVIS centre, Dept. of Environment, Govt. of Tamil Nadu, Chennai.
7. Ragavan, P., Alok Saxena,Jayaraj,R.S.C., Mohan, P.M., Ravichandran, K., Saravanan,S. and Vijayaraghavan, A. 2016. A review of the mangrove floristics of India. *Taiwania*. 61(3): 224–242
8. Oza, R. M.and Zaidi, S. H. 2001. A Revised Checklist of Indian Marine Algae. CSMCRI Publication, Bhavnagar, India. 296 pp.
9. Silas, E. G., Chennubhotla, V. K. S. and Kaliaperumal, N. 1986. Seaweed resources products and utilization. *Seaweed Resource Utilization*. 9(1-2): 11-24.
10. Kathiresan, K. and N. Rajendran, 1998. Mangrove - associated communities. *In*:Biodiversity of Gulf of Mannar Marine Biosphere Reserve, (eds.) Rajeswari M., Anand, K. Dorairaj and A. Parida, MSSRF, Madras, pp.156-164.
11. Tamilnadu Forest Department, 2007. Integrated Management Plan for the Gulf ofMannar Marine National Park and Biosphere Reserve (2007-2016). Published by theGulf of Mannar Biosphere Reserve Trust, Ramanathapuram. p. 647.