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Seagrass meadows in India and their certain ecosystem services

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ABSTRACT

Seagrass meadows also known as marine prairies have attained tremendous significance and their services as ecosystem are greatly valued for food, feed, shelter, refuge marine biodiversity hotspots and nursery grounds to many marine vertebrates and invertebrates of commercial and ecological importance, besides their highest primary production and their role in checking ocean acidification and global warming impacts through their excellent carbon sequestration potential. Ecosystem services of certain seagrass meadows available in Indian coasts within the four categories such as cultural, provisioning, regulating and supporting are discussed in this communication. While exploiting the services offered by the seagrass meadows, their conservation should assign top priority

Key words: Coastal gleaning, Carbon sequestration, Gulf of Mannar, Seagrass ecosystem, *Halophila beccarii*, Lakshadweep, Provisioning services, Regulatory services, *Tellina angulate, Murex vergineus*

INTRODUCTION

Seagrass meadows are known as Prairies in the sea as they serve as feeding, breeding and nursery grounds for many vertebrates and invertebrates of commercial and ecological importance. Detailed overview of goods and services provided by seagrass meadows can be gleaned from the works of Terrados & Borum (2004) and Unsworth & Unsworth (2013). A total of 14 species of seagrasses from six genera are reported to occur in Indian waters (Lakshmanan & Rajeswari, 1982; Jagtap, 1991; Ramamurthy *et al.*, 1992; Kaliaperumal *et al.*, 1989; Kannan *et al.*, 1999). The ways in which all the benefits of any ecosystem being enjoyed by the society collectively are known as ecosystem services. Services of seagrass meadows available in Indian coasts grouped under the broad categories of cultural, provisioning, regulating and supporting are discussed in this communication. As early as 1950s the wise and farsighted elders of Lakshadweep Islands did seagrass transplantation to many northern atolls for controlling land erosion. Even now seagrass of Lakshadweep Islands are known as *kavarathi pullu* (grasses from Kavarathi Island) in local parlance as it was introduced from Kavaratti lagoon. These meadows provide critical habitats for more than 100 species of finfish, turtles, seahorses, dugong, shrimps, crabs, sea cucumbers, seaurchins, starfish, gastropods, bivalves, ascidians, sponges, anthozoans, marine algae and phytoplankton.

Habitat loss is the major reason (Orth*et al.*, 2006; Waycott *et al.*, 2009) cited for decline in dugong population. They require 30-40 kg of seagrass shoots a day and the green turtles require 40-50 kg a day for foraging (D'Souza *et al.*, 2015). Seeds of seagrasses especially of *Enhalus acoroides*, *Cymodocea* spp. and *Thalassia hemrichii* are edible. The seeds are eaten raw or boiled or roasted. When roasted they have a chestnut like flavour. *Enhalus* flour can be exchanged for white flour in a chocolate cake or cookie recipe (Kaladharan and Baby Ushakiran, 2014). Dry seeds of *Thalassia* and *Enhalus* are consumed some times by the coastal fishers of Ramnad District, Tamil Naduas porridge. Seagrass meadows of Gulf of Mannar and Lakshadweep during the low tide attract many coastal fishers especially women and children for collecting ornamental shells, opercula of gastropods and others for sport fishing, octopus fishing, ornamental fish collection etc for food and livelihood support (Figs. 1-3).

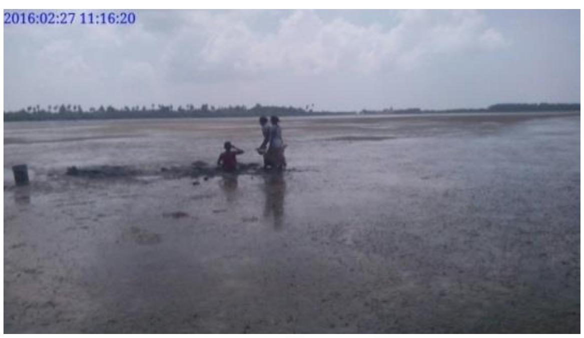

Fig.1

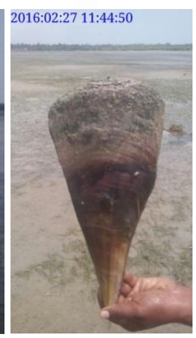

Fig.2


Fig.3

Figure 4 Huge quantity of seagrass leaf litter piled in the shore near Maraikayar pattinam, Mandapam

Ornamental shells like milky white *Tellina angulata* (Paper shell) and *Cardium* sp. are collected from several locations along the seagrass meadows of Gulf of Mannarby fisherwomen as an alternative livelihood options. Chinnapalam is a small coastal village situated in Pampan area at the southern part of Rameswaram Island. Majority of people are involved in fishing activities. Usually fisherwomen in a group of 3-5 and many such groups (maximum 7 active groups) are involved in the shell mining activities during the low tide hour which is being continued daily as a regular practice. Shells like *Tellina angulata*, *Arca* and *Cardium* are collected as water level during low tide is very less than adjacent areas. Quantity supplied is approximately 1-2 kgs per group depending upon duration of collection and the group's efficiency. Theseshells are sorted out according to their type, size and colour. *Tellina* sp. is sold to the shell craft units at INR 100/ kg and the other varieties fetch between Rs. 15- 40 per kg based on size and coloration. Income so generated is shared among group members. Though this is an income generating spare time avocation to the coastal women folks, this regular practice is causing drastic impacts on seagrass beds and its biota ranging from microbes to marine mammals. Thangaradjou *et al.* (2008) have estimated the impact of shell mining to 56.08% reduction in seagrass cover over the seagrass meadows of Chinnaplam area. Seagrass meadows of Gulf of Mannar area offer regular fishery of gastropods mainly chanks and *Murex vergineus* (Fig. 5) though not on large scale caught on bottom set gill nets (Fig. 6).

Figure 5 Catch of *Murex vergineus* from Seagrass meadows

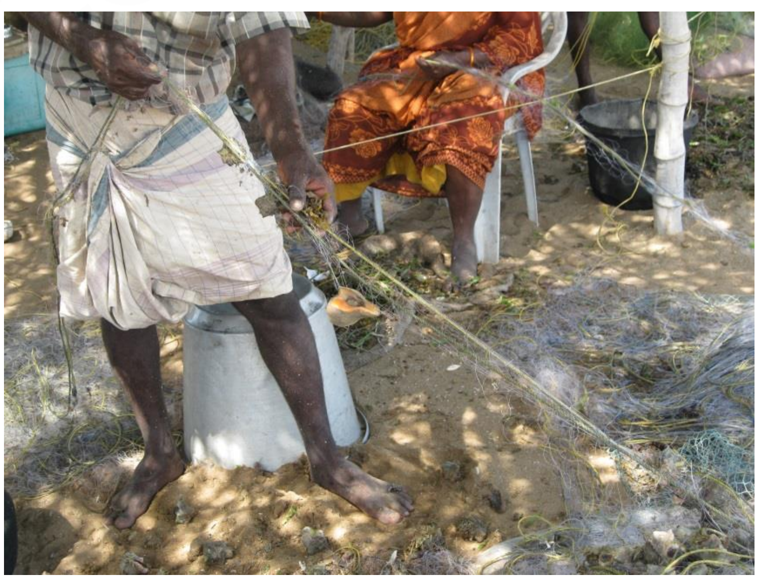

Figure 6 Net operated in seagrass meadows near Thonithurai, Mandapam showing the catch.

Seagrass meadows are involved in cycling of nutrients from water column as well as sediments. They stabilize beaches, act as a buffer against strong waves and land runoff, prevent siltation, improve water transparency and save coral polyps from mortality due to siltation. Large quantities of leaves of *Thalassia, Cymoodcea* and *Syringodium* detached due to strong wave action and by senescence are regularly washed ashore and get accumulated in the beach (Fig.4). This upon decay supplies nutrients back to seawater and nourishes the beach sediment besides supporting many benthic fauna such as Isopods and Polychaetes.

Seagrasses have shown decisive role in the productivity and Oxygen budget of coral atoll (Qasim & Bhattathiri, 1971; Nair & Pillai, 1972). Seagrasses are one of the foundation species that can determine community structure and biodiversity of coastal zones and their presence or absence can often decide the trophic level of lagoons into autotrophic or heterotrophic. Among the Amindivi group of Laccadive atolls, Amini (11˚07′N and 72˚44′E) is one of the atolls supporting dense vegetation of *Cymodocea* and *Thalassia*, whereas its closely adjoining Kadamat atoll (11˚13′N and 72˚47′E) was lacking seagrass vegetation during 1987. Net primary productivity (NPP) determined through diurnal oxygen curve of Amini atoll was 3.327gC/m^3/day and that of the Kadamat atoll was only 2.013gC/m^3/day. This significant difference of 65% hike in the NPP in Amini atoll was attributed only to the contribution of seagrass beds (Kaladharan & David Raj, 1989).

Seagrass ecosystems are one of the most productive ecosystems in the world and have very high growth rates producing organic matter organic matter to the tune of 43.5% of its NPP (Duarte and Cebrian, 1996). Specific rate of net primary production (NPP) of four seagrass species of Minicoy Island (8°15'N; 73° 03'E) studied in *in situ* conditions have revealed highest rates (9.2 g C/m^3/d) with maximum compensation point (P/R of 3.34) for *Thalassia hemprichii*, indicating maximum contribution of net primary production to the atoll. The maximum tidal amplitude of Minicoy atoll is 1.57 m (Gardiner 1930) and seagrass vegetation in Minicoy lagoon was found extended to an area of 2 sq.km. It was estimated that an impairment upto 50% on the NPP of seagrass plants was caused by the prolonged exposure (emersion) of the seagrass meadows to bright sunshine in the intertidal areas during the ebb tide when compared to those seagrass plants growing in submerged habitats within the lagoon (Kaladharan *et al*., 1998).

The seagrass meadows are known to serve as antacid to contain ocean acidification as they can sequester dissolved CO_2 and enrich the lagoon with oxygen through canopy photosynthesis and storage of blue carbon (12 %) in their underground shoot and root systems. Seagrass species are capable of absorbing CO_2 at higher rates that one sq km seagrass meadow can absorb equal quantity of CO_2 that can be absorbed by 50 sq km of tropical forests. That is, a seagrass meadow per unit area can store twice as much carbon as the world's temperate and tropical forests -an acre can sequester 3,350 kg of carbon per year (NASCM, 2015). Carbon sequestration efficiency of five species of seagrasses from the Gulf of Mannar was estimated recently (Kaladharan *et al.,* 2014). Light harvested CO_2 fixation rates varied considerably among the species studied, registering maximum of 8.03 kg C/ton wet weight/day for *Halophila ovalis* and a minimum of 1.63 kg C/ton wet weight/day for *Enhalus acoroides*. However their carbon storage in sediment in the form of rhizome and root wet biomass showed maximum for *Enhalus acoroides* (1.173 kg/ m^2) followed by *Cymodocea serrulata* (0.945 kg/m^2) and the lowest by *Halophila ovalis* (0.535 kg/ m^2) (Table- 1). As most of the seagrasses are perennial rooted flowering plants and their root/shoot ratio is always higher, CO_2 fixation by leaves and carbon storage by rhizomes and roots greatly help checking the ocean acidification. Experimental data collected from Netarts Bay (Northern Oregon Coast) on the survival of oysters in the eelgrass beds (Waldbusser & Salisbury, 2014) due to absorption of excess CO_2 and the resultant reduced acidification while its failure to establish inareas devoid of eelgrass beds is the ample testimony to suggest that seagrass meadows can contain ocean acidification and support shell fish growth.

Figure 7 *Halophila beccarii* and its bed in Kadalundi estuary

Table 1 Carbon fixation by leaves and Carbon storage in underground parts of five seagrass species from Gulf of Mannar

No	Species	Carbon fixation through leaves (kg C/ton wet wt/day)	Carbon Storage (kg C/m²)
1	*Cymodocea serrulata*	2.8	0.95
2	*Enhalus acoroides*	1.63	1.173
3	*Halophila ovalis*	8.03	0.535
4	*Halodule uninervis*	4.08	0.640
5	*Syringodium isoetifolium*	3.44	0.727

Large extensive seagrass bed of *Halophila beccarii* (Fig. 7) was observed and reported from Kadalundi community reserve area (11°07'42"N; 75°49'51"E) close to the bird sanctuary covering an area of more than 2 hectaresfor the first time (Kaladharan & Asokan, 2012). The substratum was predominantly clayey. During the low tide the seagrass bed remained exposed. The density of Halophila plants ranged from nil during June and July to 420 g/m^2 (260 plants/ m^2) during December-January. The associated and depended fauna in *Halophila* meadow of Kadalundi area include Amphipods, Isopods, Crayfish juveniles, polycheate worms, juveniles of eel, shrimps, crab, *Liza*, *Ambasis* and gastropod *Cerithium* sp. Out of these major groups, *Cerithium*, polycheates and isopods were observed throughout the observation period in considerable numbers (Table 2).

All these services offered by seagrass ecosystems have immense economic values to the mankind and can directly influence our socio-economic status. These ecosystems all over the world are vanishing rapidly at the rate of 7% annually (Waycott *et al.,* 2009) and hence their conservation should assign top priority.

Table 2 Associated fauna and benthic organisms (no /m^2) from *Halophila* bed (After Kaladharan *et al*. 2014)

Groups	Period of occurrence and number of animals /m²						
	11/7/12	21/8/12	29/9/12	6/7/13	12/8/13	21/9/13	4/11/13
Amphipod	-	-	2597	-	1	5	1
Fish larvae	-	-	1	-	-	3	-
*Cerithium*sp	40	2	100	27	74	164	12
Oikopleura	-	-	2	-	-	-	-
Polycheate	298	1217	322	160	99	780	783
Crayfish juvenile	-	-	2839	-	-	-	-
Tanaids	-	6	278	-	-	16	6
Isopods	-	4	20	-	4	14	5
Orconectus virilis	-	-	2	-	-	-	-
Chiton egg	-	-	-	-	-	-	1
Crab larvae	-	-	-	-	-	-	2
Diptera larvae	-	-	-	-	-	6	1
Ostracoda	-	-	-	-	-	-	2
Stonefly (perlodid)	-	-	-	-	-	-	2
Crab juveniles	-	23	-	-	-	-	-
Unidentified 1	-	-	-	-	-	-	17
Unidentified 2	-	-	-	-	-	-	33

Table 3 Summary of services offered by seagrasses and their ecosystems

No	Seagrass/ parts of seagrass	Services
1	Leaves/ shoots	Cattle bedding in Stables
		Packing materials (insulators) for packing pottery, glass etc
		Thatching roof of huts/ cottages,

		Roof covering to adjust inside weather
		Soil amendments, moisture retention
		Hiding places for juveniles and larvae to avoid predation
		Dissipate wave energy, calm water
2	Fresh leaves	Feed for pigs, rabbits, cattles, etc.
		Forage for dugongs, green turtles
3	Leaves detached by wave action, senescence and accumulated in the beaches	Improve sediment fertility
		Increase organic carbon content
		Organic manure for crop plants/ potting mixture
		Nutrient recycling
		Support beach benthic fauna and intertidal fauna
4	Rhizomes and roots	Maintain beach stability and check erosion , Habitat for benthic fauna
5	Organic/ Primary production	Organic matter to the tune of 43.5% of its NPP
6	Seagrass meadows	Increase habitat diversity,
		Enhance marine biodiversity,
		Promotes bait fish fishery in Atolls
		Key habitats in the life cycle of many fish resources
		Improves water quality/ transparency of water column
		Higher irradiance at the bottom- good for corals
		Coastal gleaning- livelihood support
7	High rate of photosynthesis	Carbon sequestration, Prevents ocean acidification
8	Share of blue carbon storage	12% total quantity of C stored in ocean sediments
9	Seagrass fauna and Tourism	Attract more tourists for viewing ornamental species of shrimps, shells, urchins and starfishes and sport fishing
10	Value of seagrass ecosystem service	Worth about 15837 Euro/ha/yr (Borum *et al*., 2004)

CONCLUSION

Seagrasses are important in stabilizing bottom sediments as they slow water movement which otherwise promotes sedimentation of particulate matter. They prevent erosion, trap and bind sediment and organic detritus, provide a stable habitat for epiphytes and associated flora and fauna. Moreover, most of the fish species spend at least part of their life cycle inside the sea grass community, which reveals that sea grass is vital to fishing industry. Sensitivity of seagrass to external environmental change can cause wide fluctuations in the populations of marine fauna they support (Table 3). Economic value of services being offered by seagrass ecosystem can be measured through commercial fishing and wildlife tourism. Another most important benefit of seagrasses for the world's oceans is carbon sequestration. The preservation of these ecosystems may prove essential in combating the global warming.

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