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# Seagrass Ecosystems of Andaman and Nicobar Islands: Status and Future Perspective

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**ABSTRACT**

Seagrasses are unique marine flowering plants that play an important ecological role by yielding primary production and carbon sequestration to the marine environment. Seagrass ecosystems are rich in organic matter, supporting the growth of bio-medically important epi and endophytic microorganisms and harbor rich marine biodiversity. They are an essential food source for endangered Andaman state animal Dugongs. Seagrasses are very sensitive to water quality changes, and therefore they serve as ecological bio-indicators for environmental changes. The benthic components in and around the seagrass beds support a significant food chain for other Micro and organisms apart from fishery resources. The epiphytic bacterial communities of the leaf blades support the sustenance against the diseases. Recent reports have shown that the loss of seagrass beds in tropical and temperate regions emphasizes the depletion of these resources, and proper management of seagrass is urgent. The decline of seagrass will impact primary production, biodiversity, and adjacent ecosystems, such as reefs. Therefore, restoring the seagrass meadows could be possible with effective implementing management programs, including seagrass meadows in marine protected areas, restoration projects, seagrass transplantation, implementation of legislative rules, monitoring coastal water quality and human activities in the coastal zone. Lacunas on the seagrass ecosystem management in Andaman & Nicobar Islands are addressed.

## 1. INTRODUCTION

The world ocean species diversity comprises around 230,000 marine species [1], and 91% of marine diversity is not yet described [2]. Among these diverse groups of marine organisms, seagrasses are a critical lesser-known group that plays a crucial role in maintaining ocean health. Seagrasses evolved around 100 million years ago, and presently about 72 different species belonging to four major groups of Cymodoceaceae, Hydrocharitaceae, Posidoniaceae, and Zosteraceae have were reported [3]. Seagrasses are submerged marine flowering plants with a true root system, veins, seeds, fruits, and their population is limited by asexual and sexual reproduction. They are globally distributed in intertidal to subtidal regions on different substrata types such as sandy, loamy, silt to clay, and coral rubbles [4]. They are found to occur at a maximum depth of 86m (*H. decipiens*) and grow up to a maximum size of about 7m (*Zostera caulescens*) [5].

Seagrass ecosystems critically influence the adjacent community structure, food web, nutrient cycling, and water quality. Unlike coral reefs and mangroves, seagrass ecosystems are comparatively high in productivity [6], supporting the growth of commercial/ recreational fishery resources [7], and other groups of marine organisms [8]. Significantly seagrass meadows are well known for the occurrence of endangered megaherbivores like turtles, dugongs, and manatees, indicating the intrinsic importance of these meadows [5].

The Andaman and Nicobar group of Islands are located about 1500 km from the mainland, consisting of a chain of 572 Islands from North to Southern on longitude 93°-94° east and latitude 6°-17° north. Out of these 572 islands, only 38 islands are inhabited, and eight islands are covered under various settlement programs. These islands have erratic weather conditions with rich marine biodiversity that distinguish them from other geographic places. Studies on seagrass beds in these pristine islands are needs to be well understood their biogeography, community assembly, and the ecological role and protect them by different management practices. Unlike coral reef and mangrove ecosystems, very little is known about seagrass distribution in Andaman and Nicobar Islands. Since seagrass meadows are essential shelters for endangered marine organisms and responsible for regulating global climate change, it is necessary to assess a defined research plan on monitoring the seagrass species composition and management in these pristine Islands. Here we have detailed a brief review of studies carried out so far on seagrasses and lacunas.

## 2. ECONOMIC IMPORTANCE OF SEAGRASSES

Seagrasses are known to have excellent nutritional values with species such as *Cymodocea* spp. and *Enhalus acoroides* as a source of edible seafood in different parts of the South Asian countries such as China, India, Indonesia, Japan, Malaysia, Philippines, and Thailand [4]. Due to the high silicon content in seagrasses, they are used as insulation in some houses and some radio stations as sound proof insulators. Commonly seagrass is used as thatch for roofing, upholstery, packing material in exports of crabs, paper making, basket

weaving, etc. Seagrass mulch is used as manure for seed germination, resistant to soil erosion, and food for poultry (*Posidonia oceanica*) [9]. Seagrasses have medicinal properties for rheumatism relievers, treatment of skin diseases and wounds [4], tranquilizers for babies, muscle pains, stomach problems [9], and are known to produce pharmaceutically significant secondary metabolites [10]. Epi and endophytic bacteria and fungi of certain seagrasses have been reported to show antibacterial [11], antiviral [12], antifungal [13], and antifouling activities [14].

## 3. ENVIRONMENTAL IMPORTANCE OF SEAGRASSES

Approximately 177,000 km$^2$ area of seagrass is distributed worldwide [15]. These ecosystems inhabit only 0.1% of the seafloor- yet they are essential biodiversity hot spots providing rich proteinaceous food for billions of people. Seagrass meadows are referred to "*lungs of the sea*" due to the release of oxygen into the water column as well as into sediments through their roots (approximately produces about 10 liters of oxygen/square meter of the area in a day), thereby enhances oxygenic environment [9]. They also play a significant role in the uptake of nutrients and other contaminants in the water column, thus improving water quality and reduce eutrophication [16]. Seagrass species are reported to accumulate different heavy metals; therefore, seagrasses are inferred as potential indicating markers in coastal environs [17]. They are well known as "*carbon sequestrates*" as they fix atmospheric carbon dioxide to organic matter into sediments, also called "blue carbon" [sequestrating between 4.2 and 8.4 Gt (1 GT = 1 billion metric tonnes) of organic carbon/year] [18]. Since seagrasses are known to increase the pH levels during photosynthesis, they are referred to as "*the warriors of ocean acidification*" [9].

Seagrass meadows are essential "*shelters*" as they provide substantial feeding and nursery grounds for lesser-known marine organisms (prokaryotes to megaherbivores) and endangered species like dugongs and sea turtles. Seagrasses are important "*primary producers*" that provide nutrients to the food web. Due to high nitrogen and low fiber contents, these seagrasses are the main diet for the dugongs and other animals [19]. Seagrass meadows are referred to as "*Prairies of the sea*" as they stabilize the coastal seabed and reduces soil erosion by controlling hydrodynamic conditions caused by currents and waves [20].

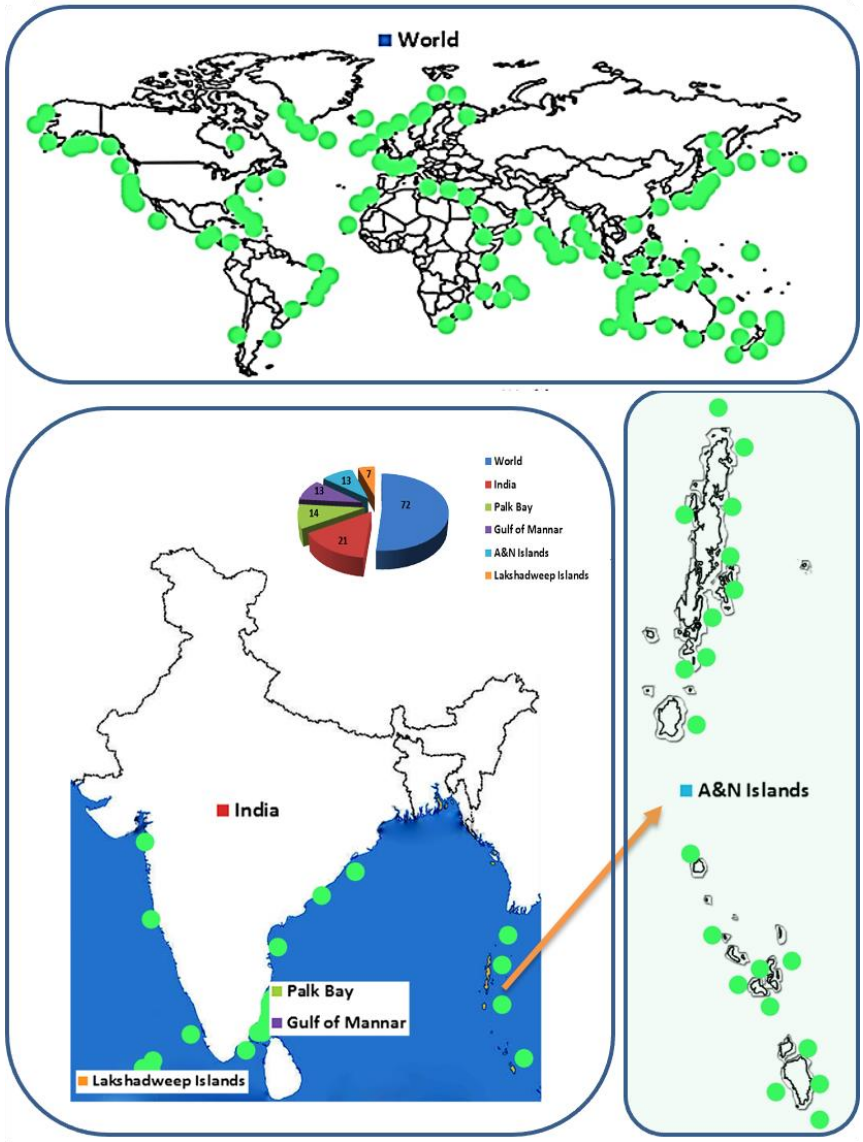


**Figure 1.** Distribution of seagrass habitats around the world and different parts of India

## 4. BIODIVERSITY OF SEAGRASSES IN INDIA & ANDAMAN AND NICOBAR ISLANDS

Seagrass flora of the world is encompassed by 72 species belonging to 14 genera distributed in tropical and temperate regions [3]. Only seven genera are reported from the tropical areas, and others are from temperate waters. In India, around 21 species belonging to 6 genera have been reported [21]. Recently, 44 seagrass meadow locations across the Andaman and Nicobar archipelago are reported where the dugongs have been sited to graze in these meadows [22]. So far, 13 vulnerable species of seagrasses- *Halodule uninervis, H. pinifolia, Cymodocea rotundata, C. serrulata, Enhalus acoroides, Thalassia hemprichii, T. hestidinum, Halophila ovalis, H. ovata, H. beccarii, H. decipiens, H. minor,* and *Syringodium isoetifolium* are reported from these Islands [22-25]. Similarly, 13 species from the Gulf of Mannar [26], seven species from the Lakshadweep Islands [27], and 13 species from Palk Bay have been recorded [28] (Figure 1).

## 5. EPIPHYTIC MICROORGANISM ON SEAGRASSES

Studies from a seagrass meadow dominated by *Cymodocea rotundata* (75.4%) from the Burmanallah coast was found to be overwhelmed with all the three groups of seaweeds accounting for 40%, fishes and brittle stars (10%) [29]. The total heterotrophic bacterial population from two species of seagrasses *C. rotundata* and *Thalassia hestidinum* was investigated and found the dominance of bacteria of $9.8\times10^3$ CFU/ml in *C. rotundata* and $6.9\times10^3$ CFU/ml from *T. hestidinum* [30].

## 6. REASONS FOR THE DECLINE OF SEAGRASS

Over the years, a rapid depletion of coastal habitats, including seagrass meadows has been reported worldwide. The destructive form of the feeding of dugongs, which feed recurrently on the entire seagrass body, would decimate species diversity and could alter the spatial and temporal habitat of seagrass meadows [22]. Directly or indirectly, anthropogenic activities such as boating, anchoring, fishing, and coastal developments are found to show catastrophic effects on seagrass biodiversity. Previous studies had found the disappearance of some of the seagrass meadows in the Nicobar group of islands after the mega-tsunami of 2004 [31]. During 2013, the Lehar's cyclone destroyed around 1.96 ha in certain seagrass beds of the South and North Andaman Islands [32]. The harsh impact of introducing invasive species in some seagrass meadows has also been reported [6]. High temperatures and intense light were also found to cause burn symptoms in some seagrass species. In contrast, the influx of land runoff, sedimentation, and turbid water during the rainy season appears to cause anoxic conditions that release toxic sulphides, which influence the survival of seagrass species (Figure 2).

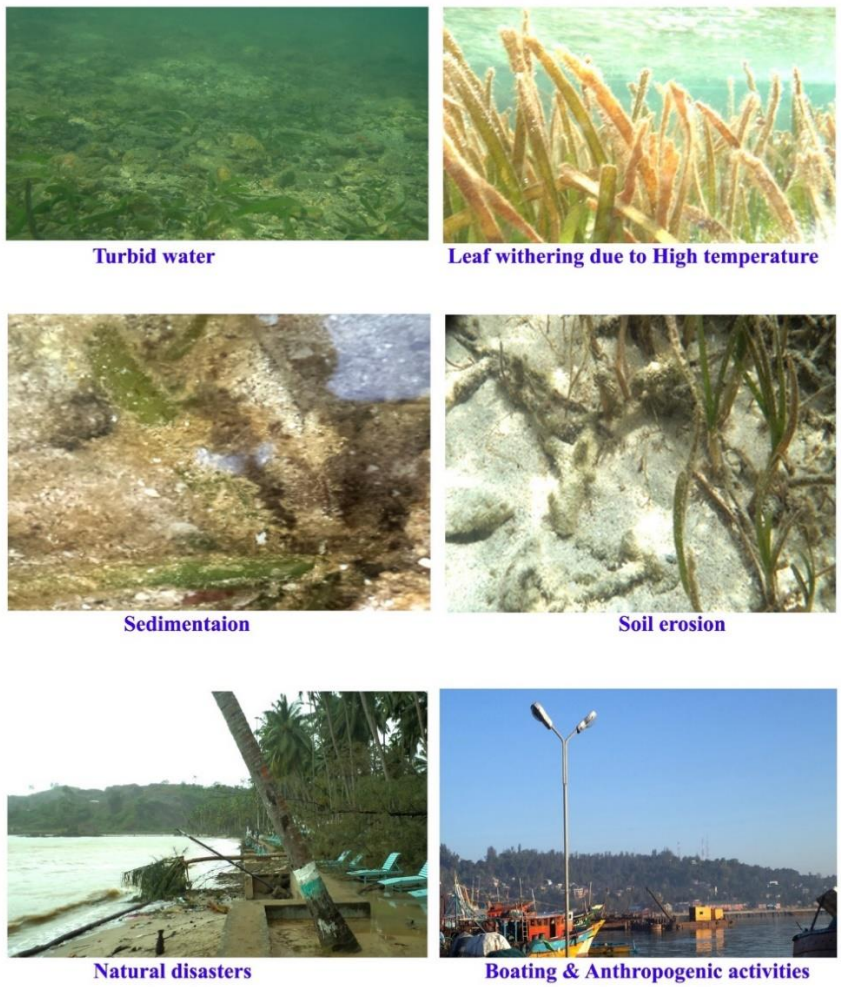


**Figure 2.** Various reasons are affecting the seagrass ecosystem of A&N Islands

## 7. LACUNA ON SEAGRASS MANAGEMENT IN A&N ISLANDS AND MANAGEMENT STEPS

Understanding assemblage of seagrasses species and their distributions are major steps in monitoring the complex habitats. Based on the literature review, certain lacunas like the spatial and temporal distribution of seagrass meadows in the Andaman and Nicobar Islands have not been well defined. The majority of the diversity of seagrasses species are mostly from the meadows where dugongs are found to feed. Extensive documentation is imperative to expand and create a baseline database on the species diversity and distribution irrespective of dugongs represented meadows.

Application of IRS ID satellite imagery for mapping of seagrass meadows have been limited in the Andaman and Nicobar group of Islands [21], hence extending the use of this technique would undoubtedly provide a defined database of seagrass density, productivity, and spatial statistics for evaluating past and future impacts on global and local seagrass ecosystems as well as adjacent ecosystems like coral reefs. Understanding the association of other organisms with seagrasses has to be emphasized since more information reveals the adaptability and nutrient recycling in these meadows. The association of microorganisms with different seagrasses species would yield potential primary and secondary metabolites as natural pharmaceutical products. Further, studies on biomass, biochemical composition, biology, and other studies need to be undertaken.

Efforts on Seagrass conservation around the Andaman and Nicobar Islands need to be undertaken by outreach awareness programs on the importance of seagrasses among the local fisher community, that would undoubtedly ameliorate the seagrass ecosystem management practices. Preliminary studies have focused only on dugong encountered meadows [31]; therefore, other vast untouched areas need to be surveyed. Due to erratic weather conditions and logistics, most of the Islands have been remained untouched. In the Andaman and Nicobar group of islands, 105 Islands have been listed under Marine Protected Areas (MPAs); a detailed survey of the other seagrass meadows could be included in the MPAs. Therefore, priorities should be given for R & D programs to survey meadows and understand the organisms associated with these beds. Other advanced techniques such as remotely operated vehicles are to be introduced apart from SCUBA diving & Snorkeling methods to assess deep-water seagrass beds in these pristine islands for an integrated research approach. The use of appropriate tools for collecting seagrasses is a crucial concern to be considered in management [33].

Other challenges to be regulated frequently in seagrass management are monitoring water quality, dredging activities, fishing activities, dumping of plastic and debris, the influx of sewage, coastal constructions, seasonal variation of floral and faunal assemblages in these meadows, sediment trap track, and constituting inter-governmental integrated management committee, and rehabilitation of seagrass species in tsunami-affected areas.

## 8. DISCUSSION

In the last four decades, the drastic decline of seagrass meadows around the world has raised a global crisis on seagrass management [34, 35], with a declining annual rate of seagrasses about 1.5% globally [36]. A literature survey shows that directly or indirectly, depletion of seagrass meadows is mostly due to ecological or anthropological influences [37]. Several case studies have reported the decline of seagrass meadows worldwide [34]. The loss or regeneration of seagrass biomass depends on the megaherbivores' frequency and intensity like dugongs destructive feeding habits and on re-colonization rate and time of seagrass species [22].

Studies on the seagrass species diversity and management approach from the significant seagrass meadows of India viz. Gulf of Mannar, and Palk Bay, Lakshadweep Islands has been well understood, but not many studies have been undertaken in the Andaman and Nicobar group of Islands. The mega-tsunami of 2004 has distracted many seagrass meadows, and some of them have been reported to be disappeared [31]. Studies are mainly focused on the coral reef and mangrove ecosystems and not much emphasis on seagrass ecosystems. Thangaradjou et al. [24] suggested three key points for seagrass management after the post-tsunami survey in the Andaman Islands- vast unexplored seagrass critical conservation of seagrass ecosystem and transplantation of seagrasses in degraded areas.

The biomass estimation of certain seagrasses from Lakshadweep [27] and the Gulf of Mannar have been undertaken [38]. Duarte and Chiscano assessed the average annual global seagrass production to be about 1012g DW $m^{-2}$ per year [39]. Around 156.21 ha has been identified in Lakshadweep's six different islands for seagrass restoration [40]. Seagrass restoration in an area of 800$m^2$ was undertaken in Vaan and Koswari Islands, Gulf of Mannar, and found increased shoot densities during December to May period [41]. Recent observations revealed the washed-up seagrass as the green tide in large biomass along the Mandapam and Keelakarai coasts [42]. However, there have been no such investigations on these aspects from the Andaman and Nicobar Islands. Therefore, it is a current research concern to monitor and identify untouched fragmented or continuous seagrass meadow patches present across a vast area of the rich biodiversity hotspot of Andaman and Nicobar Islands to establish the local baseline database for seagrass management for further comparative studies.

## 9. FUTURE PERSPECTIVE

Effective management programs including adding seagrass meadows to marine protected areas, undertaking restoration projects, seagrass transplantation, implementing legislation, monitoring coastal water quality, fishing activities, and anthropogenic activities in Andaman & Nicobar Islands are essential for protecting seagrass ecosystems. Monitoring the seagrass meadows through remote sensing techniques is also important to undertake restoration and conservation practices.

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## REFERENCES


[1] Appeltans, W., Ahyong, S.T., Anderson, G., et al. (2012). The magnitude of global marine species diversity. Current Biology, 22(23): 1-14. https://doi.org/10.1016/j.cub.2012.09.036

[2] Mora, C., Tittensor, D.P., Adl, S., Simpson, A.G.B., Worm, B. (2011). How many species are there on Earth and in the Ocean? PloS Biology, 9: e1001127. https://doi.org/10.1371/journal.pbio.1001127

[3] Short, F.T., Polidoro, B., Livingstone, S.R., Carpenter, K.E., et al. (2011). Extinction risk assessment of the world's seagrass species. Biological Conservation, 144(7): 1961-1971. https://doi.org/10.1016/j.biocon.2011.04.010

[4] Parthasarathy, N., Ravikumar, K., Ganesan, R., Ramamurthy, K. (1991). Distribution of seagrasses along the coast of Tamil Nadu, southern India. Aquatic Botany, 40(2): 145-153. https://doi.org/10.1016/0304-3770(91)90092-J

[5] Green, E.P., Short, F.T. (2003). World Atlas of Seagrasses. University of California Press, Berkeley.

[6] Short, F.T., Carruthers, T., Dennison, W., Waycott, M. (2007). Global seagrass distribution and diversity: A bioregional model. Journal of Experimental Marine Biology and Ecology, 350(1-2): 3-20. https://doi.org/10.1016/j.jembe.2007.06.012

[7] Beck, M.W., Heck, K.L., Able, K.W., Childers, D.L., Eggleston, D.B., Gillanders, B.M., Halpern, B., Hays, C.G., Hoshino, K., Minello, T.J., Orth, R.J., Sheridan, P.F., Weinstein, M.P. (2001). The identification, conservation, and management of estuarine and marine nurseries for fish and invertebrates. Bioscience, 51(8): 633-641. https://doi.org/10.1641/0006-3568(2001)051[0633:TICAMO]2.0.CO;2

[8] Jagtap, T.G., Komarpant, D.S., Rodrigues, R.S. (2003). Status of a seagrass ecosystem: An ecologically sensitive wetland habitat from India. Wetlands. 23: 161-170. https://doi.org/10.1672/0277-5212(2003)023[0161:SOASEA]2.0.CO;2

[9] NISCAIR. (2013). Seagrasses, the oxygen pumps in the sea. In: Wealth India Raw Materials Series. CSIR-National Institute of Science Communication and Information Resources, New Delhi.

[10] Athiperumalsami, T., Kumar, V., Jesudass, L.L. (2008). Survey and phytochemical analysis of seagrasses in the Gulf of Mannar, southeast coast of India. Botanica Marina, 51(4): 269-277. https://doi.org/10.1515/BOT.2008.038

[11] Ravikumar, S., Thajuddin, N., Suganthi, P., Jacob Lnbaneson, S., Vinodkumar, T. (2010). Bioactive potential of seagrass bacteria against human bacterial pathogens. Journal of Environmental Biology, 31(3): 387-389.

[12] Ibrahim, A.K., Youssef, A.I., Arafa, A.S., Foad, R., Radwan, M.M., Ross, S., Hassanean, H.A., Ahmed, S.A. (2013). Anti-H5N1 virus new diglyceride ester from the Red Sea grass *Thallasodendron ciliatum*. Natural Products Research, 27(18): 1625-1632. https://doi.org/10.1080/14786419.2012.742082

[13] Supaphon, P., Phongpaichit, S., Rukachaisirikul, V., Sakayaroj, J. (2014). Diversity and antimicrobial activity of endophytic fungi isolated from the seagrass Enhalus acoroides. Indian Journal of Geo-Marine Sciences, 43(5): 785-797.

[14] Iyapparaj, P., Revathi, P., Ramasubburayan, R., Prakash, S., Palavesam, A., Immanuel, G., Anantharaman, P., Sautreau, A., Hellio, C. (2014). Antifouling and toxic properties of the bioactive metabolites from the seagrasses *Syringodium isoetifolium* and *Cymodocea serrulata*. Ecotoxicology and Environmental Safety, 103: 54-60. https://doi.org/10.1016/j.ecoenv.2014.02.009

[15] Spalding, M., Taylor, M., Ravilious, C., Short, F.T., Green, E. (2003). The distribution and status of seagrasses. In: Green, E.P., Short, F.T. (eds) World Atlas of Seagrasses. University of California Press, Berkley.

[16] Hemminga, M.A., Duarte, C.M. (2000). Seagrass Ecology. Cambridge University Press, Cambridge, UK. https://doi.org/10.1017/cbo9780511525551

[17] Thangaradjou, T., Nobi, E.P., Dilipan, E., Sivakumar, K., Susila, S. (2010). Heavy metal enrichment in seagrasses of Andaman Islands and its implication to the health of the coastal ecosystem. Indian Journal of Geo-Marine Sciences, 39(1): 85-91.

[18] Ocean Health Index. (2016). http://www.oceanhealthindex.org/methodology/components/seagrass.

[19] Preen, A. (1995). Impacts of dugong foraging on seagrass habitats: observational and experimental evidence for cultivation grazing. Marine Ecology Progress Series, 124: 201-213. https://doi.org/10.3354/meps124201

[20] Koch, E.W., Ackerman, J.D., Verduin, J., Van Keulen, M. (2006). Fluid dynamics in seagrass ecology-from molecules to ecosystems. In: Larkum, A.W.D., Orth, R.J., Duarte, C.M. (eds) Seagrasses: Biology, Ecology and Conservation. Springer Netherlands. https://doi.org/10.1007/978-1-4020-2983-7_8

[21] Thangaradjou, T., Saravanakumar, A., Balasubramanian, T. (2014). Mapping seagrasses in India–Issues, Challenges and Way forward. http://Indomareclim-Nerci.in/Publication/Workshop2014/Workshops2014/Thangaradjou_seagrass.Pdf.

[22] D'Souza, E., Patankar, V., Arthur, R., Marbà, N., Alcoverro, T. (2015). Seagrass herbivory levels sustain site-fidelity in a remnant dugong population. PLoS One, 10: e0141224. https://doi.org/10.1371/journal.pone.0141224

[23] Immanuel, T., Goutham-Bharathi, M.P., Sawhney, S., Ragavan, P., Sankar, R.K. (2016). New record of the pantropical seagrass *Halophila decipiens* Ostenfeld (Hydrocharitaceae) from the Andaman and Nicobar Islands, India. Botanica Marina, 59(1): 79-83. https://doi.org/10.1515/bot-2015-0090

[24] Thangaradjou, T., Sivakumar, K., Nobi, E.P., Dilipan, E. (2010). Distribution of seagrasses along the Andaman and Nicobar Islands: A post tsunami survey. In: Ramakrishna, Raghunathan, C., Sivaperuman, C. (eds) Recent Trends in Biodiversity of Andaman and Nicobar Islands. Director, Zoological Survey of India, Kolkata.

[25] Savurirajan, M., Lakra, R.K., Ganesh, T. (2015). A new record of the seagrass *Halophila beccarii* Ascherson from the Port Blair coast, Andaman and Nicobar Islands, India. Botanica Marina, 58(5): 409-413. https://doi.org/10.1515/bot-2014-0076

[26] Umamaheswari, R., Ramachandran, S., Nobi, E.P. (2009). Mapping the extend of seagrass meadows of Gulf of Mannar Biosphere Reserve, India using IRS ID

satellite imagery. International Journal of Biodiversity and Conservation, 1(5): 187-193. https://doi.org/10.5897/IJBC.9000091

[27] Nobi, E.P., Dilipan, E., Sivakumar, K., Thangaradjou, T. (2011). Distribution and biology of seagrass resources of Lakshadweep group of Islands, India. Indian Journal of Geo-Marine Sciences, 40: 624-634.

[28] Manikandan, S., Ganesapandian, S., Parthiban, K. (2011). Distribution and zonation of seagrasses in the Palk Bay, Southeastern India. Journal of Fisheries and Aquatic Sciences, 6(2): 178-185. https://doi.org/10.3923/jfas.2011.178.185

[29] Niraimathi, R.D. (2006). Survey of seagrass ecosystem in Burmanallah. Masters dissertation, Pondicherry University.

[30] Mohanraju, R., Mishra, A.K. (2012). Studies on epiphytic bacterial symbionts of seagrass *Cymodocea rotundata* from Port Blair waters. In: National Conference on Biology and Bioinformatics of Economically Important Plants and Microbes. University of North Bengal.

[31] D'Souza, E., Patankar, V. (2011). Ecological studies on the *Dugong dugon* of the Andaman and Nicobar Islands: A step towards species conservation. Nature Conservation Foundation, Mysore.

[32] Sachithanandam, V., Mageswaran, T., Sridhar, R., Purvaja, R., Ramesh, R. (2014). Assessment of Cyclone Lehar's impact on seagrass meadows in Ross and Smith Islands, North Andaman. Natural Hazards, 72: 1253-1258. https://doi.org/10.1007/s11069-014-1040-8

[33] Cunha, A.H., Serrão, E.A. (2011). Tools for seagrass conservation and management in Portugal. Ecologia, 3: 22-34.

[34] Larkum, A.W.D., Orth, R.J., Duarte, C.M. (2006). Seagrasses: Biology, ecology and conservation. Springer Netherlands. https://doi.org/10.1007/978-1-4020-2983-7

[35] Orth, R.J., Carruthers, T.J.B., Dennison, W.C., Duarte, C.M., Fourqurean, J.W., Heck, K.L., Hughes, A.R., Kendrick, G.A., Kenworthy, W.J., Olyarnik, S., Short, F.T., Waycott, M., Williams, S.L. (2006). A global crisis for seagrass ecosystems. Bioscience, 56(12): 987-996. https://doi.org/10.1641/0006-3568(2006)56[987:AGCFSE]2.0.CO;2

[36] Fourqurean, J.W., Duarte, C.M., Kennedy, H., Marbà, N., Holmer, M., Mateo, M.A., Apostolaki, E.T., Kendrick, G.A., Krause-Jensen, D., McGlathery, K.J., Serrano, O. (2012). Seagrass ecosystems as a globally significant carbon stock. Nature Geoscience, 5: 505-509. https://doi.org/10.1038/ngeo1477

[37] Short, F.T., Koch, E.W., Creed, J.C., Magalhães, K.M., Fernandez, E., Gaeckle, J.L. (2006). Seagrass net monitoring across the Americas: Case studies of seagrass decline. Marine Ecology, 27: 277-289. https://doi.org/10.1111/j.1439-0485.2006.00095.x

[38] Manikandan, S., Ganesapandian, S., Singh, M., Kumaraguru, A.K. (2011). Seagrass diversity and associated flora and fauna in the coral reef ecosystem of the Gulf of Mannar, Southeast Coast of India. Research Journal of Environmental and Earth Sciences, 3: 321-326.

[39] Duarte, C.M., Chiscano, C.L. (1999). Seagrass biomass and production: A reassessment. Aquatic Botany, 65: 159-174.

[40] Nobi, E.P., Dilipan, E., Thangaradjou, T., Dinesh, P.K. (2013). Restoration scaling of seagrass habitats in the oceanic islands of Lakshadweep, India using geospatial technology. Applied Geomatics, 5: 167-175. https://doi.org/10.1007/s12518-013-0109-5

[41] Edward, J.K.P., Raj, K.D., Mathews, G., Kumar, P.D., Arasamuthu, A., D' Souza, N., Bilgi, D.S. (2019). Seagrass restoration in Gulf of Mannar, Tamil Nadu, Southeast India: A viable management tool. Environmental Monitoring and Assessment, 191: 430. https://doi.org/10.1007/s10661-019-7546-5

[42] Ramesh, C.H., Koushik, S., Shunmugaraj, T., Murthy, M.V.R. (2020). Occurrence of green tides on Palk Bay and Gulf of Mannar regions, Southeast coast of Tamil Nadu, India. Journal of the Marine Biological Association of India.