



Legislation and policy options for conservation and management of seagrass ecosystems in India

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ABSTRACT

Seagrass meadows are recognized as one of the most productive ecosystems in the coastal zone supporting a wide variety of keystone and ecologically important marine species from diverse trophic levels. This paper examines existing policies and legislations that can help in the protection, conservation and threats to seagrass ecosystems. The paper i) reviews the key legislations with provisions to conserve seagrass ecosystems in India such as the Coastal Regulation Zone (CRZ) Notification (2011) issued under the Environment (Protection), Act 1986, the Wildlife (Protection) Act, (1972), Biodiversity Act, 2002 and the Marine Fishing Regulation Acts of different coastal states in India; ii) identifies threats to the seagrass meadows and iii) suggests measures for enhancing conservation of seagrass.

1. Introduction

Seagrasses are marine flowering and submerged plants occurring in shallow oceanic and estuarine habitats (Barbier et al., 2011), colonizing soft substrates, especially in wave-sheltered conditions. Seagrass meadows are recognized as one of the most productive ecosystems in the coastal zone (Duarte et al., 2010; Short et al., 2011). The extent, diversity and health of seagrass beds are declining at an alarming rate throughout the world, largely due to intense anthropogenic activities such as discharge of industrial wastes, river runoff, nutrient loading, land reclamation, port construction, fisheries and unplanned aquaculture practices (Duarte, 2002; Orth et al., 2006; Short et al., 2007). Further, global climate change is predicted to have deleterious effects on seagrass, both directly and indirectly (Waycott et al., 2009), a growing challenge for coastal management. In general, sea level change, increased temperature, UV-radiation exposure, or increased storm activities are likely to restrict seagrass habitat, growth, distribution and diversity (Short and Neckles, 1999; Björk et al., 2008).

In India, the total seagrass cover is estimated as 517 km² (Geevarghese et al., 2016) with major seagrass meadows in Palk Bay and Gulf of Mannar along the southeast coast of India; the Andaman & Nicobar Islands in the Bay of Bengal; the Gulf of Kachchh in the west coast; and in the lagoons of the islands of the Lakshadweep in the Arabian Sea. These ecosystems are of high importance to the local fisheries and as habitat for endangered species such as the *Dugong dugon* and sea turtles.

There are two aspects to the protection of seagrass ecosystems: (i) explicit protection granted to the ecosystem (or its entities) and (ii) addressing the threats that cause degradation of seagrass ecosystems. This paper examines the available options in terms of legislation and policy under both the aspects for the protection and conservation of seagrass ecosystems in India.

2. Protection and conservation of seagrass ecosystems

The National Environmental Policy (NEP, 2006) of the Government of India, highlights the importance of mangroves, coral reefs, estuaries and coastal forests; but seagrass ecosystems have not been considered. However, the National Policy on Marine Fisheries, 2017 (NPMF, 2017) clearly emphasizes the importance of seagrasses, (along with mangroves and coral reefs) as an integral part of the coastal marine ecosystems that provide a range of ecosystem services, including habitation for many fish species and marine mammals (e.g. Dugong) and therefore shall be protected from anthropogenic impacts.

Although an exclusive policy or legislation for protection of seagrass ecosystems does not exist currently, there are various laws that can be effectively used to protect and conserve these ecosystems (Fig. 1). The Wildlife Protection Act, 1972, the Notifications under the Environment (Protection) Act, 1986 and the Biological Diversity Act, 2002 are a few key legislations that are relevant to the conservation and protection of seagrass ecosystems are discussed in detail below.

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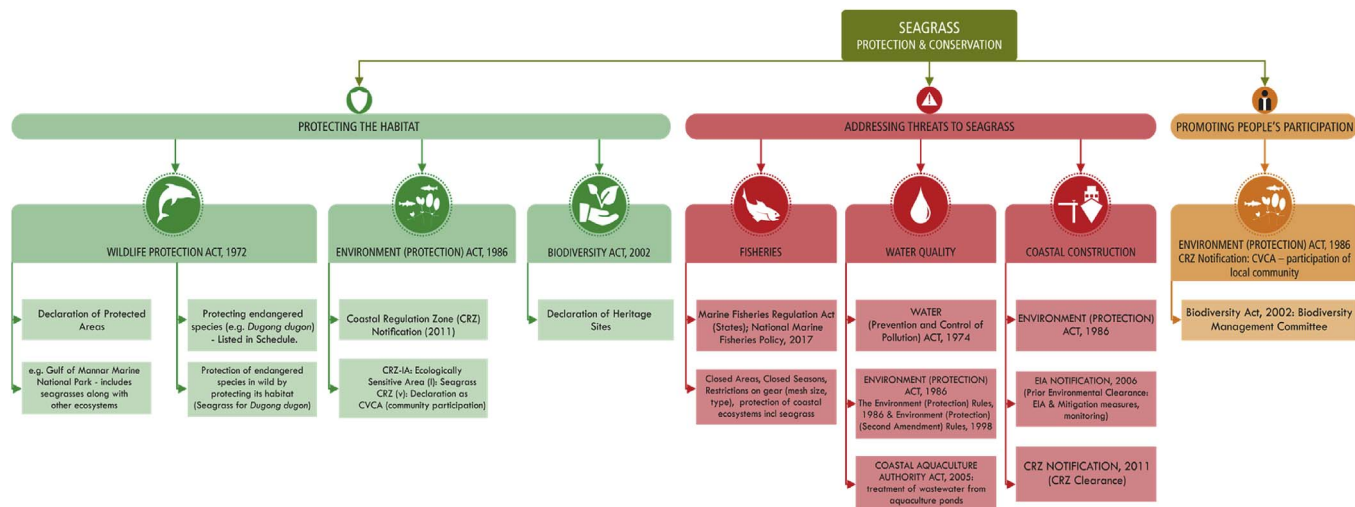


Fig. 1. List of legislation for protection and conservation of seagrass ecosystems.

2.1. The Wildlife protection Act, 1972

The Wildlife (Protection) Act (WLPA) ¹ 1972 provides for both species and spatial conservation strategies. The endangered species are protected regardless of location in the former, while all species in designated areas, called sanctuaries or national parks are protected in the latter strategy (Divan and Rosencranz, 2001). In the first case, *Dugong dugon*, listed as a protected species under Schedule 1 of the WLPA (which affords it the highest degree of protection under the Act) is an example. Dugongs are found in the Gulf of Mannar, Palk Bay, Gulf of Kachchh, and Andaman and Nicobar Islands. India has a National Level Task Force for Dugong Conservation and a National Conservation Action Plan for Dugongs and their habitats (Sivakumar, 2013). Since *Dugong dugon* is a protected species, the best form of conservation is to protect its vital habitat, which is seagrass.

Chapter IV of the WLPA provides details of the declaration of sanctuaries, national parks and closed areas. Various levels of restrictions apply with reference to entry and activities within such areas. Protected areas with a marine/coastal component, are referred as Marine Protected Areas (MPA). In India, Protected Areas (PAs) that fall entirely or partially within the swathe of 500 m from the high tide line and the marine environment are considered to be in the MPA Network (Sivakumar, 2013). In mainland India there are 25 MPAs with a total area of 8231 km². The Andaman and Nicobar and Lakshadweep Islands consist of 106 MPAs with an extent of 1570 km². The Gulf of Kachchh Marine National Park, Gulf of Mannar National Park, Sundarban National Park and Wandoor Marine National Park are some of the important MPAs of India (Sivakumar, 2013). The MPAs, *inter alia*, the Gulf of Mannar Marine National Park, Chilika Wildlife Sanctuary, the Gulf of Kachchh Marine National Park and Marine Sanctuary off mainland India have extensive seagrass beds. Thus, protection of seagrasses is alongside protection of other ecosystems occurring in the designated Marine Protected Area. It is ironical however, that in the case of Lakshadweep Islands, the green turtle has been considered a threat to seagrass meadows because of intensive grazing pressure. However, turtle populations cannot be controlled in India, as they are listed as protected species under the WLPA, 1972 (Kaladharan et al., 2013; Kelkar et al., 2014).

2.2. The environment (protection) Act, 1986

The Environment (Protection) Act² is an enabling umbrella Act, under which there are specific notifications, which enable demarcation of specific areas as ecologically sensitive. The Coastal Regulation Zone (CRZ) Notification (2011) issued under the above Act, regulates development activities in the defined 'Coastal Regulation Zone' which encompasses a seaward stretch up to the territorial waters (12 NM) from the low tide line, the inter-tidal zone and 500 m landward from the high tide line. CRZ Notification (2011) classifies the coast into four zones and the CRZ-I area includes 'areas that are ecologically sensitive and the geomorphological features, which play a role in maintaining the integrity of the coast'. Seagrass beds are included in the list given under CRZ-IA.

No new construction is permitted apart from some essential activities such as weather tracking radars, pipelines and transmission systems and defense related activities in CRZ-I areas. In addition, activities requiring 'CRZ Clearance' as part of obtaining prior Environmental Clearance (if they are located in the coastal areas) require submission of information as per 'Form 1' which requires the project proponent to indicate if the project is located within the CRZ-I area and the distance from it. The notification mandates the respective states to prepare Coastal Zone Management Plans demarcating all four coastal regulation zones in all coastal areas so that the ecologically sensitive areas are identified and recognized. Mapping of seagrass meadows has been completed on a national scale (Geevarghese et al., 2016). This base information would ensure that seagrass beds are not threatened by coastal development activities by providing guidance for conservation and protection of seagrass meadows of the country.

2.3. Biodiversity Act, 2002

The Biological Diversity Act,³ 2002, was enacted primarily to fulfil India's obligations to the Convention on Biological Diversity. The Act contains provisions that aim at preserving biodiversity as well as establishing a system for equitable sharing of benefits arising from the use of traditional biological resources and knowledge. Biodiversity Heritage Sites (BHS) may be declared under this Act (Section 37). Thus, the Act may be used if there are locations with seagrass meadows that can qualify for protection under this Act. The Act can also be used to notify

¹ <http://envfor.nic.in/division/wildlife>.

² <http://envfor.nic.in/division/environment-protection>.

³ <http://envfor.nic.in/division/biodiversity>.

Table 1
Pressures on Seagrass Ecosystems

| Causative Factor | Pressure | Impact | Location(s) | Reference | Relevant regulatory and policy frameworks |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fisheries related | a) <i>Navigation</i> : Anchoring of boats & damage by the propellers b) <i>Fishing gear</i> : Use of push nets, trawl nets, bottom set gill nets c) <i>Harvest</i> : Shell harvesting of <i>Tellina angulata</i> a) Nutrient enrichment from aquaculture wastes b) Proliferation of macroalgae c) Sewage and industrial wastes d) Disposal of fish waste and solid waste | <i>Direct impact</i> : Uprooting of seagrass, Physical damage to the seagrass leaves and rhizomes <i>Indirect Impact</i> : loss of fisheries, and tourism Physical damage to the seagrasses by uprooting the plants and removing healthy leaves Physical destruction of seagrass rhizomes and roots | a) Palk Bay b) Gulf of Mannar; c) Gulf of Kachchh; d) Andaman and Nicobar Islands & Lakshadweep Islands e) Lakshadweep Islands a) Palk Bay b) Gulf of Mannar a) Gulf of Mannar | Thangaradjou and Nobi, 2009; Mathews et al., 2010; Nobi et al., 2013; Kamboj, 2014 Thangaradjou and Nobi, 2009; Sridhar et al., 2010; Mathews et al., 2010; D'Souza et al., 2013 Thangaradjou et al., 2007; Thangaradjou and Nobi, 2009, Sridhar et al., 2010; Thangaradjou et al., 2013; Priyadarsini et al., 2014 Kamboj, 2014 Thangaradjou and Nobi, 2009 | <ul style="list-style-type: none"> Marine Fishing Regulation Act of the different States; National Policy on Marine Fisheries, 2017 |
| Coastal Pollution/ Waste Disposal | | Eutrophication, growth of algae/ seaweed competing with seagrass, reduced light availability and sediment quality Eutrophication and formation of algal blooms Localized eutrophication and seagrass damage | a) Palk Bay b) Chilika Lagoon a) Gulf of Kachchh a) Lakshadweep Islands | Thangaradjou et al., 2010; Thangaradjou et al., 2013; Priyadarsini et al., 2014 Kamboj, 2014 Thangaradjou and Nobi, 2009 | <ul style="list-style-type: none"> Water (Prevention and Control of Pollution) Act, 1974; Environment (Protection) Rules, 1986 & Environment (Protection) (Second Amendment) Rules, 1998; Coastal Aquaculture Authority Act⁴, 2005, National Environmental Policy, 2006; National Policy on Marine Fisheries, 2017 |
| Coastal Construction | e) Cultivation of exotic seaweeds a) Dredging & channel deepening; b) Coastal Construction – breakwaters for ports | Reduced light penetration and seagrass die-off Uprooting of seagrass; increase in sedimentation, solid waste and marine pollution | a) Palk Bay a) Chilika Lagoon; b) Gulf of Kachchh | Mathews et al., 2010 Priyadarsini et al., 2014; Kamboj, 2014 | <ul style="list-style-type: none"> Coastal Aquaculture Authority Act, 2005 EIA Notification, 2006 |

threatened species (Section 38), although no coastal area has been identified as BHS in India as yet.

3. Addressing threats to seagrass ecosystems in India

3.1. Threats to seagrass ecosystems

Seagrass ecosystems are affected by both natural and anthropogenic disturbances. Natural disturbances include cyclones, storms, tectonic movement, grazing by herbivores and diseases (Jagtap et al., 2003; Mathews et al., 2010; Ragavan et al., 2013). Thangaradjou and Nobi, 2009, reported a decrease in seagrass area in the Andaman archipelago, as a consequence of the tectonic movement/coastal uplift and sediment dumping on seagrass after the 2004 Indian Ocean Tsunami. Increase in rainfall intensity and cyclones damaged the seagrass meadows at various locations by uprooting the plants, affecting seawater clarity through input of high suspended matter. Thangaradjou and Nobi (2009) reported localized effect on reduced leaf cover and biomass distribution in the seagrass meadows of Lakshadweep and Andaman Islands due to grazing by sea turtles.

Seagrass meadows are affected primarily by human activities occurring along the coast and through land-based inputs, leading to consequent loss in both seagrass area and diversity (Prabhakaran, 2006; Thangaradjou et al., 2007; Singh et al., 2015). Fishing using trawl/gill nets and boating activities is among the most important threats to seagrass in India (Thangaradjou and Nobi, 2009; Mathews et al., 2010). Other prolonged disturbances such as continuous loading of nutrients/fresh water, often result in the phase shift of seagrass meadows to macroalgae beds, as seen in Palk Bay region (Thangaradjou et al., 2013), where the alga *Cladophora* outcompetes mainly the smaller leaved seagrass and to some extent *Thalassia hemprichi*. In addition, change in salinity cause a shift in seagrass species in Chilika Lagoon, with colonization by new species (Kumar and Patnaik, 2010). Further, high levels of turbidity affect seagrasses by reducing light penetration, preventing photosynthesis.

The important pressures on seagrass ecosystems have been classified into three major categories based on cause, impact and potential solution (legal) and are presented in Table 1; Fig. 1. Locations where such problems have been observed are also provided as additional information.

3.1.1. Threats related to fisheries

Seagrass meadows are rich in fish habitats and subjected to huge fishing pressure. Commonly reported fisheries-related threats to seagrass habitats include anchoring of boats in seagrass meadows, cutting or damage to seagrass leaves by the propellers and use of fishing gear such as push nets and bottom trawls that damage benthic habitats (Table 1). Such issues can be mitigated through the effective implementation of the respective State's Marine Fishing Regulation Act⁵.

Fisheries is a State subject as per the Constitution of India and the coastal states exercise control up to its territorial limits. Each coastal state has enacted its own Marine Fishing Regulation Act (MFRA) based on a model Bill prepared by the Government of India. The MFRA has the powers to regulate, restrict or prohibit fishing in specified areas by either class of fishing vessel, number of vessels or type of fish caught and also regulate, restrict or prohibit gear used for fishing. Such clauses can be effectively implemented locally where seagrass meadows are present by declaring closed areas or closed seasons and also prohibiting the use of fishing gear that can damage the bottom habitat. In places where tourism is practiced, not only fishing boats, but also tourist boats may anchor in seagrass meadows. In such cases, advisories and awareness programmes to boat operators as well as visitors, followed by

⁴ <http://caa.gov.in/uploaded/doc/COMPUPD2014.pdf>.

⁵ http://mpeda.gov.in/MPEDA/state_mfras.php#.

punitive action under the MFRA for repeat offenders may be helpful in reducing damage to seagrass beds. The new National Policy on Marine Fisheries identifies seagrasses as important coastal ecosystems to be protected as they provide a range of eco-system services, including habitation for many fish species and marine mammals. Hence, the policy could help directing fisheries and fish harvesting systems in a manner that ensures their sustainable use.

3.1.2. Threats due to coastal pollution

Poor water quality in seagrasses habitat has been indicated as one of the major causes of destruction of meadows (Table 1). This is often due to the disposal of wastes (sewage, industrial effluents, aquaculture wastes etc.) in creeks and coastal waters, which eventually reach the seagrass meadows. High nutrient levels causing phytoplankton blooms, resulting in shading of the seagrass, reducing their ability to photosynthesize. Coincidentally, there is a spur in the growth of macroalgae that compete with seagrasses and result in reduction in seagrass area.

A number of laws are in place to prevent water pollution. The Water (Prevention and Control of Pollution) Act⁶ was enacted in 1974 under which Central and State Pollution Control Boards have been established. The Act applies to streams, inland waters, subterranean (underground) waters and coastal waters. The Act requires the consent of the State Board before establishment of any industry or process or treatment or disposal system which might result in discharge of waste effluents into receiving waters or land. Maps of seagrass distribution and sensitizing the State Pollution Control Boards on the significance of their role in implementing not only the provisions of Water Act, but also those in EPA, 1986, would aid in conservation of the seagrass meadows.

In the case of coastal aquaculture, the guidelines and regulations of the Coastal Aquaculture Authority (CAA) (Chapter II of CAA rules) indicates that nutrients and organic wastes produced in shrimp ponds need to be managed by matching loads with the capacity of the environment to accept the waste materials so that they do not result in adverse impacts on the quality of the receiving waters. The Guidelines also recommend secondary aquaculture projects such as culture of mussels, oysters, seaweeds, etc., which will improve the wastewater quality. Effluent treatment systems with standards for discharge are mandatory for farms above 5 ha.

The Environment (Protection) Rules specify the limits of the various parameters for effluent discharge. In addition, the Environment (Protection) (Second Amendment) Rules, 1998 classified coastal waters (in terms of their water quality) based on their designated best use. Thus, salt pans, shell fishing, mariculture and ecologically sensitive zones come under Class I with highest water quality standards.

It is clear from the above facts that there are adequate legislations to control coastal pollution with effective standards. However, in many cases, the enforcement is weak; resulting in untreated or inadequately treated effluents reaching the coastal waters. Stricter enforcement, simpler and more effective treatment technologies and wider awareness on the impacts of wastewater discharge on sensitive ecosystems such as seagrasses may help control wastes reaching seagrass meadows to function more efficiently.

3.1.3. Threats related to coastal construction

Dredging and channel deepening are often required to maintain depth of waterways for navigation. However, such activities often can be destructive to neighboring ecosystems such as seagrasses because the increase in turbidity during dredging or other construction activities can result in reduced light penetration, thus hampering photosynthesis, which in turn can destroy seagrass. Construction of breakwaters for ports and construction of coastal protection structures such as seawalls and groynes often disrupt sediment transport causing siltation. Since

dredging and coastal construction activities require prior Environmental Clearance (EC) as per the Environmental Impact Assessment Notification, 2006, the EIA reports and conditions given in the Environmental Clearance shall clearly state mitigation methods such as the use of silt screens while dredging to control turbidity and also design breakwaters that permits unhindered littoral drift along the coast.

4. Conservation and restoration by participatory action

One of the major threats to seagrasses is the use of nets such as shore seines and trawl nets that can damage seagrasses (Raj et al., 2017). Similarly, it is known that propellers of boats can cut the leaves of the submerged aquatic plants and cause destruction, while anchoring in seagrass beds destroy their rhizomes. In the case of motorized boats, whether used for fishing or tourism, awareness is essential to ensure that they stay clear of shallow areas that contain seagrass beds. Anchoring in seagrass beds needs to be prohibited. Apart from implementing provisions of the MFRA as discussed in the earlier section, community based management and participatory resource management techniques can be used as a preferred method of managing coastal resources (Nickerson-Tietze, 2000).

The CRZ Notification under the EPA, 1986 and the Biodiversity Act, both have clauses providing for involving the community for the conservation of sensitive ecosystems. For example, notification of seagrass meadows in areas of high fish productivity and consequently high fishing pressure as Critically Vulnerable Coastal Areas (CVCA), as provided under CRZ, 2011, along with appropriate capacity building, may be used to ensure protection of seagrass ecosystems by ensuring sustainable methods of harvesting fish. In the case of the Biodiversity Act, 2002, there is a provision for the constitution of local-level Biodiversity Management Committees (BMC) for promoting conservation and sustainable use of biodiversity (Fig. 1). In locations where local populations are highly dependent on the natural coastal/marine resources the support of BMCs shall be used to protect and conserve seagrass meadows.

5. Summary and conclusions: priorities for sustainable management

Seagrass meadows are listed as Ecologically Sensitive Areas as per the CRZ Notification, 2011. They are of high value as a habitat for many fishes, endangered sea cow, *Dugong dugon* and sea turtles, in India, which requires robust protection and conservation. While there are no laws or policies exclusive for seagrass protection, clauses in different laws, including the Wildlife Protection Act, 1972 and the Environment (Protection) Act shall be used to protect seagrass meadows. Major anthropogenic threats to seagrasses are grouped under three classes and appropriate laws, including the State Marine Fishing Regulation Acts may be effective in diminishing these threats to control further degradation and promote self-restoration of seagrass meadows. The power of participatory action, provided under different laws can also be used to conserve seagrass ecosystems.

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⁶ <http://envfor.nic.in/division/water-pollution>.

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