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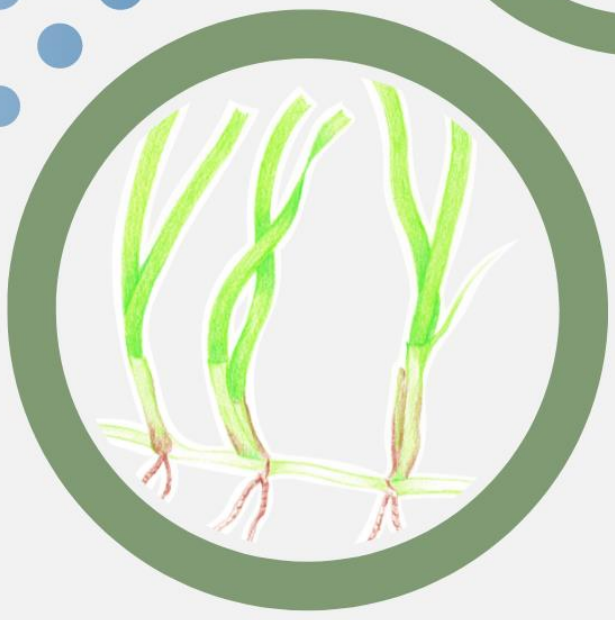
Wildlife Institute of India

SEAGRASS AND SEAWEED HABITATS IN GULF OF MANNAR AND SOUTH PALK BAY REGION



Report Submitted to
Ramanathapuram Wildlife Division, Tamil Nadu

Study awarded under the scheme of Tamil Nadu Biodiversity Conservation and Greening Project (TBGP)

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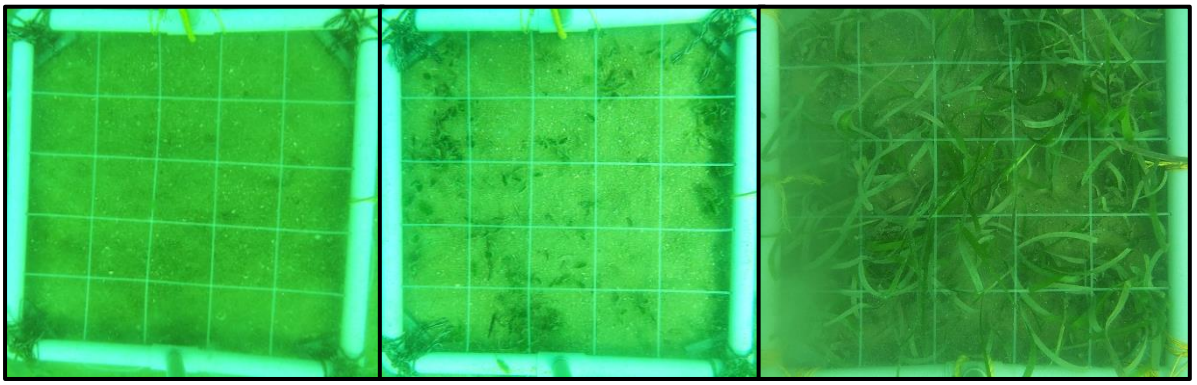

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Wildlife Institute of India

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SEAGRASS AND SEAWEED HABITATS IN GULF OF MANNAR AND SOUTH PALK BAY REGION

Background

The Ramanathapuram Wildlife Division is one of the biodiversity rich areas, which comprise of two eco-regions South Palk Bay and Gulf of Mannar Marine National Park. The Gulf of Mannar region harbours a cornucopia of marine biodiversity which makes it one of India's richest coastal habitats. Further, the region is recognised as one of the richest marine biodiversity hotspots in India and the portion of this region has been declared as a Marine National Park in 1986 by the Government of Tamil Nadu and later, as a Marine Biosphere Reserve in 1989 by the Government of India. This region supports a diverse array of ecosystems, *viz*., mangrove forests, coral reefs, rocky shore, sandy beaches, seagrass meadows and seaweed ecosystem. Over 4223 species of flora and fauna with 117 species of corals, 158 species of arthropods, 856 species of molluscs (Balaji *et al.,* 2012) and an estimate of about 1182 species of fishes (Joshi *et al.,* 2016) were reported from this region. It also harbours the largest shallow-water coral reefs in India including the rare black coral (*Antipathes* spp.) and several threatened reef-building corals. An endemic species of *Balanoglossus*, which is a living fossil that links invertebrates and vertebrates has been recorded from Kurusadai Island. The region also has very tiny mangrove cover, which provides shelter, feeding and breeding grounds to numerous marine organisms, especially fishes and invertebrates. These mangrove vegetations play a major in shoreline protection from storms an erosion (Kathiresan and Bingham, 2001). The pelagic ecosystem of Gulf of Mannar supports a wide variety of commercially important marine resources, thus directly supporting the livelihoods of the local community as well as contribute Country's economy. This region is one of the globally repaganized as Important Marine Mammal Areas and many species of marine mammals such as dugongs, dolphins, and whales, which are inhabit in this region.

Equally, the Southern Palk Bay region supports a variety of habitats including coral reefs, seagrass meadows, seaweed beds, mangrove forests, estuaries, and mudflats. All these habitats are known to harbour unique species assemblages of over 3000 species of flora and fauna. The region supports 128 species of corals, 651 species of crustaceans, 733 species of molluscs, 273 species of echinoderms, 580 species of fishes and other marine life (Kumaraguru *et al.,* 2008). Coral reefs are one of the key features of Palk Bay and are considered a unique asset to the

region harbouring a rich biodiversity. The region also supports native and migratory bird populations.

Thus, the Ramanathapuram Wildlife Division is considered treasures troves of biodiversity globally. The biodiversity value of the region is immense which not just ensures a reliable economy for the livelihoods of the local community, but even contributes to the economic wealth of the country. For example, pearl and chank fisheries contribute towards the economy at the state as well as the country level.

Seagrass and seaweed wealth of Gulf of Mannar and Palk Bay

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, *Halodule uninervis* is extensively distributed in Gulf of Mannar and it is one of the dominant and primary species in the intertidal belt. *H. uninervis* plays an important role both as stabilizers and sediment accumulator and occurs either as a bed of monospecific community or a mixed vegetation with *Cymodocea rotundata*, *Cymodocea serrulata*, *Halophila ovalis* and *Enhalus acoroides*. *C. serrulata* occurs extensively in most of the islands of Gulf of Mannar and forms a significant browsing ground for the endangered dugong. *Thalassia hemprichii* and *H. uninervis* beds are the important habitat for Holothurians commonly known as sea cucumbers. Of a total of 15 seagrass species found along the Indian coastline, Tamil Nadu holds 14 of them except *Halophila minor*.

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 – *Sargassam* sp. (Kattakorai) and *Turbinaria* sp (Baagoda pasi). These are the native species found in Indian waters. Apart from these, the exotic seaweed *Kappaphycus alvarezii* culture is promoted in Palk Bay region for production of carrageenan.

Table 1: Diversity of seaweeds reported in Palk Bay and Gulf of Mannar coast, Tamil Nadu (Kaliaperumal *et al.,* 2004)

Algae	**Genera**	**No. of species**
Chlorophyta	23	80
Rhodophyta	60	146
Phaeophyta	18	56
Total	**101**	**282**

Seagrass and seaweed habitats are known to many ecological services to the coastal and marine ecosystem like stabilising the bottom, acting as natural buffer zones, provide feeding and spawning ground for many marine organisms and providing storm protection. Seagrass meadows also play an important role in nutrient cycling and acting as natural filters. These vast meadows provide support against coastal erosion, aide in nutrient retention and absorption of pollutants from the water column thereby improving water quality. Though, seagrass beds cover constitutes only 0.1% of the sea floor, they are known to contribute towards climate change mitigation and carbon sequestration (Duarte *et al.,* 2010). Similarly, seaweeds are primary producers, and are responsible for food production, nutrient cycling, improved water quality and carbon sequestration.

However, various man-made activities on seagrass and seaweed habitats great impact on its production and extend of cover. The major threats to these habitats are operation of bottom trawlers, boat anchoring, shore seine and push nets by the traditional fishermen are the major concern and threats which has degraded approx. 20% natural sea grass of Palk Bay due to anthropogenic activity (Kasim, 2015). Seagrass beds are also heavily affected by frequent storms and prolonged rain, affecting the water transparency, and cutting the light penetration (Syukur *et al.,* 2017). As a results, seagrass habitats quality and extend are degreasing in greater extent. In order to take a stock on the extend of seagrass and seaweed cover in the Gulf of Mannar and Southern Palk Bay region, the present investigation was under taken with the following objectives.

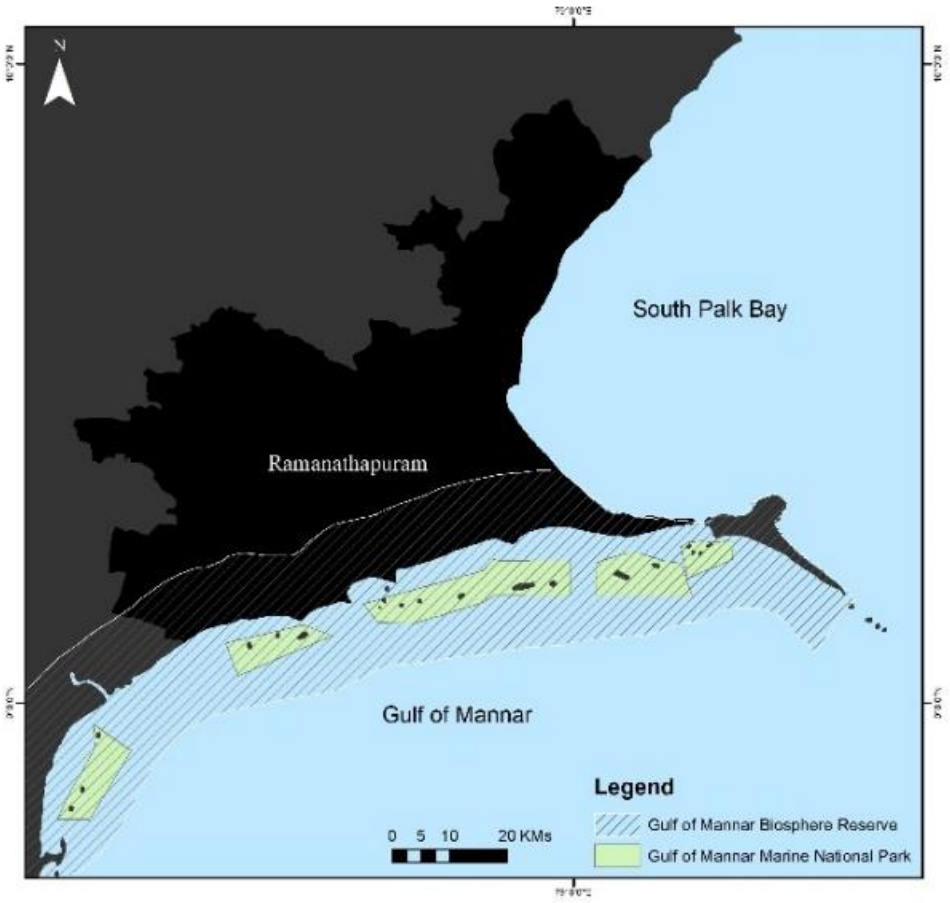
Objectives of the study

- To map the current distribution and area coverage of seagrass and seaweed in Gulf of Mannar and Southern Palk Bay region.
- Identify and demarcate the degraded seagrass habitats for adopting suitable management interventions.

Study area

The present assessment, the sampling area was considered from the South Palk Bay coast at Karankadu in the north to Toothukudi coast of Gulf of Mannar Marine National Park in the south, lying within the latitude of 9.661°N to 8.745°N and longitude of 78.986°E to 78.208°E. Other than seagrasses and seaweeds, the Palk Bay area is known for various other marine biodiversity and resources such as shrimps, lobsters, molluscs, coelenterates, holothurians, echinoderms, crabs, shellfishes, squids and fin fish. With such immense potential of economically important marine bioresources, various socioeconomic and development activities such as agriculture, aquaculture and fishing are performed. Such economic activities deliver high quantities of untreated solid and liquid waste in coastal waters. Agriculture forms the major land use followed by water bodies. Built-up areas and wastelands also share the land use and land cover pattern to some extent. Major rainfall events in this region are brought by north-east monsoon with sparce rainfall from south-west monsoon. The near shore water depth varies between 1-2 m and is nutrient rich with low wave action but high turbidity (Perumal *et al.,* 2021). Turbidity is a limiting factor in any mapping exercise in very near shore region of this area. Gulf of Mannar region has comparatively clearer waters because of its openness to the deep ocean. This region is also rich in marine biodiversity with 3,600 species of flora and fauna, including 117 hard coral species. The area is covered by Gulf of Mannar Biosphere reserve and the island complexes have a higher protection by the declaration of Gulf of Mannar Marine National Park. The biosphere reserve covers an area of 10,500 sq. km., with a larger buffer area that includes the adjoining coastline. The area under the Indian Exclusive Economic Zone (EEZ) is about 15,000 sq. km., and commercial fishing takes place in about 5,500 sq (Kannan, 2008).

A



B

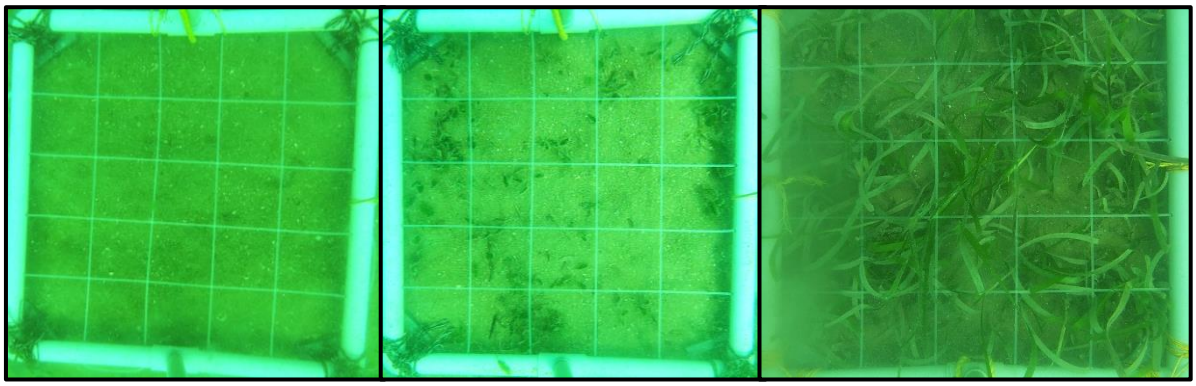
Figure 1: A. Study area of Ramanathapuram district along the Gulf of Mannar Marine National Park. B. Habitat photographs of corals, seaweeds, seagrass and mixed meadow of seagrass. Photo credit: Chinmaya Ghanekar.

Materials and Methods

In situ field data collection

In order to create the seagrass and seaweed distribution map, field survey was carried out between March and April 2023.

- In situ, presence and absence of seagrass and seaweeds data were collected from south Palk Bay from Karangadu to Gulf of Mannar at Toothukudi. A total of 365 sampling points (every station with three replicates at >50m apart.) were collected. 107 points from South Palk Bay and 258 points from Gulf of Mannar regions respectively.
- Drop-down camera record method was used to photograph and record the presence of seagrasses in the selected grids. The transects were laid perpendicular to the shore and the grids were selected starting from the low-tide line (LTL) till 10 km off-shore at an interval of 2 km. The presence-absence data on seagrass and seaweeds were recorded from the centroid (i.e., sampling station) of the selected grids with three replicates (i.e., sampling points). A Hero GoPro 9 Silver Camera at the apex of a square-based pyramidal structure was used for camera record as outlined by Bertelli *et al.,* 2021.
- At each drop location, the percentage cover of seagrass/ seaweed was calculated as illustrated in the Figure 2.



A B C

Figure 2: A. No seagrass/seaweed cover (0%), B. Moderate seagrass cover (40%), C. Dense seagrass cover (100%).

- Other physical parameters like depth and sea-surface temperature were measured using Depthtrax-1X echo sounder and transparency was measured using a *secchi disk* from every point

The detailed procedure for in situ collection of seagrass/ seaweed data and other variables are given in Figure 3.

A B C

Figure 3: A. Structure for drop down quadrat with GoPRO fixed on it. B. Assessing the transparency using a Secchi Disk. C. Dropping of the quadrat and recording the observation.

Classification and mapping

Out of 365 sampling points, videos with less water clarity were discarded and 340 videos were used for analysed for presence/absence and percentage cover for seagrasses and seaweeds. The seagrasses are clearly been identified but it is difficult to distinguish between seaweed and plant debris. Therefore, we maintained seaweeds and debris in a single class.

- Cloud-based Google Earth Engine platform was used for classification. Sentinel-2 MSI Level-2A (Surface-reflectance) composites were developed, on which cloud-masking was done by using Sentinel-2 Cloud Probability.
- Landmasking: The land was masked by the normalised difference of B3 (green) and B8 (Near-infrared) Sentinel imageries.
- Depth-invariant index (DII image composite): To nullify the effect of variation of depth on the reflectance we ran a regression analysis with the reflectance values of B2 (Blue),

B3, B4 (red) and B8 against different depths. We selected single class (i.e., sand) for this purpose.

- Feature classes were drawn as small object-based polygons for signature classes and the total data points were segregated into 70:10 for training and validation.
- Mata data generated through Sentinel-2 is presented in Table 2.

Table 2: Metadata for Sentinel 2 imageries

Satellite	Sentinel-2
Satellite number	A and B
Processing level	Level-2A
Product type	S2MSI2A
Instrument	Multispectral Instrument (MSI)
Bands used	Band 2 Blue (496.6 nm-S2A/492.1 nm-S2B)
	Band 3 Green (560 nm-S2A/559 nm-S2B)
	Band 4 Red (664.5 nm-S2A/665 nm-S2B)
	Band 8 NIR (835.1 nm-S2A/833 nm-S2B)
Spatial Resolution	10 m

- The algorithm with highest accuracy was selected for classification. Machine learning algorithms tested are: K-Means, Support Vector Machine (SVM), Maximum Distance (MD), Classification and Regression Trees (CART), Naives Bayes (NB) and Random Forest (RF).
- **Limitation:** Seaweeds are macroalgae and they are of varied colours, therefore it is very difficult to get all reflectance signals with respect to all the colours and hues. Also, our survey timeline being coinciding with the growing season of seaweeds, we received very limited number of seaweed/algae presence locations from south Palk Bay region which made the training points spatially congregated only at the Gulf of Mannar region. Therefore, we did not run the classification for the seaweed class and have represented by 1km buffer

polygons with the actual locations as the centroid. Actual locations were recorded either from the primary survey or from interviews from seaweed collecting seafarers.

- The final output maps and area calculation were done using ArcMAP v.10.8.

Findings

As stated in the beginning, Palk Bay and Gulf of Mannar region inhabit 14 species of seagrass and some of the common and abundant seagrass occur in in this region is given in the Figure 4. Similarly, the common and most abundant seaweed occur in Palk Bay and Gulf of Mannar region is given in Figure 5.

Based on the 340 points drop down quadrate method, seagrass cover along the south Palk Bay and Gulf of Mannar region was prepared. The seaweed map was prepared by making 1km buffer polygons around the actual locations recorded during the survey. From the map it is calculated that an area of **873.81 km^2 (87381 ha)** of seagrass and **185 km^2 (18500 ha)** of seaweed habitats present in the coastal region of Ramanathapuram Wildlife Division (South Palk Bay and Gulf of Mannar Region). The output of seagrass and seaweed extend maps are presented in Figure 6 and 7 respectively.

- Gulf of Mannar region though having clearer waters has less dense seagrass cover in comparison to that of Palk Bay.
- CART was found to be best-fit algorithm for mapping seagrasses in the targeted study area, whereas MD for seaweed and algae. The overall accuracy and the kappa values tested for seagrass data is presented in Table 3.
- We also identified gaps (mentioned in gradient of yellow to red with respect to area-Fig. 6) in seagrass distribution which can be regarded as degraded meadows and can be targeted as potential sites for restoration.

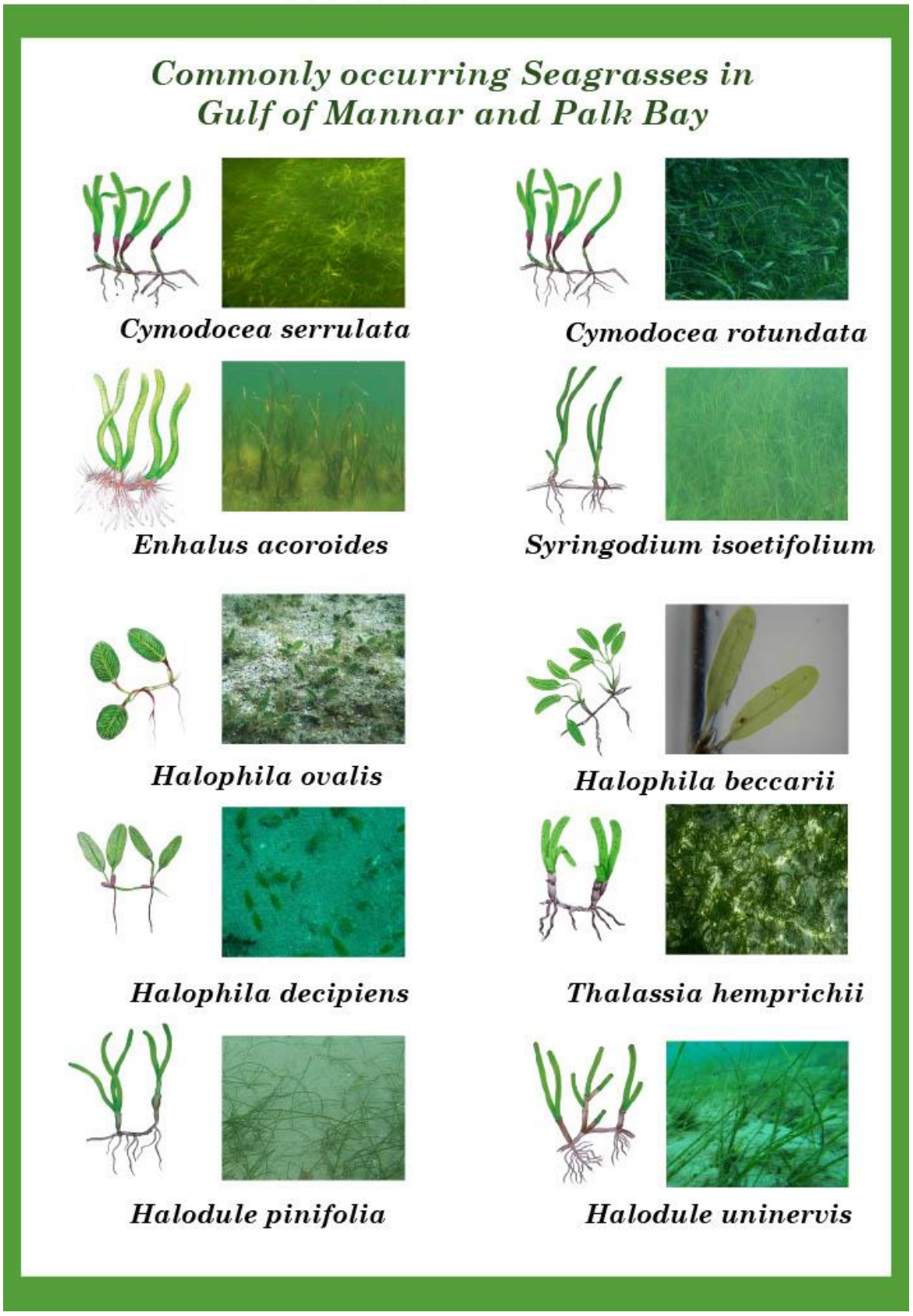


Figure 4: Some of the common and abundant Seagrasses occur in Palk Bay and Gulf of Mannar region, Tamil Nadu.

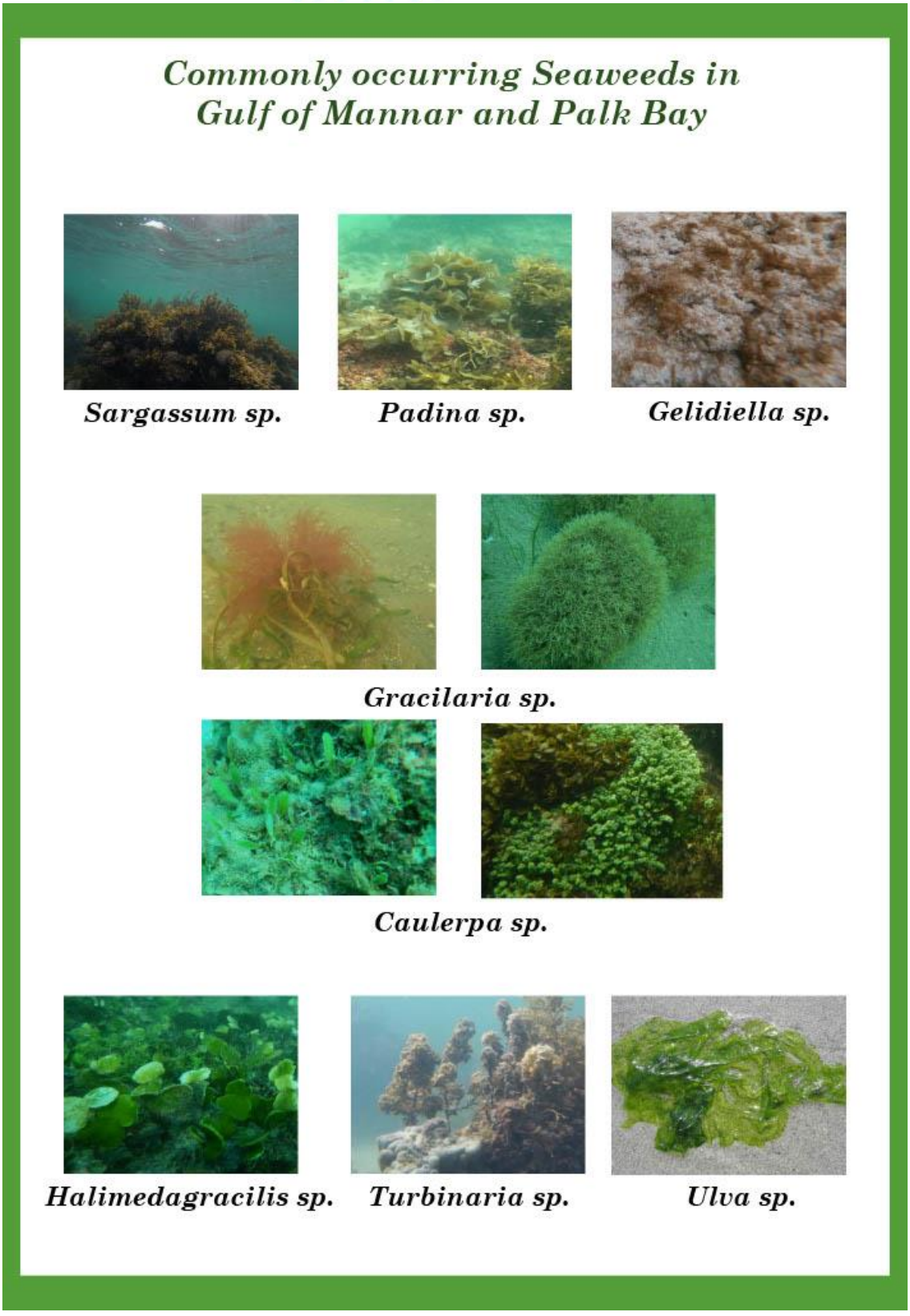


Figure 5: Some of the common and abundant Seaweeds occur in Palk Bay and Gulf of Mannar region, Tamil Nadu.

Table 3: Overall accuracy and the kappa values for every machine learning algorithm tested for seagrasses in Ramanathapuram district, Tamil Nadu.

Seagrasses		
ALGORITHMS	**Overall accuracy**	**Kappa**
K means	0.33	0
SVM	0.65	0.29
Maximum distance	0.53	0.22
CART	**0.75**	**0.44**
Naïve's Bayes	0.61	0.04
Random Forest	0.30	-0.16

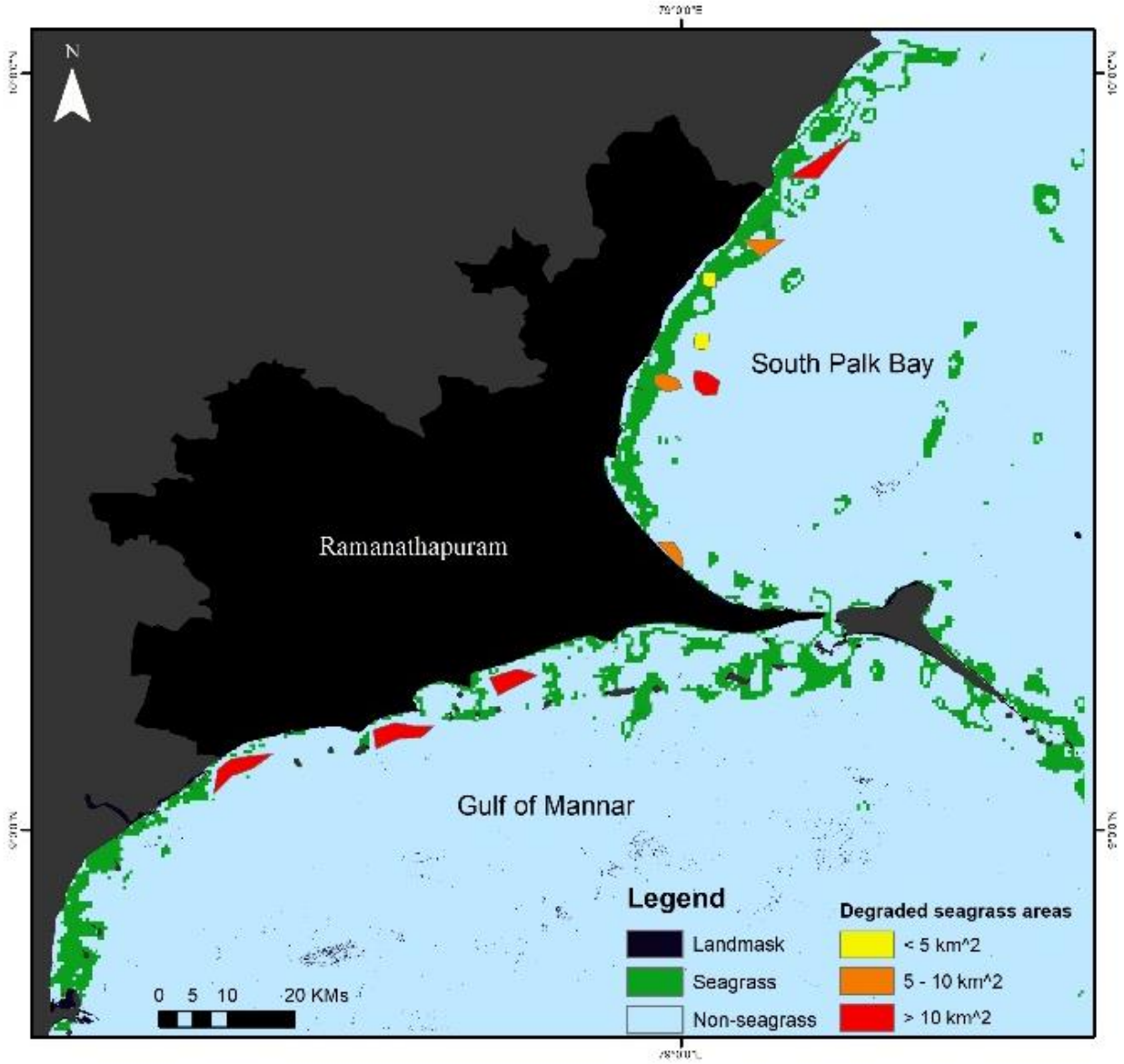


Figure 6: Seagrass map with degraded areas of South Palk Bay and Gulf of Mannar region, Ramanathapuram Wildlife Division, Tamil Nadu.

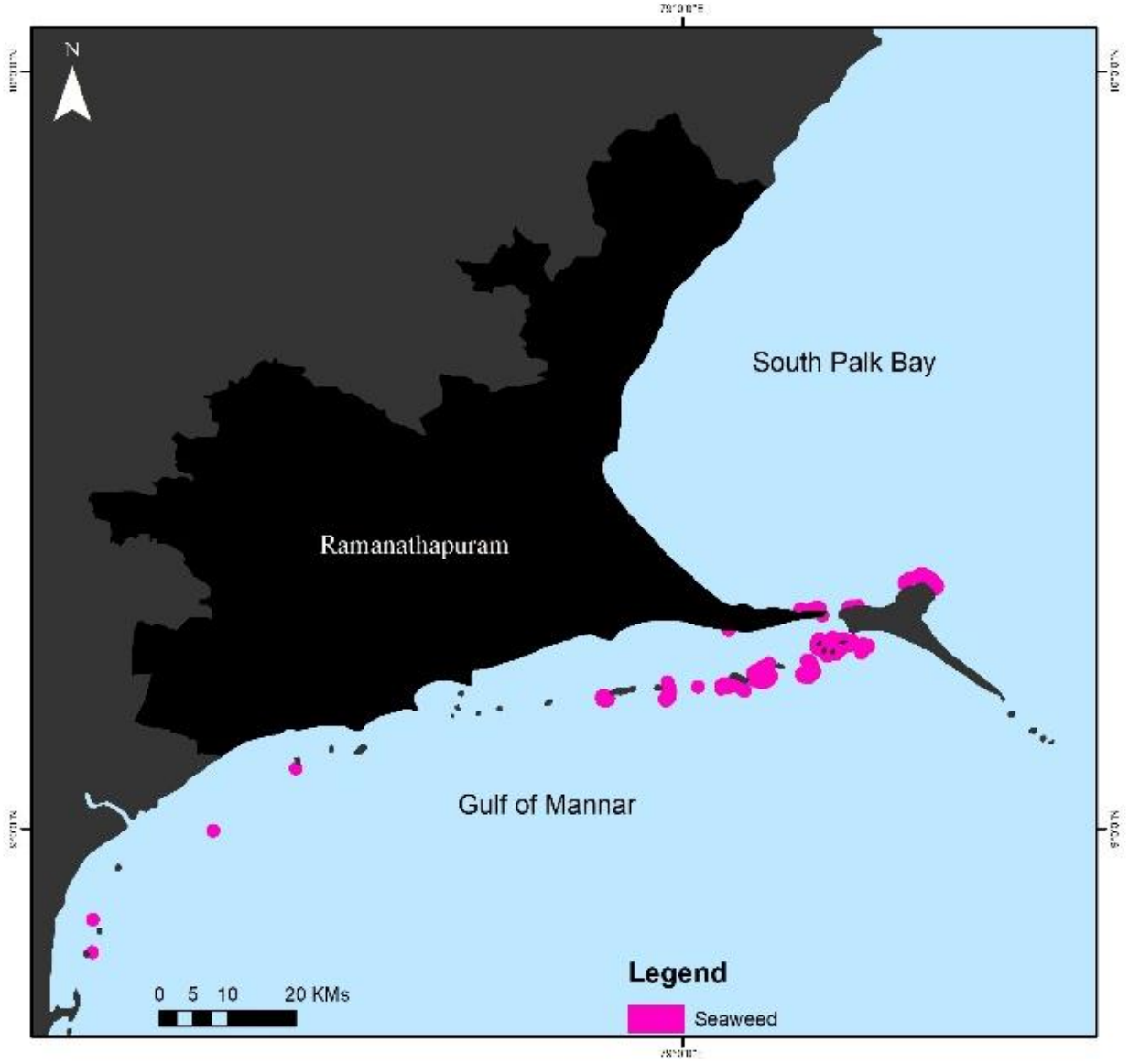


Figure 7: Seaweed map of South Palk Bay and Gulf of Mannar region, Ramanathapuram Wildlife Division, Tamil Nadu.

The major degraded seagrass habitats observed in the Ramanathapuram Wildlife Division is presented in the Table 4.

Table 4. The indicative major point of degraded seagrass habitats in Ramanathapuram Wildlife Division.

Points	Latitude (dd.dd)	Longitude (dd.dd)
1	9.862194965	79.18092596
2	9.357168032	78.99252702
3	9.591971962	79.02879501
4	9.59203097	79.02931896
5	9.592062989	78.97376698
6	9.646274038	79.02858504
7	9.727668017	79.03838097
8	9.757224033	79.10475399
9	9.757698029	79.10526202
10	9.779576976	79.08216602
11	9.779830026	79.13683799
12	9.780419022	79.08304201
13	9.780445006	79.11762902
14	9.78050896	79.11823201
15	9.780650027	79.11885001
16	9.862097986	79.14467398
17	9.915686008	79.22661102

- Change in seagrass distribution is subjected to the availability of past data on distribution.

Our study suggests that there is a great amount of seagrass distribution in both Gulf of Mannar and South Palk Bay when compared to the previous study. This is mainly due to more robust and intensive in situ data collection and accuracy in data analysis. The comparison of seagrass cover data available in Palk Pay and Gulf of Mannar region is presented in Table 5.

Table 5: Seagrass change dynamics with time from previous studies.

Gulf of Mannar		
Year	**Cover (km2)**	**Reference**
1998	85.71	ICMAM PD (2001)
2004	26.58	Sridhar et al., (2010)
2005	57.1	Susila et al., (2012)
2007	13.27	Thangaradjou et al., (2008)
2023	**307**	**Current study by WII**
South Palk Bay		
2007-2009	175	Manikandan et al., (2011); Mathews et al., (2010)
2014	329.7*	Geevarghese et al., (2017)
2023	**566**	**Current study by WII**
		*This study is for entire Palk Bay (both north and south)

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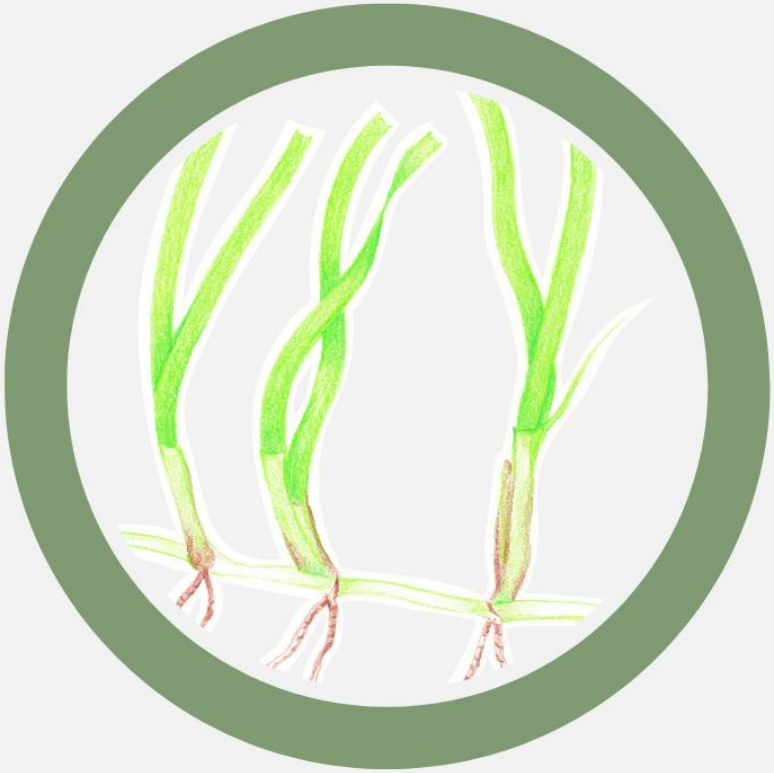

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தமிழ்நாடு உயிர்ப்பன்மை பாதுகாப்பு
மற்றும் பசுமையாக்குதல் இட்டம் (TBGP)