A Guide to the SEAGRASSES *of* Sri Lanka

PROJECT GREENER WAVE

BRITISH COUNCIL YCA PROGRAMME

- PROJECT GREENER WAVE -

Citation

PROJECT GREENER WAVE, (2026). A Guide to the Seagrasses of Sri Lanka: Project Greener Wave.

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PROJECT GREENER WAVE

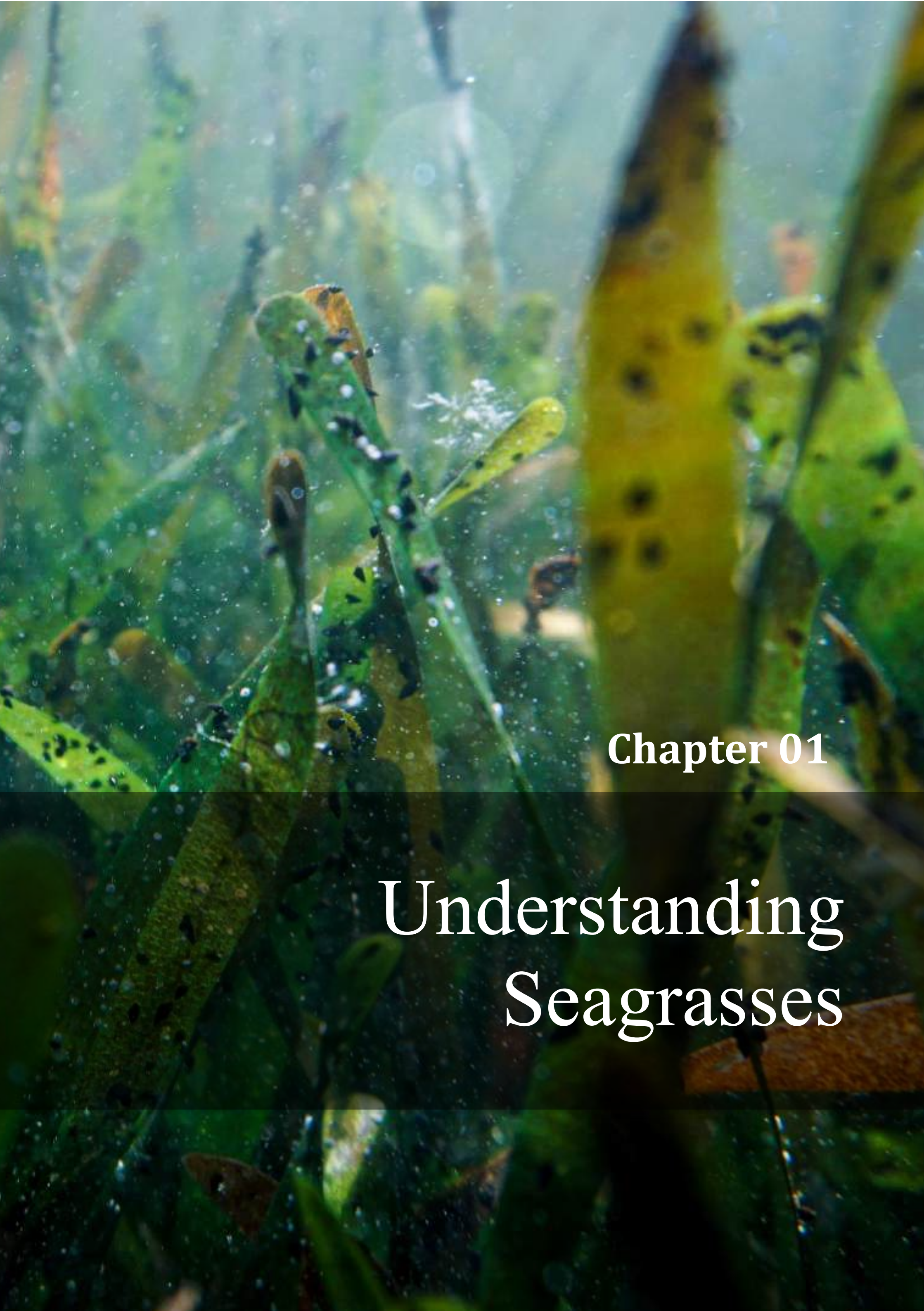
Acknowledgement

This publication was developed as part of the prestigious Youth Climate Ambassador Programme 2025, a British Council initiative, delivered in partnership with Earth Lanka. We would like to express our sincere gratitude for the invaluable guidance and support received throughout the development of this project. We extend our deepest appreciation to Ms. Thushara Gunasekara of the British Council and Mr. Sudarsha De Silva, Founder of the Earth Lanka Youth Network, for overseeing and reviewing this work. Sincere thanks are also due to Mr. A. K. A. W. Adhikari, Project Mentor, for his insightful mentorship and continued encouragement during the preparation of this publication. Their expertise and guidance were instrumental in shaping the quality and direction of this work.

We also extend our sincere gratitude to Miss. Nipunika Nethsarani, Project Coordinator representing the Ocean University of Sri Lanka, for her dedicated coordination and support throughout the programme. Special thanks are further extended to Dr. Kasunthi Amarasakera, Lecturer in the Department of Coastal and Marine Resource Management at the Ocean University of Sri Lanka, for her academic guidance and valuable insights. We further acknowledge Ms. Chathurika De Zoysa, Head of the Department of Coastal and Marine Resource Management at the Ocean University of Sri Lanka, for her valuable support and encouragement. Finally, we gratefully acknowledge all those whose support, commitment, and collaborative efforts contributed to the successful completion of this publication.

- ***Project Greener Wave***

Contents



Chapter 01

Understanding Seagrasses

1.1. Purpose and Scope of the Guide

This guide provides a definitive taxonomic and morphological reference for identifying seagrass species within Sri Lankan coastal waters. It is designed for field and laboratory use by university students, marine biologists, coastal resource managers, conservation practitioners, and environmental surveyors. The scope encompasses detailed, illustrated profiles of all seagrass species documented in the country, with recent surveys confirming the presence of 15 true seagrasses species across seven genera. The guide focuses on diagnostic vegetative and reproductive features to enable reliable species identification. By consolidating current scientific knowledge into an accessible format, it supports species level monitoring, ecological research, and conservation initiatives. To aid local application, the guide includes a special review of the ecologically significant seagrass meadows in Sri Lanka as a detailed case study.

1.2. Characteristics of Seagrass

Seagrasses are submerged, marine flowering plants (angiosperms) that occur in coastal and estuarine environments on all continents except Antarctica. They inhabit shallow marine waters from the intertidal zone to depths of approximately 90 m, where sufficient light penetrates to support photosynthesis (Short et al. 2007). Extensive areas dominated by seagrasses are commonly referred to as seagrass beds or meadows, which may range in size from a few square meters to several hundred square kilometers. Although seagrasses comprise a relatively small number of species approximately 72 species distributed among 6 families and 14 genera their high productivity and complex physical structure allow them to support a remarkably diverse and abundant assemblage of associated organisms. Despite their limited global areal coverage (about 0.2 % of the ocean surface), seagrasses play a disproportionately large ecological role in coastal marine ecosystems.

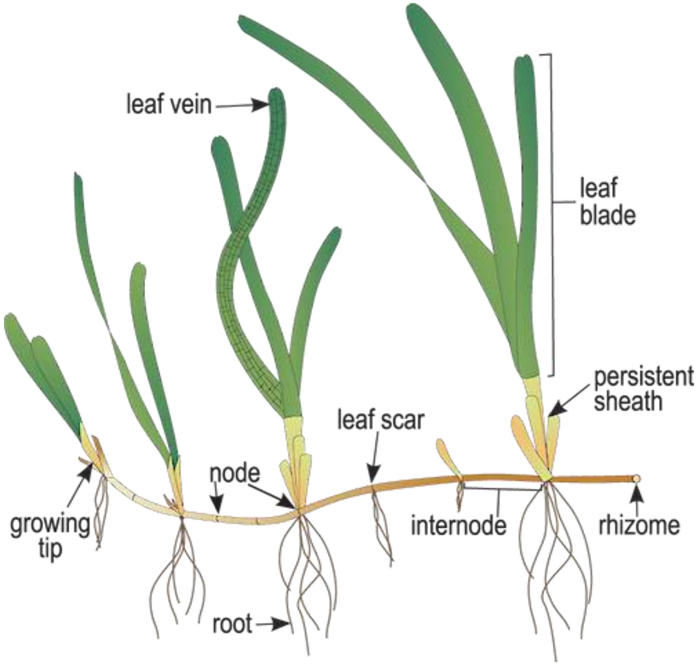


Figure 1: Seagrasses structure

Seagrasses are not true grasses, even though they are monocotyledons. They do not share a single evolutionary origin and are therefore considered a polyphyletic group (den Hartog 1970). Adapted to life fully sub-merged in saline environments, seagrasses possess specialized morphological and physiological traits, including flattened leaf blades (with some exceptions), rhizomes, and extensive belowground root systems that anchor them in soft substrates.

Most seagrass species grow in sandy or muddy sediments, although some, such as *Phyllospadix spp*., are adapted to rocky substrates. Their belowground structures contain substantial amounts of non-photosynthetic tissue and require efficient oxygen transport to maintain aerobic conditions in otherwise anoxic sediments. Consequently, seagrasses have higher light requirements than most other marine plants and are typically confined to shallow waters where light availability is sufficient (Hemminga and Duarte 2000).

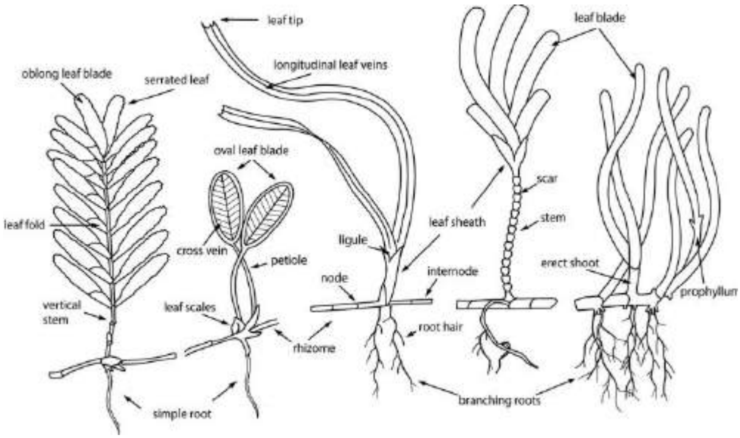


Figure 2: Composite illustration demonstrating morphological features used to distinguish main seagrass taxonomic groups.

Seagrasses are the only flowering plant that is completely submerged in saltwater and cannot survive for long periods in either the marine environment or a freshwater system. Their ability to successfully occupy the nearshore underwater habitat is the product of their specialized reproduction strategy that predisposes them to thrive in the dynamic marine conditions. Seagrasses are angiosperms that possess sexual as well as asexual methods of reproduction. Most marine plant species only reproduce in one manner.

One of the major modes of reproduction for seagrasses is asexual reproduction via rhizomes. A rhizome is an underground stem that grows horizontally to produce new leaves and roots close to the mother plant thus, seagrasses are able to expand horizontally under the ocean floor. For instance, under conditions of storming, grazing by herbivores as well as human activities such as anchoring, rhizomes are normally ruptured. Pieces of these rhizomes are capable of surviving for several weeks while suspended in the water column above eventually, they are able to establish new sites elsewhere.

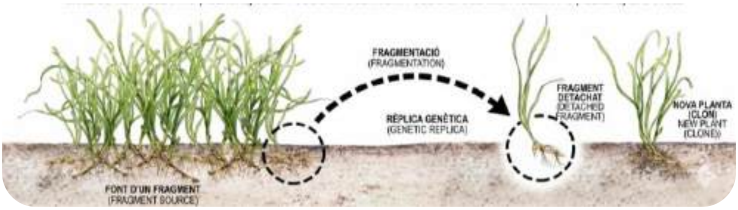


Figure 3: Illustration of Transplantation of Seagrass.

Just as with grasses found on land, seagrasses also breed through flowers and pollination. Nevertheless, the manner in which pollination occurs in seagrass, which grows in an underwater setting, substantially differs from that which occurs in grasses growing in a terrestrial setting. Unlike grasses that employ wind to transport pollen for fertilization during pollination, seagrasses employ and rely on abiotic factors such as tides, currents, wave action, and turbulence for such purposes. The pollen of seagrass grows and is emitted along with a mucilage fluid, which enables it to be moved along with water movement until it reaches the female flower. It can be noted that in some seagrass ecosystems, the effect of wave action and water currents might be minimal.

To limit self-reproduction and enable gene flow, seagrass species often become dioecious, thus producing male and female flowers that are distinct. Although this ability can limit seagrass clone expansion via self-pollination, it is also associated with difficulties since the pollen needs to successfully travel within the water column and reach the female flower that only lives for a short while at a genetically disparate distance. Despite these factors, there is diversity at the genetic level within seagrass meadows. In addition to that seagrasses can also be pollinated biotically. Marine invertebrates like crustaceans and polychaete worms have been found to act as efficient pollinators. The organisms that have been confirmed as pollinators of seagrasses include isopods, copepods, ostracods, mysid shrimps, tanaids, cumaceans, and zoea larvae of crustacean crabs and polychaetae worms. They either come under phylum Arthropoda or phylum Annelida. They can be compared to insect pollinators found on land.

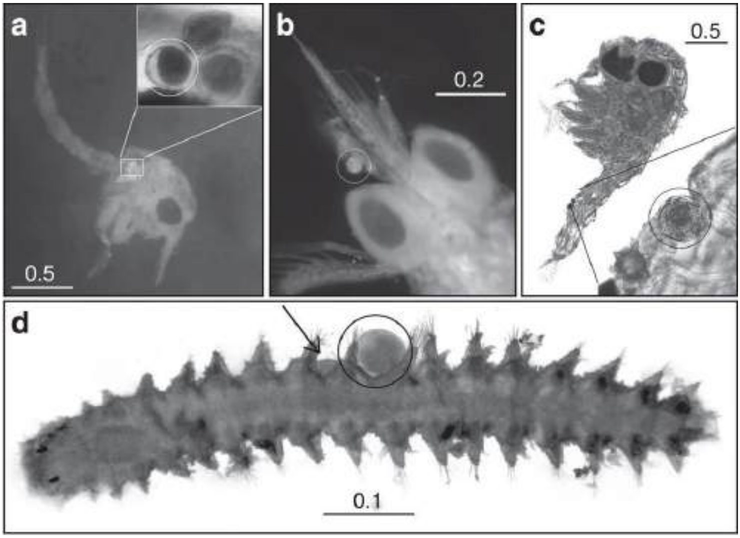


Figure 4: Pollination by marine in-vertebrates (a) *Majid zoea* larva (stage I) with a pollen grain in digestive tract (detail was obtained with different illumination). (b) *Thallasinidea zoea* (stage I) with a pollen grain near rostrum and antenna. (c) *Brachyuran zoea* (stage I) with a pollen grain attached to abdomen. (d) Young Syllid polychaete with two pollen grains attached to segments; the almost hidden second grain is indicated by arrow. The pollen grains are indicated by circles. The bars represent mm.

Most of the seagrass species exhibit flowering during the night, in sync with the nocturnal activity of these invertebrates that come out of the sediments in search of food. The flowers of seagrass are usually found close to the leaf base and near the bottom, making it easy to access by benthic organisms. The sticky pollen grains will adhere to their bodies or be ingested, resulting in fertilization of female flowers.

Seed Dispersal and Recruitment After a successful fertilization process, seagrasses give rise to seeds that can spread across a range of distances. As some seeds germinate close to their mother plants, others can travel hundreds of kilometers in the oceans. In addition, giant herbivores in the oceans like green sea turtles and dugongs help in seed dispersal through their consumption of seagrass fruits and seeds, which are later deposited in nutrient rich form in distant areas through their feces.

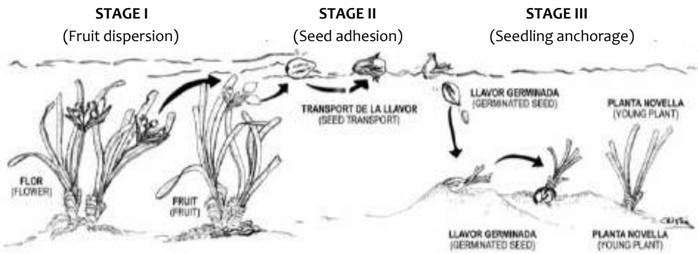


Figure 5: Schematic representation of the three sexual recruitment stages of *P. oceanica*, including dispersion and settlement.

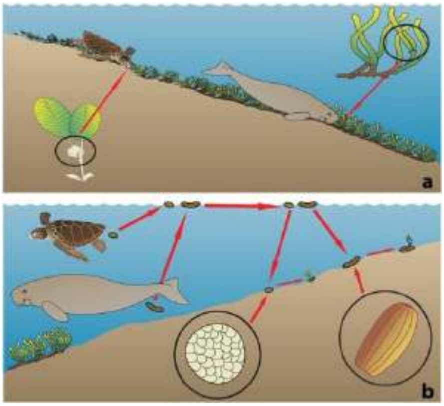


Figure 6: Illustration of biotic dispersal of seagrass seeds by marine mega-herbivores. (a) Ingestion of seagrass seeds or propagules by a dugong or green sea turtle allows long distance dispersal of the seed; (b) before settlement and growth into a seedling.

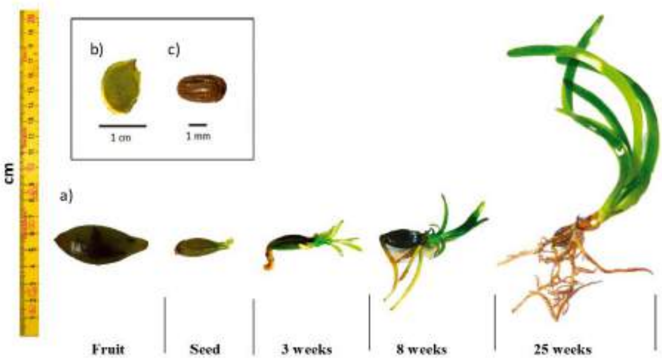


Figure 7: *Posidonia oceanica* early life stages: (a) fruit and seed (0 weeks old), and seedlings at 3, 8 and 25 weeks of age. Also shown are seeds of (b) *Cymodocea nodosa* and (c) *Zostera marina*

1.3. Global Distribution and Diversity of Seagrasses

Seagrasses are widely distributed along temperate and tropical coast lines worldwide. Despite their broad geographic range, no seagrass species has been fully investigated with respect to its complete global distribution or genetic diversity across its range. Although global seagrass species diversity is relatively low, individual species often extend across thousands of kilometers of coastline.

Ten seagrass genera are shared between the northern and southern hemispheres, with only one genus unique to each hemisphere. Overall, temperate and tropical regions support roughly similar numbers of seagrass genera and species. *Ruppia maritima*, only recently classified as a seagrass, is among the most widely distributed flowering plants on Earth, occurring across both tropical and temperate zones and occupying a wide range of habitats.

Figure 8: Seagrass distribution worldwide

The distribution of seagrass species reflects a combination of sexual reproduction, clonal growth, dispersal capacity, and environmental constraints (Spalding et al. 2003). While many seagrass populations are highly clonal and rely predominantly on asexual reproduction through rhizome growth, others produce large numbers of sexual propagules or vary their reproductive strategies in response to environmental conditions. All seagrasses are capable of asexual reproduction via horizontal rhizomes, producing genetically identical ramets, while sexual reproduction occurs through seed and fruit production or, in some species, viviparous seedlings.

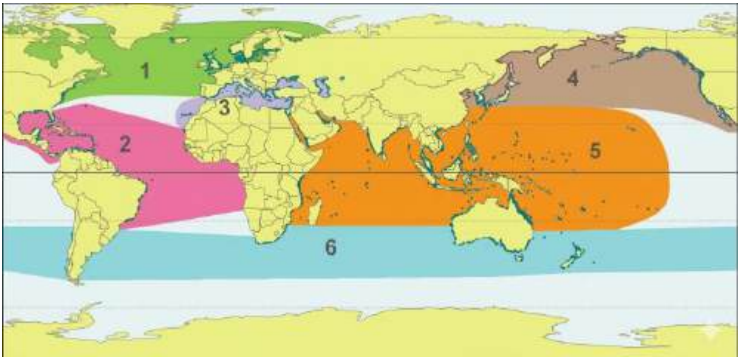


Figure 9: Seagrass bioregions: 1 Temperate North Atlantic, 2 Tropical Atlantic, 3 Mediterranean, 4 Temperate North Pacific, 5 Tropical Indo-Pacific, and 6 Temperate Southern Oceans

Globally, seagrasses are grouped into six major bioregions including four temperate and two tropical (Short et al. 2007). The temperate bioregions include the Temperate North Atlantic, Temperate North Pacific, Mediterranean and Temperate Southern Oceans. All temperate regions contain species of the genus Zostera. The two tropical bioregions, the Tropical Atlantic and the Tropical Indo Pacific support large populations of mega herbivores such as sea turtles, dugongs, and manatees.

The Temperate North Atlantic bioregion is characterized by relatively low seagrass diversity, dominated by *Zostera marina* (eelgrass), which commonly inhabits estuaries and lagoons. Eelgrass is the most extensively studied seagrass species globally and experienced severe population declines during the wasting disease outbreak of the 1930s. In European waters, *Zostera noltii* occupies shallow intertidal zones, while *Ruppia maritima* occurs in brackish estuaries and hypersaline salt marsh pools across both North America and Europe.

The Temperate North Pacific supports higher seagrass diversity with approximately 15 species. Zostera species dominate estuaries and lagoons, while *Phyllospadix* species occupy high energy surf zones. *Zostera marina* occurs around the Pacific Rim, from East Asia through the Bering Sea to the Gulf of California. *Phyllospadix* species are uniquely adapted to rocky substrates, using modified rhizomes to anchor in exposed coastal environments. The Mediterranean bioregion contains extensive seagrass meadows of moderate diversity, dominated by the endemic *Posidonia oceanica*. This species forms thick, long lived matte structures composed of roots and rhizomes that may persist for thousands of years. Other species include *Halophila stipulacea,* which entered the Mediterranean from the Indian Ocean via the Suez Canal. The Temperate Southern Oceans bioregion includes extensive meadows dominated by species *of Posidonia* and *Zostera*, with additional representation of *Ruppia*. Seagrasses occur across South America, Africa, and Australia in diverse habitats, including surf zones. A total of 18 species are presenting, with *Ruppia maritima* representing the southernmost seagrass recorded, occurring in the Straits of Magellan.

The Tropical Atlantic bioregion contains approximately ten seagrass species and is dominated by *Thalassia testudinum*, *Syringodium filiforme* and *Halodule wrightii*. These species may occur as monospecific stands or as mixed assemblages along ecological successional gradients. The region is largely carbonate based, extending from shallow back reef environments to deep sandbanks. *Halophila johnsonii*, listed as threatened in the United States, is restricted to Florida's east coast, while the invasive *Halophila stipulacea* has rapidly expanded throughout the Caribbean since its first detection in 2002 (Willette et al. 2014). The Tropical Indo-Pacific bioregion is the most extensive and species rich, supporting 24 seagrass species. Species diversity decreases eastward across the Pacific, with the highest diversity observed in the western Indian and western Pacific Oceans (Green and Short 2003). Seagrasses in this region commonly occur inshore of coral reefs, with *Thalassia hemprichii, Syringodium isoetifolium*, and *Halodule uninervis* dominating reef platforms. Unique species such as *Enhalus acoroides,* which is pollinated at the water surface, and *Thalassodendron ciliatum,* adapted to withstand strong wave action, further illustrate the ecological diversity of this bioregion. High seagrass diversity, typically 12-14 species characterize the tropical Indian Ocean region.

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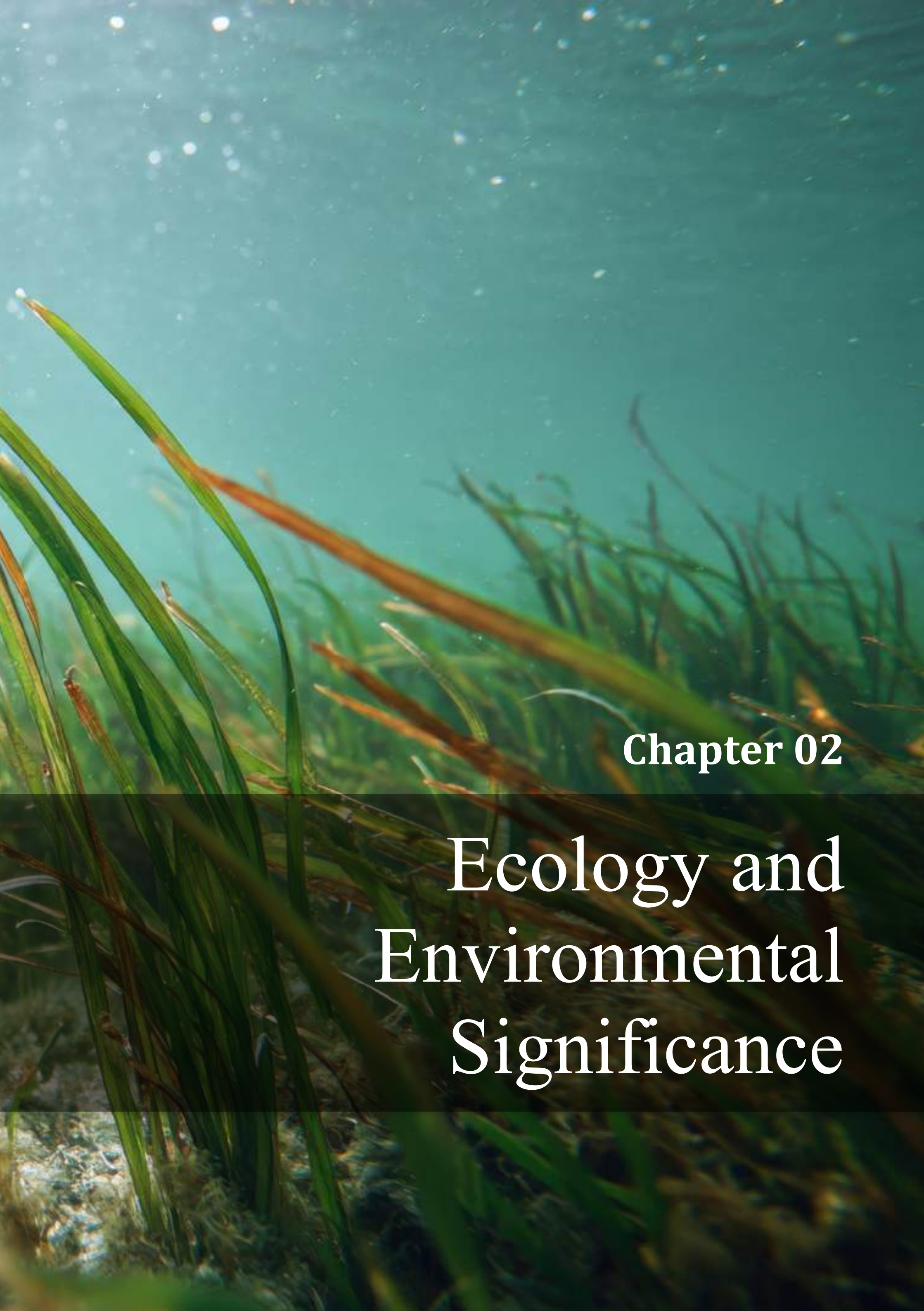


Chapter 02

Ecology and Environmental Significance

2.1. Ecological Functions and Services

Seagrasses are flowering plants that grow in shallow coastal waters around Sri Lanka. They form dense underwater meadows in la-goons like Puttalam and Negombo, and along the southern and eastern coasts. These meadows provide habitats for fish, sea urchins and other marine life while stabilizing sediments against waves and currents. Seagrasses do a great role in the environment by trapping carbon and nutrients from the water. They store significant amounts of blue carbon, helping fight climate change and improve water clarity for other ecosystems. Seagrasses also support biodiversity by providing food and shelter, making them essential for coastal health. This chapter explores the ecology of Sri Lank.an seagrasses, including their growth patterns and covers their environmental importance.

Seagrasses perform a wide array of ecological functions that sustain marine life and maintain environmental balance. These underwater plants form dense meadows in lagoons, coastal areas where they stabilize sediments, enhance water clarity and support food webs for countless species. Their roots and rhizomes bind loose substrates like sand and mud, preventing erosion from waves and currents that are common in Sri Lanka's monsoon-driven coasts. This sediment stabilization is necessary in dynamic environments where tidal fluctuations and boat traffic could otherwise resuspend particles, clouding water and smothering benthic organisms. By trapping fine particles during tidal cycles, seagrasses improve light penetration for photosynthesis among algae and other plants, fostering a clearer aquatic environment that benefits the entire lagoon ecosystem. Studies from Sri Lankan lagoons highlight how these meadows act as natural filters, reducing turbidity by up to 50% in protect-ed bays compared to unvegetated areas (Jayakody and Jinadasa, 2020). This function extends to nutrient cycling, where seagrasses absorb excess nitrogen and phosphorus from runoff, mitigating eutrophication risks from nearby agriculture and urban waste.

Beyond physical stabilization, seagrasses provide essential habitat complexity that boosts biodiversity. Their leaves create three dimension-al structures offering shelter for juvenile fish, crabs and shrimp, which use the meadows as nurseries during vulnerable early life stages. In Sri Lanka, over 100 fish species, including commercially important ones like sigani and rabbitfish, rely on these habitats for growth before migrating to reefs or open waters. Sea urchins, such as *Tripneustes gratilla*, graze on epiphytes coating seagrass blades maintaining plant health while serving as prey for predators. This grazing dynamic regulates algal overgrowth, preventing meadows from being choked and preserving the balance between primary producers and herbivores. Studies in Puttalam Lagoon shows seagrass beds hosting 2-3 times higher densities of macroinvertebrates than bare sediments, underscoring their role as biodiversity hotspots (Samarakoon and Weerakkody, 2010). These inter-actions form intricate food webs, where detritus from decaying leaves biodiversity hotspots (Samarakoon and Weerakkody, 2010). These interactions form intricate food webs, where detritus from decaying leaves fuels microbial communities that, in tum, nourish deposit feeders and higher trophic levels.

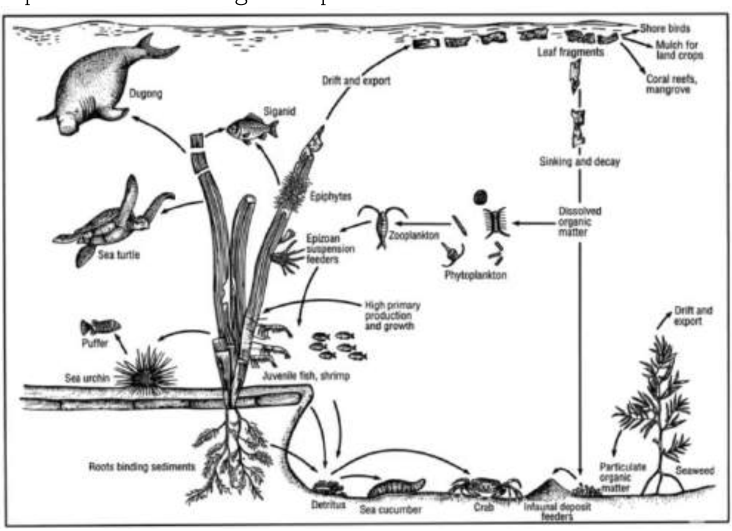


Figure 10: Food chain in seagrass ecosystems showing the potential uses of the plants and their functions in the coastal environment

One of the most important ecological services of seagrasses is carbon sequestration, often termed blue carbon. These plants photosynthesize at rates rivaling terrestrial forests, fixing CO_2 and storing it long term in sediments through slow decomposition in low oxygen conditions. In tropical settings seagrass meadows accumulate organic carbon at 200-400 grams per square meter annually, with belowground biomass retaining it for centuries. This outpaces many mangroves in storage efficiency per unit area, making seagrasses key allies against climate change in island nations like Sri Lanka vulnerable to sea level rise. A study on Trincomalee Bay meadows estimated total carbon stocks exceeding 10 tons per hectare, comparable to global tropical averages but amplified by Sri Lanka's nutrient rich lagoons (UNEP-WCMC, 2018). Nitrogen and phosphorus burial alongside carbon further enhances soil fertility, supporting resilient meadow expansion during favorable conditions.

Seagrasses also contribute to coastal protection by dissipating wave energy and reducing shoreline erosion. Leaf blades flex with currents, absorbing up to 40% of incoming wave height in shallow zones. This damping effect shields mangroves and salt marshes inland, creating interconnected blue corridors that amplify protection. During storms, these meadows trap floating debris, preventing it from abrading corals or smothering beaches, thus safeguarding tourism dependent economies.

Nutrient dynamics represent another pillar of seagrass ecology. As efficient uptake specialists, they recycle dissolved inorganic nutrients and converting them into biomass that supports grazers and detritivores. In eutrophic lagoons influenced by shrimp farming effluents, seagrasses act as biofilters assimilating ammonium and phosphates. This process curbs harmful algal blooms. Epiphytes on blades further enhance filtration, hosting nitrogen fixing bacteria that enrich surrounding waters without excess release. One of peer reviewed work from southern beds reveals seagrasses retaining 15-25% of watershed nutrient loads, stabilizing oxygen levels and preventing hypoxic events (Nguyen et al., 2020).

Oxygen production through photosynthesis sustains aerobic microhabitats in otherwise oxygen poor sediments. Daytime release from leaves diffuses into porewater, supporting infaunal communities like polychaetes and bivalves that aerate soils. This oxygenation cycle promotes denitrification, where bacteria convert nitrates to harmless nitrogen gas, reducing greenhouse emissions. In warm waters, where stratification limits mixing, seagrasses counteract deoxygenation maintaining habitable conditions for fisheries.

Seagrasses foster symbiotic relationships that amplify ecosystem resilience. Fungi associated with roots enhance nutrient uptake, while microbes on blades degrade pollutants like microplastics entering from rivers. In Sri Lanka, Halophila species host diverse fungal endophytes producing antiviral compounds, hinting at untapped pharmaceutical potential intertwined with ecological roles. Pollinators, though rare, include tiny midges transferring pollen between flowering shoots, ensuring genetic diversity important for adapting to salinity shifts from monsoons (Nguyen et al., 2020).

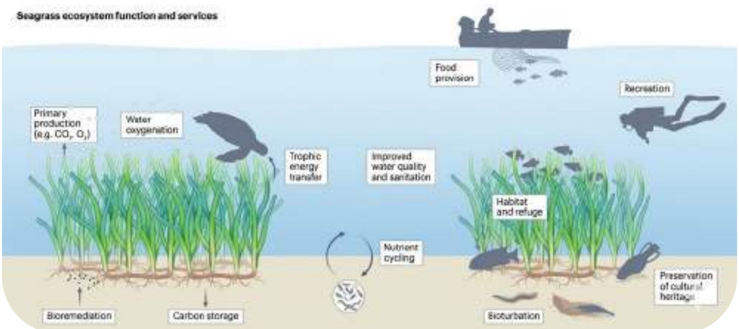


Figure 11: Seagrass supports biodiversity and ecosystem services.

2.2. Carbon Sequestration and Climate Regulation

Seagrasses do special role in carbon sequestration and climate regulation as part of the blue carbon ecosystem, alongside mangroves and salt marshes. These marine flowering plants capture atmospheric carbon dioxide (CO_2) through photosynthesis and store it long term in their biomass and underlying sediments, helping to mitigate global warming. Unlike terrestrial forests, seagrass meadows lock away carbon for centuries or even millennia due to slow decomposition in oxygen poor soils, making them disproportionately powerful for their limited global coverage.

Seagrasses absorb CO_2 dissolved in seawater, converting it into organic matter through the same process that powers land plants. Their leaves, rhizomes and roots build up biomass, but the real magic happens below ground the tangled root systems trap particulate organic carbon from algae, plankton and runoff, burying it in anaerobic sediments where bacteria struggle to break it down. This creates stable carbon stocks with studies showing average sequestration rates of 138 grams of carbon per square meter per year up to 35 times higher than tropical rainforests per unit area. Global estimates suggest seagrass meadows store 299 teragrams of carbon annually, equivalent to emissions from 65 million cars, despite covering just 177,000 to 600,000 square kilometers worldwide.

The efficiency stems from multiple pathways. First, autotrophy includes seagrasses fix CO_2 directly, producing sugars that fuel growth and export detritus to sediments. Second, allochthonous inputs including waves and currents deliver refractory carbon from distant sources, which roots filter and store. Third, epiphyte communities on blades like microalgae and invertebrates add to the organic pool with some species calcifying to form inorganic carbon reservoirs like carbonates. A global synthesis found that the top meter of seagrass sediment holds 6.0 petagrams of organic carbon and 18.0 pentagrams of inorganic carbon, rivaling peatlands in density. This dual storage including organic and inorganic buffers ocean acidification by releasing alkalinity during respiration, stabilizing pH in coastal waters vulnerable to CO_2 influx.

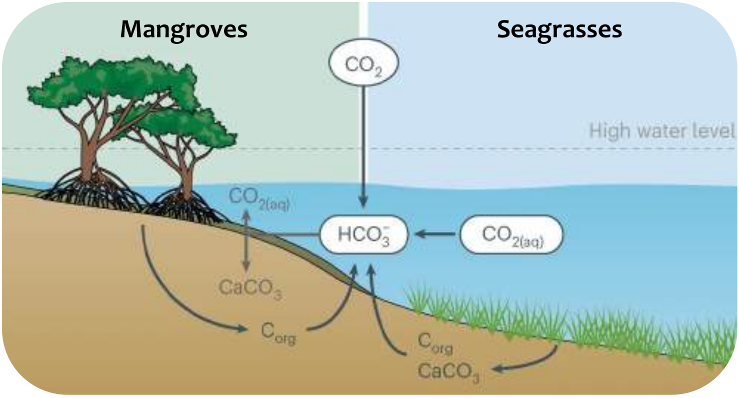


Figure 12: The Role of Mangroves and Seagrasses in Carbon Sequestration

Climate regulation extends beyond sequestration. Seagrasses moderate local temperatures by shading water and releasing oxygen, cooling sediments by up to 5°C compared to bare seafloors. This thermoregulation protects cold sensitive species and slows microbial carbon breakdown. They also influence methane (CH_4) dynamics while decomposition can produce this potent greenhouse gas, high sulfate levels in marine sediments favor sulfate reducing bacteria over methanogens, minimizing net CH_4 emissions often a sink rather than source. In shallow meadows, photosynthesis suppresses CH_4 oxidation during daylight but nighttime fluxes remain low.

Variability in sequestration reflects habitat traits. Temperate species like *Zostera marina* store more in refractory tissues as lignin rich in rhizomes, while tropical pioneers like *Halodule sp.* prioritize rapid turnover but high burial rates. Soil type matters the muddy, fine grained sediments in lagoons retain 2-3 times more carbon than sandy ones due to lower permeability. Depth gradients show shallow meadows sequestering faster from light driven productivity, while deeper edges accumulate through lateral transport.

Seagrass loss reverses these benefits, releasing stored carbon as CO_2. Eutrophication and heatwaves accelerate remineralization, disturbed meadows lose soil carbon, fueling feedback loops that warm waters further. Restoration reverses these replanted meadows doubled stocks within five years, highlighting recovery potential. Interactions with ocean chemistry amplify climate roles. Seagrasses precipitate calcium carbonate through epiphytes nearly equal to coral reefs. This calcification draws CO_2 from water but net alkalinizes systems, countering acidification that dissolves shells elsewhere. Nutrient uptake ties into the silicon cycle, where biogenic silica burial enhances long term drawdown.

2.3. Human Interactions and Ecosystem Benefits

Seagrasses interact with humans in several ways providing a wealth of ecosystem benefits that support coastal communities, economies and environmental health worldwide. These underwater meadows serve as nurseries for fish that sustain global fisheries, yielding billions in annual revenue while feeding millions. Human activities like fishing, tourism and coastal development draw directly from these benefits, but they also stress the meadows through pollution, trawling and habitat loss, creating a delicate balance where sustainable management can amplify gains for both people and nature. Scientific studies highlight how seagrasses enhance human well-being through provisioning services like food and materials, regulating services such as erosion control and water purification, cultural values including recreation and spiritual significance, and supporting services that underpin biodiversity and nutrient cycling (de los Santos et al., 2019).

Fisheries represent one of the most tangible human benefits from seagrasses, as meadows shelter juvenile fish, crabs and shrimp from predators, allowing them to grow before entering adult habitats.

Globally, seagrass associated fisheries contribute up to 15% of small-scale catches in some regions, supporting over 100 million people dependent on marine protein. In tropical bays, species like penaeid shrimp use seagrass structure for foraging, with densities 3-10 times higher than in unvegetated areas, directly boosting trap and net yields for artisanal fishers. Research modeling food webs across scales shows that human impacts like overfishing disrupt these links reducing fish biomass by 30-50%, yet intact meadows maintain resilient populations even under moderate pressure (Acheampong et al., 2021). This provisioning extends to mollusks and sea cucumbers harvested for food and trade, where seagrass proximity correlates with higher catch per unit effort, underscoring the economic imperative for protection.

Coastal protection offers another important benefit, as seagrass leaves dampen wave energy by 20-50%, reducing shoreline erosion and flood risks that cost billions annually. During storms, meadows trap sediments and debris, shielding mangroves, beaches and infrastructure. Human engineered defenses like seawalls often fail without natural buffers, but hybrid living shorelines integrating seagrasses cut erosion by 70% more effectively. Communities in vulnerable deltas rely on this service implicitly, as gradual sea level rise projected at 0.3-1 meter by 2100 amplifies the value with economic models (Paul et al., 2019). Water quality improvement stems from seagrasses' ability to filter nutrients and pollutants, benefiting aquaculture and drinking water sources. Rhizomes bind phosphorus and nitrogen from runoff, preventing algal blooms that devastate shellfish farms in estuaries, meadows process 100-500 grams of nitrogen per square meter annually. This stabilizes oxygen levels, curbing hypoxia that kills farmed fish worth millions. Human interactions intensify here, nutrient pollution from agriculture triples when meadows decline, but restoration in polluted bays has restored farm viability within years. Bacteria within seagrass sediments denitrify excess nitrates, exporting harmless nitrogen gas and enhancing downstream water clarity for tourism and recreation (Cardoso et al., 2019).

Figure 13: Seagrasses support for higher biodiversity, that poses a tourism opportunity to snorkel, diving like water activities align with eco-tourism concepts

Tourism and recreation based on seagrass vitality, attracting divers, kayakers and snorkelers to biodiverse meadows teeming with turtles, dugongs and rays. Globally, coastal tourism generates billion dollars yearly with seagrass view. Cultural benefits include indigenous harvesting traditions and spiritual connections, where meadows symbolize abundance in folklore across Pacific and Caribbean cultures. Yet, anchoring and speedboats scar beds, reducing appeal, eco certification schemes now promote seagrass friendly operators, blending profit with conservation. Health benefits emerge indirectly, as seagrasses reduce pathogen exposure in seafood and bathing waters. Dense meadows lower Vibrio bacteria load by 50% through shading and antimicrobial epiphytes, cutting disease risks for consumers and fishers. In aquaculture, proximity to intact beds halves infection rates in shrimp ponds, saving huge cost per hectare in treatments. Recent work links this to fewer human illnesses, globally amid rising seafood demand (Lamb et al., 2017). Pharmaceuticals from seagrass microbes like antibiotics and antifungals offer future promise, with compounds like avarol entering trials for antiviral uses.

2.4. Associated Flora and Fauna

Seagrasses create rich underwater habitats that support a diverse array of associated flora and fauna, forming complex communities essential to coastal ecosystems worldwide and particularly in Sri Lanka's lagoons and coastal areas. These marine flowering plants host algae, invertebrates, fish, reptiles, and mammals through their structural complexity, leaves provide shade and attachment sites while roots and rhizomes stabilize sediments for burrowing species. In Sri Lanka, meadows in Puttalam, Negombo and southern coastal areas like Bentota sustain high biodiversity, with studies recording over 100 fish species and numerous macroinvertebrates tied to seagrass health (Jayakody and Jinadasa, 2020). Globally, this assemblage supports food webs, nutrient cycling and resilience against disturbances with tropical regions like Sri Lanka exemplifying dense interactions due to warm waters and nutrient pulses from monsoons.

Epiphytic flora coats seagrass blades, enhancing habitat value and primary production. Filamentous algae such as Enteromorpha and Bryopsis dominate, photosynthesizing alongside hosts and serving as food for grazers in Sri Lankan Halophila beds, epiphyte loads reach 20-50% of blade weight, fostering microhabitats for diatoms and cyanobacteria that fix nitrogen (Nguyen et al., 2020). Diatoms like Navicula and Amphora form biofilms, contributing 30-40% of meadow productivity and stabilizing surfaces against desiccation during low tides. Macroalgae such as Sargassum fragments drift into meadows, temporarily boosting detritus for decomposers. These associations improve host fit-ness by shading competitors and recycling nutrients, while in Sri Lanka's eutrophic lagoons excessive epiphytes signal pollution stress smothering leaves and reducing oxygen.

Meiofauna like tiny nematodes, copepods, and foraminifera survive in rhizome mats and sediments, numbering millions per square meter. Harpacticoid copepods like Tisbe and Ameira dominate, grazing biofilms and aerating pores (Samarakoon and Weerakkody, 2010). Nematodes such as *Oncholaimus* prey on bacteria regulating decomposition while ostracods filter microalgae. These engineers enhance sediment turnover, promoting phosphate release for seagrass uptake and linking microbial loops to higher trophic levels.

Figure 14: Sea Hare on Seagrasses

Macroinvertebrates form the structural backbone, with polychaetes, amphipods and bivalves burrowing into rhizomes. In Sri Lanka, syllid worms and spionids like *Pseudopolydora* burrow densely, oxygenating anoxic layers. Gastropods such as *Cerithidea* graze epiphytes controlling overgrowth while isopods shred detritus. Bivalves like Tellina embed in sediments filter feeding plankton and stabilizing substrates. Sea urchins, notably *Tripneustes gratilla* in southern Sri Lankan beds, crop blades at 10-20% annually preventing algal dominance and promoting clonal growth (de la Torre-Castro et al., 2021). Crabs aerate burrows exporting nutrients and creating tidal pumps that flush meadows. Fish assemblages are diverse and functionally important with juveniles dominating as nurseries. Globally, 128 fish families use seagrass as their habitats but in tropics host pomacentrids, siganids and labrids (Yoswaty et al., 2021). Mullets forage detritus, siganids graze algae, supporting fisheries yielding yearly.

Figure 15: Green Shore crab (*Carcinus maenas*) in seagrass beds of Isles of Scilly, Cornwall, UK

Epibenthic species like syngnathids camouflage among blades, while predators like Epinephelus hunt at edges. Ontogenetic shifts see post larvae settle, grow sheltered then emigrate and boosting adult stocks.

Reptiles and birds integrate aerial marine links. Green turtles (*Chelonia mydas*) feed on *Thalassia* globally and recycling nutrients through their feces, in Sri Lanka's eastern beds foraging herds maintain patchiness. Hawksbill turtles (*Eretmochelys imbricata*) rasp sponges from blades. Seabirds like terns plunge for fish, depositing guano that fertilizes meadows. Waders like sand-pipers probe infauna at low tide, linking terrestrial subsidies.

Marine mammals anchor top-down control. Dugongs (*Dugong dugon*) graze intensively, creating feeding trails. Indo Pacific populations, including Sri Lanka's remnant herds in Palk Bay, consume 40 kg day-1 per individual, stimulating growth through tilling. Manatees in Atlantic meadows mirror this. Dolphins herd fish schools into shallows, facilitating prey capture in a mutualism observed worldwide (Nelis et al., 2024).

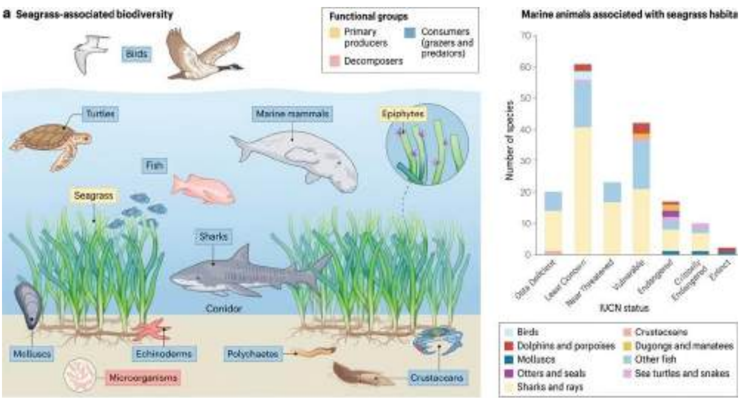


Figure 16: Seagrasses supports for higher biodiversity worldwide and it offers habitats, nursery and breeding grounds for pelagic, benthic, sediment burrowing species as well as feeding ground for avifaunal species

2.5. List of Fauna and Flora

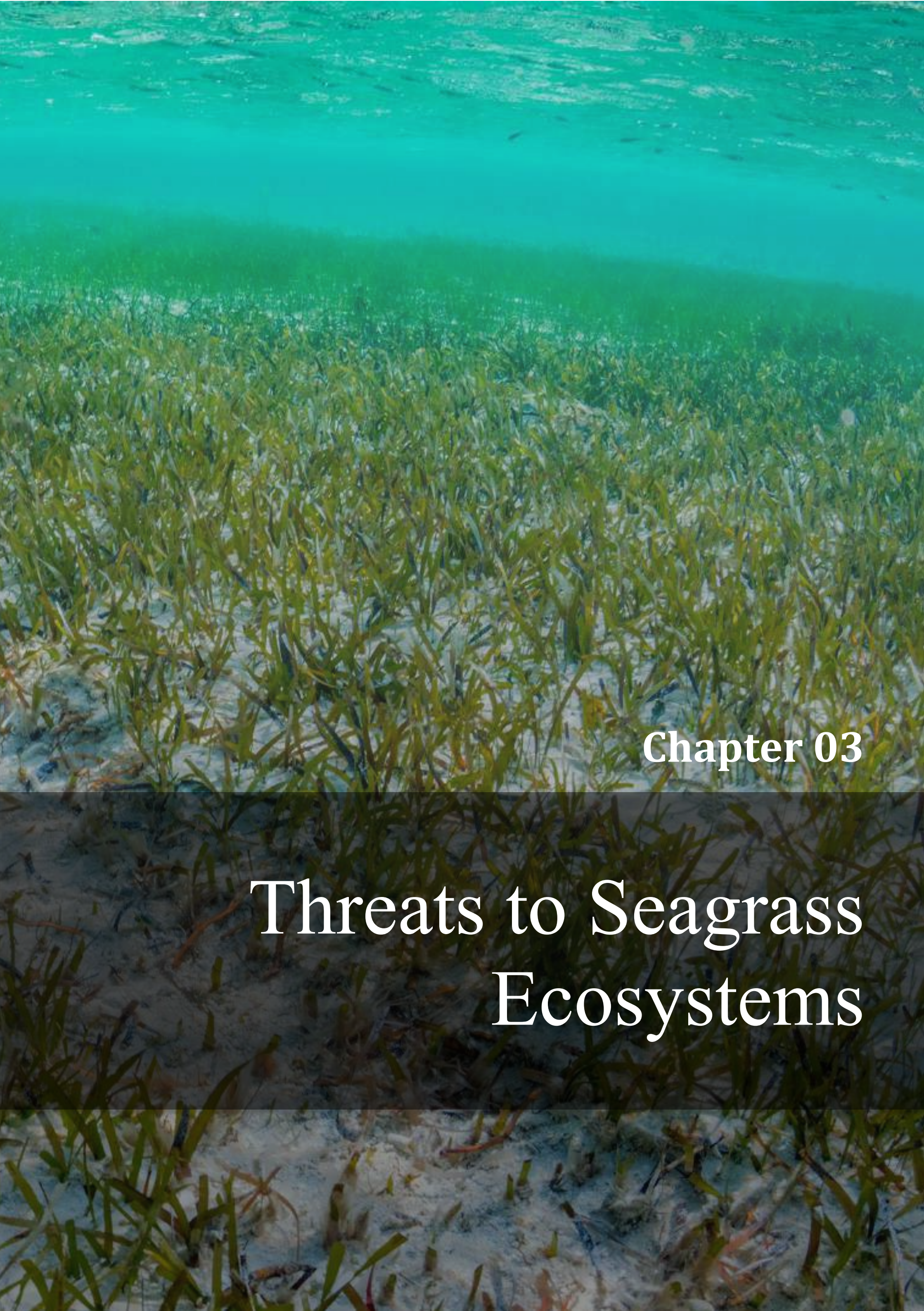
No.	Taxonomic Family	Scientific Name	Common/English Name
Class: Actinopterygii (Ray-finned Fishes)			
Order: Acanthuriformes / Perciformes			
1	Siganidae	*Siganus javus*	Java rabbitfish
2	Lethrinidae	*Lethrinus nebulosus*	Spotted emperor
3	Gerreidae	*Gerres erythrourus*	Deepbody silver-biddy
4	Terapontidae	*Pelates quadrilineatus*	Fourline terapon
5		*Terapon jarbua*	Jarbua terapon
6	Nemipteridae	*Scolopsis bilineata*	Yellowstripe monode bream
7		*Nemipterus spp.*	Various breams/snapper
8	Lutjanidae	*Lutjanus lutjanus*	Bigeye snapper
9		*Caesio spp.*	Various breams/snapper
10	Epinephelidae	*Epinephelus malabaricus*	Malabar grouper
11	Ambassidae	*Ambassis ambassis*	Glassfish
12	Leiognathidae	*Leiognathus equulus*	Common ponyfish
13	Pempheridae	*Parapriacanthus beryciformis*	Spineless velvet whiting
14	Sillaginidae	*Sillago sihama*	Silver whiting
15	Carangidae	*Carangoides malabaricus*	Malabar trevally
16		*Scomberoides lysan*	Streaked queenfish
17	Mullidae	*Upeneus vittatus*	Striped goatfish
Order: Mugiliformes			
18	Mugilidae	*Valamugil seheli*	Bluetail mullet
19		*Mugil cephalus*	Flathead mullet
20		*Liza subviridis*	Greenback mullet
Order: Atheriniformes			
21	Atherinidae	*Atherinomorus duodecimalineatus*	Feathertail silverside
Order: Beloniformes			
22	Hemiramphidae	*Hyporhamphus quoyii*	Shortnosed garfish

No.	Taxonomic Family	Scientific Name	Common/English Name
Order: Gonorynchiformes			
23	Chanidae	*Chanos chanos*	Milkfish
Order: Clupeiformes			
24	Clupeidae	*Sardinella albella*	White sardinella
25	Engraulidae	*Stolephorus indicus*	Indian anchovy
26		*Thryssa vitrirostris*	Longjaw thryssa
Order: Polynemiformes			
27	Polynemidae	*Polynemus indicus*	Indian threadfin
Order: Gobiiformes			
28	Eleotridae	*Eleotris fusca*	Dusky sleeper
29	Gobiidae	*Awaous melanocephalus*	Black-banded stream sleeper
30		*Glossogobius giuris*	Tank goby
31		*Paragobiodon echinocephalus*	Turquoise dwarf goby
Order: Syngnathiformes			
32	Syngnathidae	*Syngnathus abaster*	Black pipefish
33		*Hippichthys cyanospilos*	Blue-spotted pipefish
34		*Corythoichthys intestinalis*	Messmate pipefish
35		*Microphis lineatus*	Lined pipefish
36		*Aeichtlys kirchhoffi*	Kirchhoff's pipefish
37	Fistulariidae	*Fistularia commersonii*	Bluespotted cornetfish
Order: Tetraodontiformes			
38	Diodontidae	*Diodon holocanthus*	Longspine porcupinefish
39	Tetraodontidae	*Sphoeroides pachygaster*	Leopard puffer
40		*Torquigener randalli*	Randall's puffer

No.	Taxonomic Family	Scientific Name	Common/English Name
Class: Reptilia (Reptiles)			
Order: Testudines (Turtles)			
1	Cheloniidae	*Chelonia mydas*	Green sea turtle
2		*Eretmochelys imbricata*	Hawksbill turtle
3	Dermochelyidae	*Dermochelys coriacea*	Leatherback turtle
Order: Crocodilia			
4	Crocodylidae	*Crocodylus palustris*	Mugger crocodile
Order: Squamata (Snakes)			
5	Elapidae	*Hydrophis curtus*	Short-necked Sea snake
6		*Lapemis curtus*	Yellow-lipped Sea krait
Class: Aves (Birds)			
Order: Charadriiformes			
1	Charadriidae	*Charadrius alexandrinus*	Kentish plover
2	Laridae	*Sterna bergii*	Greater crested tern
3		*Gelochelidon nilotica*	Gull billed tern
4	Recurvirostridae	*Himantopus himantopus*	Black winged stilt
5		*Recurvirostra avosetta*	Pied avocet
6	Scolopacidae	*Tringa stagnatilis*	Marsh sandpiper
Order: Pelecaniformes			
7	Ardeidae	*Ardea cinerea*	Grey heron
8		*Egretta garzetta*	Little egret
9		*Butorides striata*	Striated heron
Order: Accipitriformes			
10	Accipitridae	*Haliaeetus leucogaster*	White bellied sea eagle
11	Pandionidae	*Pandion haliaetus*	Osprey
Order: Anseriformes			
12	Anatidae	*Anas poecilorhyncha*	Indian spot billed duck

No.	Taxonomic Family	Scientific Name	Common/English Name
Class: Invertebrata and Others			
Various Orders (Macro-invertebrates)			
1	Toxopneustidae	*Tripneustes gratilla*	Collector urchin
2	Spionidae	*Pseudopolydora sp.*	Spionid worm
3	Cerithiidae	*Cerithium cerithium*	Cerith snail
4	Tellinidae	*Tellina radiata*	Thin tellin
5	Sesarmidae	*Sesarma sp.*	Mangrove crab
6	Ocypodidae	*Uca spp.*	Fiddler crab
Other Phylums			
Various Orders of Flora and Microfauna (Epiphytic)			
1	Ulvaceae	*Enteromorpha intestinalis*	Gutweed (Algae)
2	Bryopsidaceae	*Bryopsis sp.*	Feather algae
3	Naviculaceae	*Navicula sp.*	Diatom
4	Tisbidae	*Tisbe sp.*	Harpacticoid copepod

* * * * *



Chapter 03

Threats to Seagrass Ecosystems

3.1. Natural Threats

Seagrass ecosystems face several natural threats that challenge their survival and recovery even without human interference. Storms deliver powerful waves and surges that uproot plants and bury meadows under shifting sands, while intense grazing by herbivores like sea urchins and turtles can overcrop leaves and sediment dynamics from tides and currents constantly reshape the seabed smothering roots or eroding substrates. In Sri Lanka, these forces hit hard in monsoon exposed lagoons and coastal areas, where seasonal cyclones and variable silt loads from rivers test meadow resilience (Jayakody and Jinadasa, 2020).

Storms rank among the fiercest natural disruptors, ripping up rhizomes and scattering fragments that struggle to re root. Tropical cyclones, common in the Indian Ocean that generate wave heights over 4 meters that scour shallow beds reducing cover by 30-70% in single events, and recovery of damaged bed takes 2-5 years if seeds remain viable. In Sri Lanka, the 2004 tsunami obliterated 40% of southern meadows near Galle, depositing debris layers up to 50 cm thick that blocked light and oxygen, though *Halophila sp.* recolonized edges within months due to clonal spread (Samarakoon and Weerakkody, 2010). Monsoon gales from May October further pound west coast sites, resuspending sediments and halving biomass during peak swells, as waves exceed drag thresholds for leaf attachment (Nguyen et al., 2020).

Grazing pressure varies by herbivore density and plant defenses. Sea urchins like *Tripneustes gratilla* in Sri Lankan waters crop blades at 10-25% of production and creating barren halos around reefs if populations boom post predator decline the densities over 20 m^2 tip meadows into phase shifts. Green turtles (*Chelonia mydas*) feed patches selectively, favoring softer *Thalassia* over fibrous *Halodule,* recycling nutrients through feces but overgrazing isolated beds. Dugongs, rarer in Sri Lanka's Palk Bay excavate trails up to 1 m wide while tilling sediments but exposing roots to desiccation and episodic booms after fish kills amplify this. Fish grazers like *Siganus javus* nibble epiphytes, controlling algae without collapse unless synchronized with urchins.

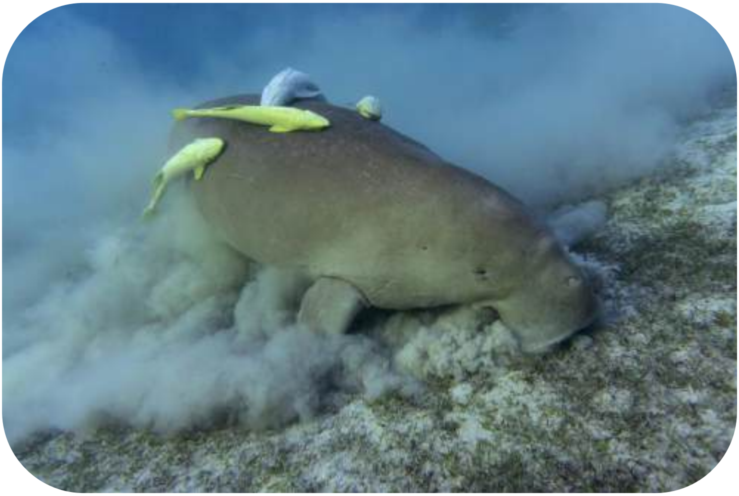


Figure 17: When grazing dugongs uproot the entire sea grass plant rather than eating only the leaves

Sediment dynamics drive chronic stress through burial, erosion and instability. High turbidity from river floods buries seedlings under 5-10 cm silt that slashing germination by 80%. Specially in Sri Lanka's wet zone rivers dump 10-50 tons per ha annually into eastern bays, favoring tolerant *Halophila* over climax species. Erosive currents along southern coasts shear rhizomes with net losses of 2-5 cm per year in exposed channels. Accretion in calm lagoons elevates beds above optimal light depths (1-5 m), prompting die offs as seen in Batticaloa where 15 cm buildup since 2010 shifted communities (Yoswaty et al., 2021). Turbidity impact on reduce photosynthesis by 50% compounding storm damage. The type of natural causes impact on seagrass community and them determine the survival of seagrasses.

3.2. Anthropogenic Threats

Human activities pose the greatest dangers to seagrass ecosystems worldwide, far outpacing natural disturbances through direct destruction and indirect stress that weakens meadows over time. Pollution from coastal runoff, industrial discharges and sewage floods these shallow waters with excess nutrients, sediments and toxins, those smothering plants and sparking algal blooms that block sunlight essential for photosynthesis. Development projects like dredging, land reclamation and port construction physically scrape away beds or bury them under spoil while overfishing removes major grazers and predators, disrupting food webs that keep algae in check. Disruptive fishing methods such as trawling and anchoring further compact sediments and tear up roots, creating scars that expand with repeated passes and lower recovery (Unsworth et al., 2019). These pressures compound globally with 90% of meadows now altered.

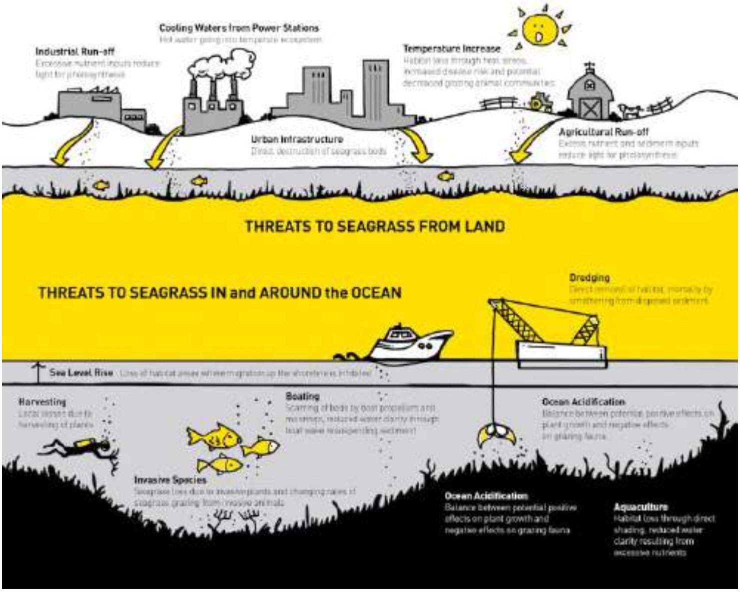


Figure 18: This illustration shows what are the threats by humans to seagrass ecosystems.

Nutrient pollution or eutrophication drives some of the fastest declines as nitrogen and phosphorus from agriculture and wastewater fuel epiphyte and macroalgal overgrowth on blades. Thick mats reduce light by 50-90%, slashing productivity and causing die offs that affected meadows lose 20-40% cover within months, as seen in many tropical bays where farm fertilizers double nutrient loads. In Sri Lanka's coastal systems, untreated sewage and shrimp pond effluents elevate ammonium levels 5-10 times above natural thresholds that promoting green tides that persist year round and favor invasive algae over native plants (Jayakody and Jinadasa, 2020). Hypoxia follows as bacteria consume excess organic matter and killing roots through sulfide intrusion with recovery stalled by ongoing inputs.

Sediment pollution from erosion mirrors nutrient effects blanketing seedlings and clogging rhizomes with silt that cuts oxygen diffusion. Construction sites and deforestation upstream deliver 10-100 tons per hectare yearly, burying beds 5-20 cm deep and shifting communities from climax species like *Thalassia* to tolerant pioneers. Sri Lankan river basins, heavy with gem mining silt, cloud waters for weeks post rain, halving photosynthesis and favoring smother resistant Halophila while climax forms vanish (Samarakoon and Weerakkody, 2010). Chemical pollutants like heavy metals and pesticides sorb to particles, bioaccumulating in grazers and inhibiting growth hormones with chronic exposure reducing seed viability. Coastal development delivers mechanical blows through dredging that resuspends toxins and removes 20-50% of adjacent beds per project. Ports, marinas and resorts shade shallows with piers, dropping light and favoring macroalgae, global reclamation has erased 30,000 hectares since 1990. In Sri Lanka, hotel expansions and causeways fragment meadows blocking larval dispersal and creating isolated patches prone to local extinction (Nguyen et al., 2020). Beach nourishment with coarse sand destabilizes substrates as fine rhizome mats fail to anchor. Overfishing depletes herbivores like parrotfish and urchins that allowing unchecked algal blooms that outcompete seagrasses for space and light. Biomass crashes 50-80% in fished areas,

Figure 19: Dredging and sand mining damage seagrass by removing or burying it and clouding the water, blocking the sunlight these plants need to survive.

3.3. Impacts of Climate Change on Seagrass Beds

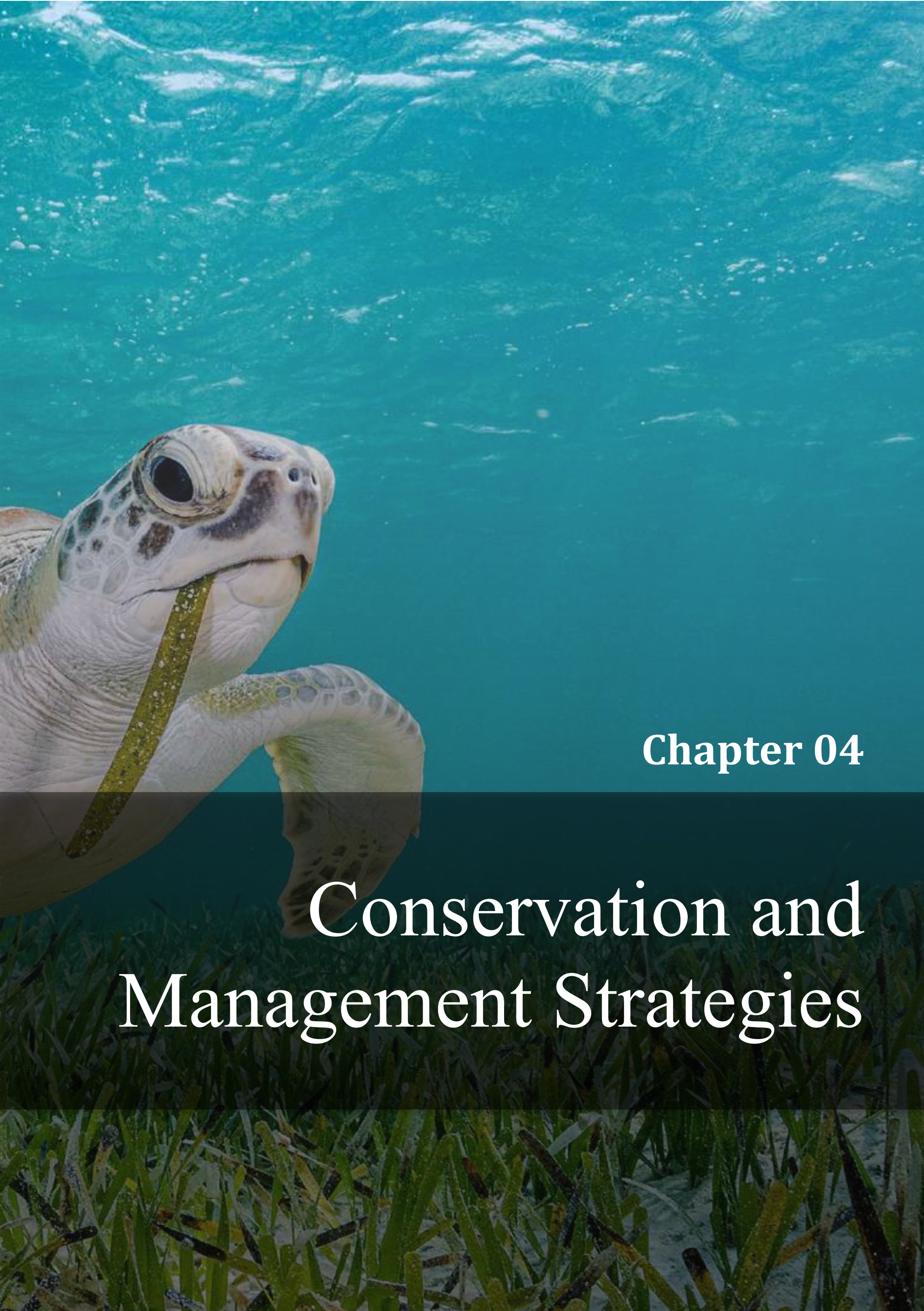
Climate change impact on seagrass beds through rising temperatures, ocean acidification, shifting sea levels and extreme weather, pushing these coastal ecosystems toward widespread decline. Warmer waters stress plants beyond their thermal limits and triggering mass die offs, while acidic conditions erode growth and reproduction, rising seas either drown meadows in deeper waters or expose them during droughts and fiercer storms rip up roots with unprecedented force. These changes ripple through food webs, releasing stored carbon and declining the biodiversity and services seagrasses provide with tropical systems facing the steepest losses due to narrow tolerance ranges (Unsworth et al., 2019). In regions like Sri Lanka where warm equatorial waters already test species limits, these pressures compound local stressors and accelerating phase shifts to algal dominance.

Ocean warming delivers the sharpest blow as seagrasses survive in narrow bands of 20-30°C but wilt above 32-35°C when respiration outpaces photosynthesis. Heatwaves lasting weeks can kill 50-90% of shoots with recovery stalled by depleted seed banks, global records show 18 major dies off events since 1990 often synced with

El-Nino peaks. Tropical species like Halophila and Halodule common in Sri Lankan meadows suffering chronic stress that halves growth rates and boosts disease like leaf spot and wasting syndrome. Enzymes denature, membranes leak and oxidative damage shreds cells while weakened plants leak more dissolved organic carbon, fueling bacterial blooms that further cloud waters (Repolho et al., 2017). Phenotypic plasticity thicker leaves or deeper roots that offers short term buffering but genetic adaptation lags centuries behind 0.2°C per decade warming.

Ocean acidification from CO_2 absorption dropping pH 0.1 units since preindustrial times that impairs calcification of epiphytes and shells, disrupting the carbonate balance that stabilizes meadows. Seagrasses tolerate low pH better than corals even benefiting from enhanced photosynthesis under doubled CO_2 but associated fauna suffer as well as bivalves and urchins show shell dissolution then reducing grazing that controls algae. Tropical calcification rates plummet 30%, weakening structural complexity and exposing sediments to erosion.

Sea level rise changes the depth distributions with 3-5 mm per year global averages submerging shallow beds beyond light reach or flooding with murky estuarine waters. Climax species need 1-7 m depths for surface irradiance but rapid rise outpaces upslope migration at 1-2 cm per year and the low-lying tropical coasts lose suitable area by 2100 under moderate scenarios. Conversely, droughts concentrate salinity, wilting roots of seagrasses (Samarakoon and Weerakkody, 2010). Sediment accretion keeps pace in some deltas but buries others under 10-30 cm silt, favoring pioneers over diverse assemblages. Extreme events like intensified cyclones and marine heatwaves deliver acute shocks. Storms with 5-10 m waves scour 30-70% seagrass cover while heat domes push weekly maximum 4 - 6°C above norms killing through metabolic collapse. Climate change directly and indirectly impacted on seagrasses and increasing climate change poses huge treat on their survival.



Chapter 04

Conservation and Management Strategies

Seagrass ecosystems in Sri Lanka represent a critical but historically underappreciated component of the nation's marine biodiversity. Located strategically in the Indian Ocean, Sri Lanka boasts extensive seagrass meadows that provide vital ecosystem services, including carbon sequestration, coastal protection, and nursery habitats for commercially important fisheries. However, anthropogenic pressures such as destructive fishing practices, unregulated coastal development, and climate change have severely threatened these marine angiosperms. Consequently, seagrass conservation in Sri Lanka has evolved into a complex, multi-layered approach. This approach integrates national laws, institutional frameworks, and grassroots community initiatives with broad global treaties, creating a synergistic framework designed to protect these diverse ecosystems amid growing existential threats. To fully comprehend the efficacy and challenges of these efforts, it is necessary to examine the conservation and management strategies through both local and global lenses. In global levels, Sri Lanka aligns with the Convention on Biological Diversity ratified 1994 committing to Aichi Target 10 on seagrass protection and post-2020 Kunming Montreal Framework's Goal C for ecosystem restoration submitting National Biodiversity Strategies and Action Plans (NBSAPs) that prioritize 20% meadow coverage increase by 2030 via seed banks and replanting (MoE, 2018). The Ramsar Convention ratified in 1990 designates major wetlands overlapping seagrass zones mandating wise use under Resolution XII.14, while UNCLOS which ratified in 1996 supports exclusive economic zone (EEZ) management and banning destructive gears beyond 12 nautical miles. Paris Agreement ratified in 2016 elevates blue carbon through Nationally Determined Contributions (NDCs) targeting 10 MtCO2e sequestration through mangrove-seagrass corridors that unlocking Green Climate Fund grants for monitoring (UNFCCC, 2021). UNESCO's World Heritage status for Sinharaja indirectly bolsters adjacent coastal protections and FAQ Port State Measures Agreement (2010) curbs illegal fishing impacting juveniles.

4.1. National Policies, Community Co-Management, and Ecological Restoration

At the national level, the conservation of seagrass meadows relies on a robust, albeit sometimes fragmented, legislative framework designed to mitigate direct anthropogenic impacts. The foundation of this legal protection is rooted in the Fauna and Flora Protection Ordinance, originally established in 1937 and significantly amended in 2009. This ordinance grants stringent legal protection to seagrass habitats located within designated protected areas, such as national marine reserves, strictly prohibiting destructive activities like bottom trawling, dynamite fishing, and unregulated boat anchoring that physically uproot and damage delicate seagrass beds. Complementing this is the Coast Conservation and Coastal Resource Management Act No. 64 of 2011, which serves as a critical preventative tool. This act mandates comprehensive environmental impact assessments (EIAs) for all proposed coastal developments. By enforcing these EIAs, regulatory bodies ensure that major infrastructural projects, such as the construction of commercial ports and luxury tourist resorts, are meticulously designed to minimize sediment burial, hydrological alterations, and shading that can suffocate photosynthetic seagrass communities (Gunawardena et al., 2021). Since 2018, the strict enforcement of EIA baselines has led to the rejection or substantial modification of approximately 15% of high-impact coastal development proposals, demonstrating a tangible shift towards prioritizing marine ecological health.

Fisheries management also plays an integral role in maintaining the biological equilibrium of seagrass ecosystems. The Fisheries and Aquatic Resources Act No. 2 of 1996, later amended in 2016, specifically regulates gear usage through the implementation of seasonal bans and strict mesh size limits. These regulations are vital for curbing the overexploitation of herbivorous fish species, which are essential for grazing on epiphytic algae that would otherwise overgrow and smother seagrass leaves. This fisheries-centric legislation is further complemented by the National Environmental Act of 1980 (amended in 2000), which establishes rigorous water quality standards designed to combat terrestrial eutrophication stemming from agricultural runoff—a primary driver of toxic algal blooms in coastal waters. Together, these laws empower state agencies like the Department of Fisheries and Aquatic Resources (DFAR) and the Coast Conservation Department (CCD) to enforce coastal zoning, levying substantial fines of up to LKR 500,000 for environmental violations. However, significant implementation and enforcement gaps persist. These shortcomings are largely attributed to limited financial resources for maritime patrols and deeply entrenched overlapping jurisdictions between various state departments, which frequently delay rapid response interventions (Jayakody and Jinadasa, 2020).

To bridge these enforcement gaps, localized management strategies have increasingly shifted toward participatory, community-based models. Community-based Fisheries Management Areas (FIMAs), pioneered under the DFAR since 1995, actively engage over 200 coastal cooperatives in localized ecological monitoring and gear restriction enforcement. This participatory enforcement has proven highly effective in reducing destructive practices within pilot zones. Furthermore, grassroots strategies shine through the establishment of Fisheries Management Committees (FMCs), wherein approximately 18,000 local fishers co-design "no-take" zones and develop alternative livelihoods, such as coastal ecotourism. These incentive-based programs have successfully reduced the use of destructive netting by up to 35% in key areas (Amarasinghe et al., 2021). Additionally, women-led seaweed farming initiatives have provided crucial income diversification, significantly alleviating the direct economic pressure on wild marine resources.

Active ecological restoration forms the final pillar of the local management strategy. The DFAR Seagrass Action Plan (2022-2027) outlines ambitious goals to restore 500 hectares of degraded meadows utilizing vegetative fragmentation techniques and biodegradable artificial substrates. Recent localized trials have achieved a commendable 60% success rate by explicitly inoculating restoration sites with resilient *Halophila* and *Halodule* genotypes that demonstrate high tolerance to thermal stress and heavy siltation. The drafting of Sri Lanka's National Blue Carbon Strategy in 2023 further bridges ecology and economics by mapping extensive meadows using advanced satellite imagery and trained scientific divers. These efforts aim to verify carbon stocks-currently estimated at 50 to 150 tonnes of carbon per hectare-for integration into emerging voluntary carbon markets, piloting localized payment systems in eastern bays where coastal communities trade conservation compliance for direct restoration funding (Senaratne et al., 2025). Furthermore, modern technological integration, including environmental DNA (eDNA) surveys to detect real-time biodiversity shifts and artificial intelligence (AI) image recognition of diver footage, now maps habitat degradation with up to 95% accuracy (Fernando et al., 2025). Despite these advances, chronic underfunding restricts patrol coverage to a mere 20% of required areas, allowing approximately 30% of illegal gear persistence to remain unchecked, while climate projections ominously forecast a 40% loss of native meadow coverage by 2050 without immediate, escalated adaptation measures (MoE, 2022).

4.2. International Treaties, Climate Commitments, and Partnerships

While local actions address immediate proximate threats, Sri Lanka's overarching conservation trajectory is heavily guided and financially supported by its integration into international environmental frameworks. At the global level, Sri Lanka's environmental policy aligns seamlessly with the Convention on Biological Diversity (CBD), which the nation ratified in 1994. Under this convention, Sri Lanka formally committed to the historic Aichi Target 10 regarding the minimization of pressures on vulnerable marine ecosystems. More recently, the nation has aligned its goals with the post-2020 Kunming-Montreal Global Biodiversity Framework, specifically Goal C, which emphasizes widespread ecosystem restoration. To meet these international obligations, Sri Lanka has submitted updated National Biodiversity Strategies and Action Plans (NBSAPs) that prioritize an ambitious 20% increase in total seagrass meadow coverage by the year 2030, a goal to be achieved through the establishment of regional marine seed banks and aggressive replanting campaigns (MoE, 2018).

The protection of critical habitats is further reinforced by the Ramsar Convention on Wetlands of International Importance, ratified by Sri Lanka in 1990. The convention designates several major coastal wetlands that directly overlap with expansive seagrass zones, thereby mandating their "wise use" under Ramsar Resolution XII.14. Similarly, the United Nations Convention on the Law of the Sea (UNCLOS), ratified in 1996, provides the macro-level legal foundation for the sovereign management of Sri Lanka's Exclusive Economic Zone (EEZ). UNCLOS supports national efforts to strictly ban destructive commercial fishing gears in offshore habitats beyond the 12-nautical-mile territorial limit, serving as an international mandate against large-scale foreign and domestic bottom-trawling fleets. Additionally, the FAO Port State Measures Agreement of 2010 acts as a vital international instrument to curb illegal, unreported, and unregulated (IUU) fishing, which directly impacts the juvenile fish populations that rely on seagrass meadows for critical nursery grounds.

In the context of the global climate crisis, the Paris Agreement, ratified by Sri Lanka in 2016, has fundamentally elevated the status of seagrasses from mere fish habitats to critical climate mitigation assets. By officially recognizing "blue carbon" ecosystems, Sri Lanka has incorporated seagrass conservation into its Nationally Determined Contributions (NDCs). The national NDCs specifically target the sequestration of 10 million tonnes of CO2 equivalent (MtCO2e) through the preservation and restoration of continuous mangrove-seagrass biological corridors. This official international commitment is highly strategic, as it unlocks vital access to international climate finance, including substantial grants from the Green Climate Fund dedicated to long-term ecological monitoring and capacity building (UNFCCC, 2021).

International partnerships and designations continue to foster a holistic conservation environment. For instance, UNESCO's World Heritage status granted to terrestrial reserves like the Sinharaja Forest indirectly bolsters adjacent coastal protections by enforcing broader watershed management that reduces downstream sedimentation into seagrass habitats. Furthermore, initiatives under the UN Decade on Ecosystem Restoration (2021-2030) have catalyzed massive public awareness campaigns, systematically training over 10,000 youth annually in marine stewardship. Global financial mechanisms, such as the Global Seagrass Fund, channel millions of dollars into Sri Lankan pilot programs, facilitating the advanced training of local marine officers in state-of-the-art restoration ecology. Looking toward the future, the strategic direction involves mainstreaming blue carbon mechanisms within NDCs and fostering public-private international partnerships aimed at funding the restoration of 1,000 hectares annually to achieve a net-gain in seagrass coverage by 2035. Through this intricate tapestry of global commitments and targeted local actions, Sri Lanka is striving to build national marine resilience and secure its vital seagrass ecosystems against unprecedented existential threats.

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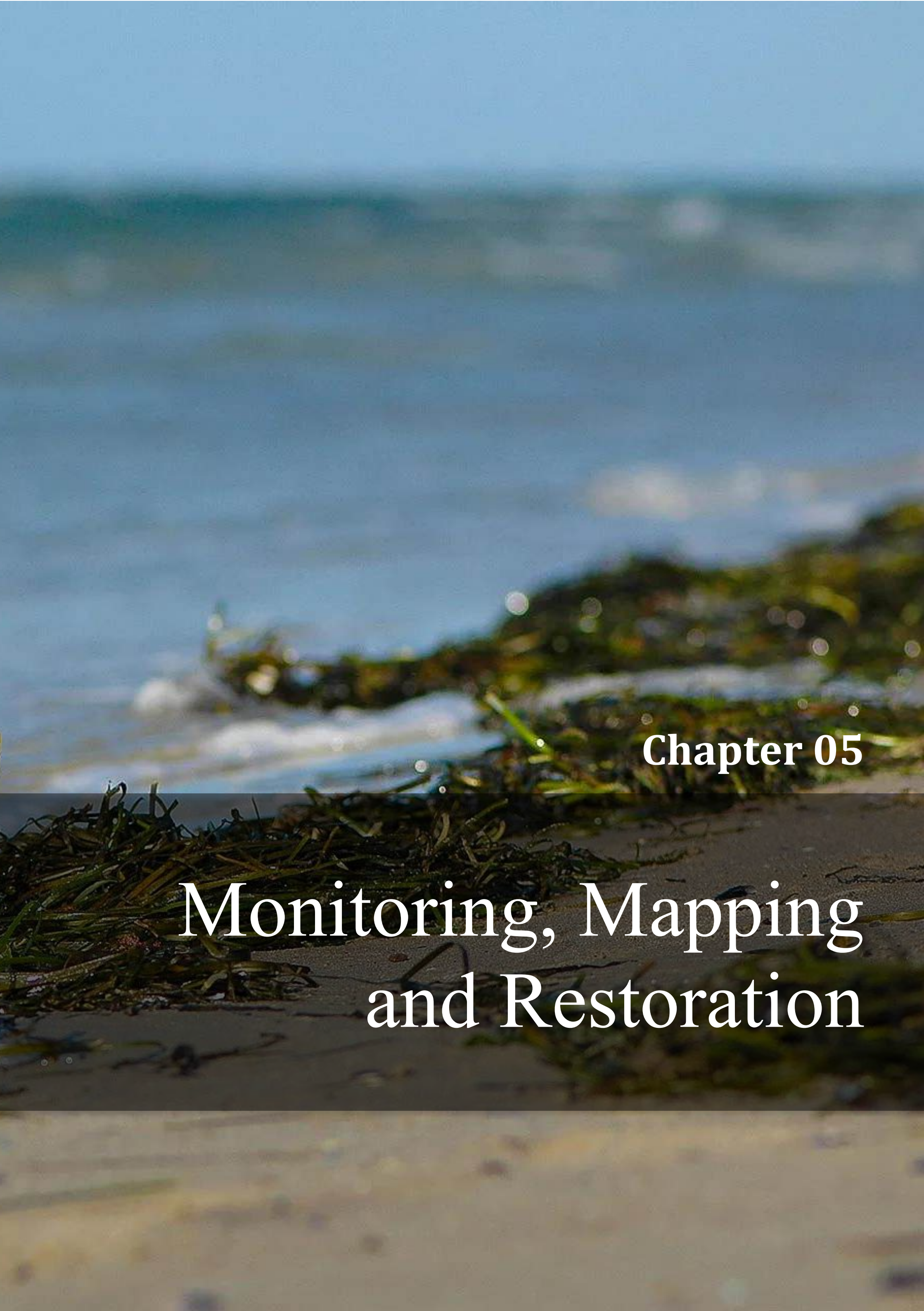


Chapter 05

Monitoring, Mapping and Restoration

5.1. Tools and techniques

Seagrass ecosystems are among the most abundant and fragile coastal habitats in Sri Lanka. Their survival depends on our ability to accurately map their distribution, monitor their condition, and restore damaged areas when natural regeneration is insufficient. As coastal development, sedimentation, and climate impacts worsen, these three components monitoring, mapping, and restoration form the cornerstone of modem seagrass management. These techniques are now essential for maintaining fisheries, biodiversity, and the ecological roles of seagrass meadows in Sri Lanka's shallow coastal seas and lagoons (Waycott et al., 2009).

In order to take measures on how seagrass ecosystems evolve and how outside factors affect their growth, monitoring is done. The most popular approach is still field based monitoring, in which scientists employ transect lines and quadrats to quantify biomass, species composition, percentage cover, shoot density and canopy height. Assessments of water quality, including turbidity, salinity, light penetration, pH and dissolved oxygen factors that directly impact plant health support these findings. In order to monitor meadow conditions, identify early indicators of stress, and get long term visual records that facilitate scientific comparisons, underwater photography and video surveys are becoming more and more popular.

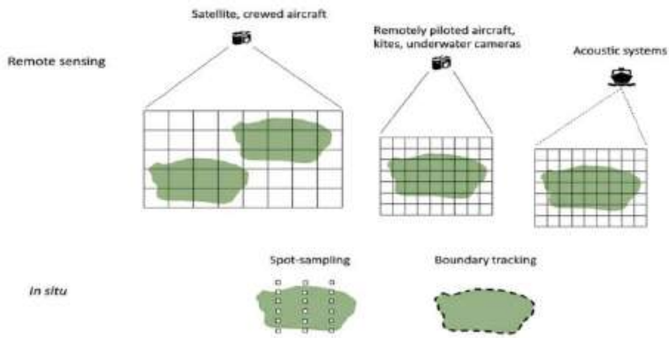


Figure 20: Visualisation of the different approaches to seagrass mapping

Furthermore, epiphyte load, sediment particle size, grazer presence and mechanical damage are examples of environmental indicators that assist researchers in understanding ecosystem stability and identifying stressors prior to significant habitat reduction (Short et al., 2011). Because it offers spatial information for management, conservation zoning and policy choices, mapping seagrass ecosystems is equally significant.

Scientists may find submerged vegetation in shallow seas by utilizing remote sensing techniques using platforms like Sentinel-2, Landsat and high-resolution multispectral sensors. These satellite photos are useful for monitoring broad, hard to reach coastal areas, identifying fractured patches and evaluating changes in seagrass extent. These satellite results are combined with field data using Geographic Information Systems (GIS) to create precise habitat maps that display biological boundaries, distribution patterns and conservation priority regions. Drone based mapping has grown in value in Sri Lanka, particularly in shallow lagoons where UAVs can take fine scale pictures that satellites are unable to resolve.

Figure 21: seagrass monitoring to identify effects of grazing on by mega herbivores

Researchers can monitor seasonal changes and react swiftly to environmental disruptions by using drone footage to create high resolution maps of meadow borders, patchiness and restoration sites (Roelfsema and Phinn, 2009). Restoration is required when seagrass beds are seriously damaged by dredging, sedimentation, destructive fishing, boat anchoring or pollution. The first step in a successful restoration is choosing a suitable location. This entails assessing elements including water flow, nutritional conditions, light availability, sediment stability and the lack of ongoing disturbance.

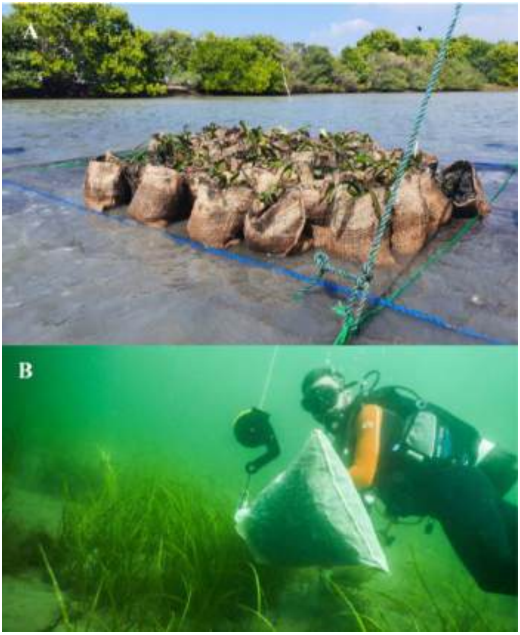


Figure 22: A-Seagrass restoration technique using bags for establish plant materials, B-Seagrass seed collection for restoration purpose

Restoration success is often greater in locations with solid sandy muddy soils and clear water. The next stage is to choose a restoration technique when a suitable location has been selected. One of most popular methods is transplantation, which entails healthy shoots transplant, rhizome piece, or sods gathered from the donor meadows. Because of their comparatively quick development and adaptability, species like *Thalassia hemprichii* and *Halophila ovalis* are frequently. employed. To anchor shoots and lessen erosion, biodegradable planting mats, metal frames or coconut fiber units may be utilized. Another successful strategy is seed based restoration, especially for species that reproduce easily through seeds. This approach promotes natural adaptability and genetic diversity. After being gathered, cleaned and stored, seeds are carefully dispersed into predetermined locations where they will sprout under ideal environmental circumstances. This approach can create resilient meadows with great ecological stability but it takes longer. According to research conducted worldwide, choosing the right species, comprehending the features of the site and offering post restoration monitoring are necessary to the effectiveness of restoration (van Katwijk et al., 2016).

Monitoring after restoration guarantees that seeded or transplanted meadows endure and blend in with their surroundings. Shoot survival, new rhizome development, sediment movement, water clarity and the restoration of related wildlife are all assessed by researchers. Recolonization by fish, crustaceans and invertebrates as well as incremental improvements in shoot density and decreased silt resuspension, are characteristics of successful restoration sites. Because restoration results rely on seasonal cycles, climatic variability, and human activity. Long term monitoring also aids in improving restoration techniques and determining which strategies are most effective in certain island locations. In general, seagrass habitats are protected and their long-term resilience is ensured by monitoring, mapping and restoration. When natural recovery is restricted, restoration revitalizes degraded meadows, mapping gives spatial information for planning and management and monitoring offers scientific proof of ecosystem health. Strengthening these conservation measures will be necessary for sustaining biodiversity, fisheries, climate regulation and the livelihoods of coastal populations.

* * * * *

Chapter 05

Seagrass Species of Sri Lanka

6.1. Seagrass Diversity

Sri Lankan seagrass meadows are important element of the coastal ecosystem that offering essential services such as nutrient cycling, shoreline stabilization and carbon sequestration that directly support for fisheries, tourism and climate resilience. Nestled within the Indo Pacific bioregion, Sri Lanka's seagrass flora well known for its high richness relative to its 1,800 km coastline which hosting 15 confirmed species across two orders Alismatales and Potamogetonales that belongs three families Hydrocharitaceae, Cymodoceaceae and Ruppiaceae, as documented in checklists (Silva et al., 2013; Jayakody and Jinadasa, 2020; Udagedara et al., 2017, 2020). This diversity surpasses many equatorial nations with longer shores reflecting the island's wide continental shelf up to 50 km varied substrates from coral rubble to mudflats and monsoonal turbidity gradients that create niche mosaics. Globally, seagrasses presence about 72 species belongs to 6 genera (Short et al., 2007). The largest meadows survive in shallow, nutrient rich shallows of northern and northwestern lagoons where biomass exceeds 500 g dry weight per square meter while dwarfing sparse southern fringes battered by swells.

Species distribution decided by the environmental gradients, wide shelves in the northwest foster expansive *Halodule sp,* and *Cymodocea sp*. beds on sandy muddy bottoms while turbid eastern bays suit light efficient *Halophila sp*.. Monsoonal rains spike nutrients from October-March peaking productivity in Potamogetonales like *Halodule uninervis* but southwest gales resuspend sediments confining dense stands to leeward bays (Samarakoon and Weerakkody, 2010). Hydrocharitaceae dominates with 10 species, including cryptic *Halophila ovalis* complexes, Cymodoceaceae contributes *Enhalus acoroides* in calmer zones, Ruppiaceae's *Ruppia maritima* fringes hypersaline edges which tolerating 50 ppt. Species like *Halophila minor* colonize disturbed sands rapidly by seeds, stabilizing for successors like *Syringodium isoetifolium*, which anchors by dense rhizomes (Nguyen et al., 2020). The *Halophila sp.* complex exemplifies taxonomic nature long muddled by plasticity, morphological keys lumped variants until molecular tools clarified identities. Udagedara et al. (2020) used ITS and rbcL markers to distinguish *H. ovalis* from *H. major* and confirm *H. decipiens* absence, highlighting hybridization zones where alleles blend which boosting adaptive potential amid warming (Udagedara et al., 2020). Globally, more than 20 species Halophila species drive Indo Pacific seagrass diversity with cryptic speciation through ploidy shifts while Sri Lanka is 7 species among them.

Family breakdowns highlight functional guilds, Hydrocharitaceae's leafy opportunists excel in turbid flows exporting detritus, the Cymodoceaceae's strap leaved perennials build carbon stocks, the Ruppiaceae bridges marine brackish habitats. Richness peaks northwest presence 12 spp., while south presence 6 spp. due to exposure mirroring global latitudinal peaks at 10-20°N (Green and Short, 2003). Endemism is low, there are zero true endemics but intraspecific variants adapt locally within northwestern *H. ovalis* withstands silt, southern resist desiccation. Threats erode diversity, eutrophication favors Halophila over Enhalus, trawling fragments Syringodium (Jayakody and Jinadasa, 2020).

6.2. Species Account of Sri Lanka

No.	Scientific Name	National Conservation Status (2012)	Global Conservation Status	Population Trend (Global)	Recorded Region in Sri Lanka
Family: Hydrocharitaceae					
1	*Halophila decipiens*	NT	LC	Increasing	NE, NW, SE
2	*Halophila ovalis*	LC	LC	Stable	SW, NW, NE, SE
3	*Halophila beccarii*	EN	VU	Decreasing	NE, NW, SE
4	*Halophila ovata*		LC	Stable	NW
5	*Halophila major*		NA		SW, NW
6	*Halophila minor*		LC	Unknown	NW
7	*Halophila stipulacea*		LC	Increasing	NW
8	*Thalassia hemprichii*	NT	LC	Stable	NW, SW, NE, SE
9	*Enhalus acoroides*	NT	LC	Decreasing	NW, NE, SE
Family: Cymodoceaceae					
10	*Cymodocea rotundata*	NT	LC	Stable	NW, NE, SW
11	*Cymodocea serrulata*		LC	Stable	NW, NE
12	*Halodule uninervis*	NT	LC	Stable	NW, NE, SE, SW
13	*Halodule pinifolia*		LC	Decreasing	NE, SW
14	*Syringodium soetifolium*	NT	LC	Stable	NW, NE, SW
Family: Ruppiaceae					
15	*Ruppia maritima*	LC	LC	Stable	NE, SE, SW

6.3. Seagrass Recorded Regions in Sri Lanka

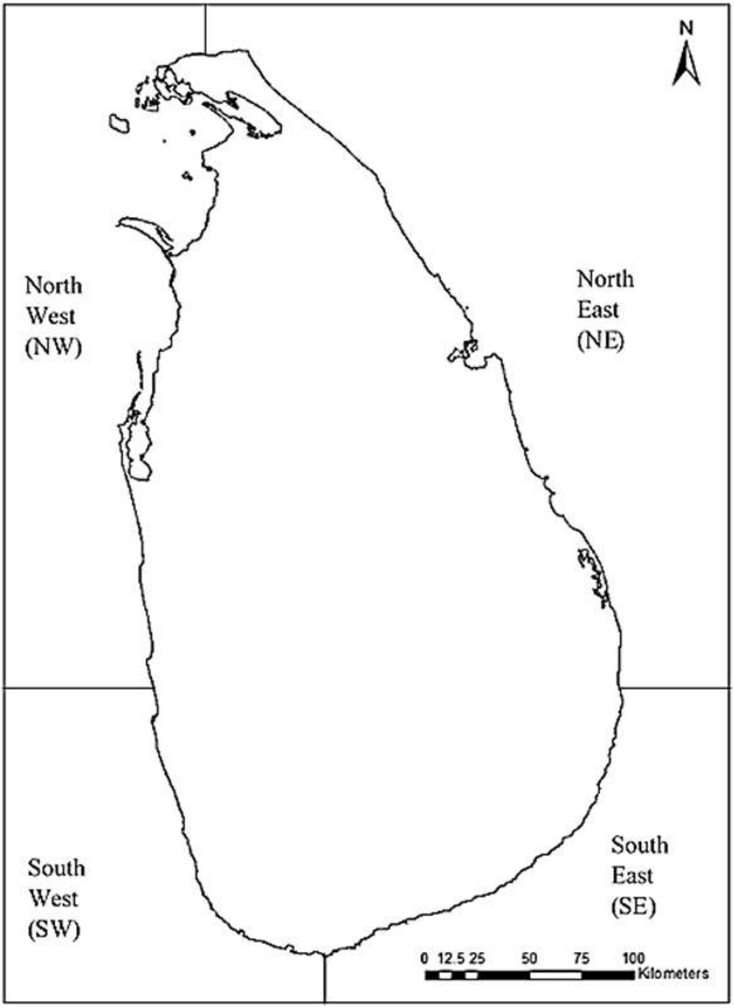
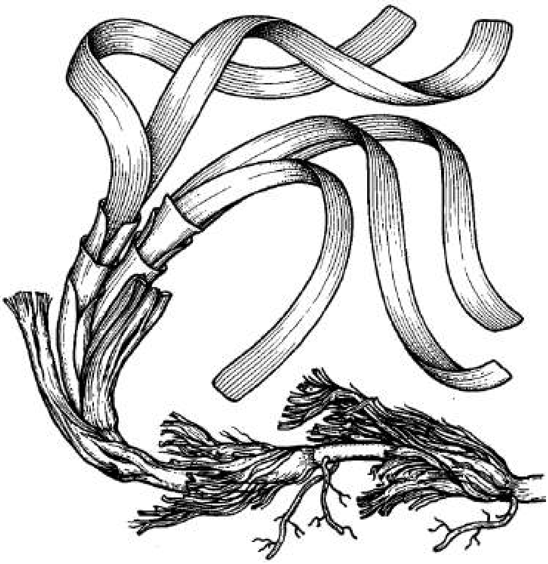


Figure 24: Seagrass recorded regions in Sri Lanka



From this point onwards, a summary featuring photographs and easily identifiable characteristics of all recorded Seagrass species of Sri Lanka is presented. The plant families to which these trees belong are listed in English alphabetical order.

6.4. Instructions to Use

Main Image

Scientific Name

National Conservation Status

EN Endangered

NT Near Threatened

LC Least Concerned

NE Not Evaluated

Global Conservation Status

VU Vulnerable

LC Least Concerned

NE Not Evaluated

Taxonomic Family colour code

Ruppiaceae

Cymodoceaceae

Hydrocharitaceae

Taxonomic Family Name

Hydrocharitaceae

Halophila decipiens

Ostenf, 1902

LC

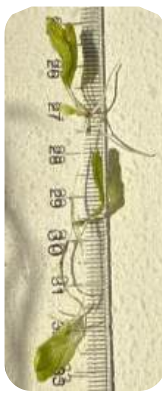
NT

Halophila decipiens is a small, delicate marine angiosperm that typically forms sparse, low-density seagrass meadows. The species spreads through thin, creeping rhizomes that grow just beneath the sediment sur-face. Rhizomes are slender and bear fine roots that provide anchorage in soft sandy or muddy substrates. Leaves are arranged in opposite pairs at each node. Leaf blades are ovate to elliptic, generally 1-4 cm long, thin textured and bright green. A distinct midrib is present, accompanied by several cross veins that may be faint or moderately visible. Petioles are short, and leaf size can vary depending on depth, light availability and water clarity. Compared with other Halophila species, *H. decipiens* is notable for its relatively small leaves and tolerance of deeper waters.

Reproductive Morphology The species is dioecious, with male and female flowers occurring on separate plants. Flowers are minute and inconspicuous, produced close to the sediment surface. Pollination occurs underwater (hydrophily), facilitated by water movement in the surrounding environment. Sexual reproduction plays an important role in maintaining genetic diversity, particularly in populations distributed across a wide depth range. Fruits are small and ovoid, containing several brown seeds. Seeds are capable of dispersal by currents and sediment movement, allowing colonization of suitable habitats over a broad geographic area.

Distribution widely distributed in tropical and subtropical regions of the Indo-West Pacific and Atlantic oceans. Its range includes the Indian Ocean, Red Sea, western Pacific, Caribbean, and parts of the western Atlantic. The species often shows a patchy distribution influenced by depth and substrate conditions.

Ecology and Habitat This species commonly inhabits subtidal environments, ranging from shallow waters to depths exceeding 30 m. It grows on sandy or muddy bottoms in relatively calm offshore areas, lagoons, and shelf regions. *Halophila decipiens* is considered a deep-water seagrass and is well adapted to low-light conditions, distinguishing it from many other seagrass species.



Hydrocharitaceae

Halophila ovalis

Hook f., 1858

LC

LC

Halophila ovalis is a small, delicate marine angiosperm forming low-growing seagrass meadows. The plant spreads primarily through slender, creeping rhizomes that facilitate rapid colonization of disturbed or newly available substrates. Rhizomes are thin, short jointed, and anchored in soft sediments by fine roots. Leaves are paired at each node, ovate to elliptic in shape, measuring approximately 1--4 cm in length. Leaf blades are bright green with smooth margins and typically display 6-12 distinct cross-veins intersecting a prominent midrib, a key diagnostic feature. Petioles are short to moderate in length, and leaf size varies considerably in response to environmental conditions such as light availability and nutrient levels.

Reproductive Morphology dioecious, producing separate male and female plants. Flowers are small, inconspicuous, and borne close to the sediment surface. Pollination occurs underwater through hydrophilous mechanisms involving water movement. Male flowers release pollen into the water column, while female flowers possess specialized structures to capture drifting pollen. Sexual reproduction contributes significantly to genetic diversity, particularly in disturbed or dynamic environment Fruits are small, ovoid to spherical, and contain multiple seeds. Seeds are adapted for short-distance dispersal through water movement and sediment transport. Successful seedling establishment is common in soft substrates, allowing *H. ovalis* to function as an early colonizer in seagrass success10n.

Distribution this species has one of the widest distributions of any seagrass. It occurs throughout the tropical and subtropical Indo-Pacific region, including the Indian Ocean, Red Sea, Southeast Asia, northern Australia, and the western Pacific. The species is also present in Sri Lanka and along much of the eastern African coastline.

Ecology and Habitat This species typically inhabits shallow coastal waters, lagoons, estuaries, reef flats, and sheltered bays, growing on sandy or muddy substrates. *Halophila ovalis* occurs from the intertidal zone to depths exceeding 30 min clear waters. It is often found forming mixed meadows with other seagrasses or as a pioneer species following physical disturbance. Due to its rapid growth rate and short life cycle, *H. ovalis* plays an important role in sediment stabilization and early habitat formation, supporting juvenile fish and invertebrates.

Hydrocharitaceae

Halophila beccarii

Ascherson, 1871

VU

EN

Halophila beccarii is a small, delicate marine angiosperm forming low, sparse seagrass meadows. It spreads primarily through slender, creeping rhizomes that run shallowly beneath the sediment surface. The rhizomes are thin and fragile, producing fine roots that anchor the plant in soft substrates. Leaves are small, ovate to elliptic, typically 0.6-2.5 cm long, borne in opposite pairs at each node. Leaf blades are bright green with smooth margins and a prominent midrib, accompanied by several faint cross-veins. Petioles are short, and leaf size may vary depending on light availability, salinity, and nutrient conditions.

Compared to other Halophila species, H. beccarii is characterized by its smaller stature and preference for intertidal habitats.

Reproductive Morphology *Halophila beccarii* is dioecious, with male and female flowers occurring on separate plants. Flowers are minute, inconspicuous, and borne close to the sediment surface. Pollination occurs underwater (hydrophily), facilitated by tidal movements and water currents in shallow coastal environments. Sexual reproduction contributes to genetic diversity and population persistence, particularly in highly dynamic intertidal habitats subject to frequent disturbance.

Fruits are small and ovoid, containing several seeds. Seeds are adapted for short distance dispersal by tidal currents and sediment movement. Seedling establishment occurs rapidly on exposed mudflats and shallow sediments, enabling the species to recolonize disturbed areas.

Distribution and Ecology *Halophila beccarii* has a restricted geographic distribution, occurring primarily in the tropical Indo-West Pacific region. It is recorded from India, Sri Lanka, Bangladesh, Myanmar, Thailand, Vietnam, southern China, Malaysia, Indonesia, and parts of northern Australia. The species has a fragmented distribution and is often confined to localized coastal areas. This species is typically found in very shallow coastal waters, intertidal mudflats, estuaries, lagoons, and sheltered bays. *Halophila beccarii* grows on muddy or fine sandy substrates, often in areas exposed during low tide. Due to its shallow distribution and low growth form, *H. beccarii* is highly sensitive to physical disturbance, coastal development, sedimentation, and changes in hydrology.

Hydrocharitaceae

Halophila ovata

Gaudichaud, 1827

LC

NE

Halophila ovata is a small, delicate marine angiosperm forming low-growing seagrass patches in shallow coastal waters. The species propagates mainly through creeping, slender rhizomes that run just beneath the sediment surface. Rhizomes are thin and fragile, producing fine adventitious roots that anchor the plant in soft substrates. Leaves occur in opposite pairs at each node and are characteristically ovate to broadly elliptic, typically 1- 4 cm long. Leaf blades are bright green, thin and smooth margined with a distinct midrib and several cross veins. Petioles are short to moderate in length. Compared to other *Halophila* species, *H. ovata* is distinguished by its broader leaf shape and relatively soft leaf texture.

Reproductive Morphology *H. ovata* is dioecious with male and female flowers borne on separate plants. Flowers are minute, inconspicuous, and produced near the sediment surface. Pollination occurs underwater (hydrophilous pollination), assisted by water movement in shallow marine environments. Sexual reproduction contributes to population resilience and genetic variability, especially in dynamic coastal habitats. Fruits are small and ovoid, containing several seeds. Seeds are brown and adapted for dispersal by tidal currents and sediment transport. Germination generally occurs in shallow, calm environments with fine sediment.

Distribution *H. ovata* is distributed throughout the tropical Indo-West Pacific region. It has been recorded from the eastern Indian Ocean, Southeast Asia, northern Australia, and several Pacific Island regions. Its distribution is often patchy and influenced by local environmental conditions.

Ecology and Habitat The species inhabits shallow subtidal to intertidal zones, commonly occurring on sandy or muddy substrates in sheltered bays, lagoons, and nearshore waters. *H. ovata* can tolerate moderate turbidity and variable salinity, and it is often found growing in association with other small seagrasses such as *Halophila ovalis*.

Hydrocharitaceae

Halophila major

(Zollinger) Miquel, 1856

NE

NE

Halophila major is a small to medium-sized marine angiosperm forming low growing, patchy seagrass meadows. The plant spreads by means of slender, creeping rhizomes that grow within soft sediments and produce fine roots for anchorage. Leaves occur in opposite pairs at each node. Leaf blades are elliptic to oblong-ovate, generally larger and broader than those of *Halophila ovalis*, typically measuring 2-6 cm in length. The leaves are bright to dark green, with a distinct midrib and numerous cross-veins that are clearly visible, a key diagnostic feature of the species. Petioles are short but well developed, and leaf size may vary according to depth and light availability.

Reproductive Morphology *H. major* is dioecious with male and female flowers borne on separate plants. Flowers are very small and produced near the sediment surface. Pollination occurs underwater (hydrophilous pollination), assisted by water movement. Although sexual reproduction occurs, population maintenance is largely supported by clonal growth through rhizome extension. Fruits are small, globose to ovoid, and contain several brown seeds. Seeds contribute to dispersal and recolonization of disturbed habitats, particularly following physical disturbance of seagrass beds.

Distribution *H. major* is distributed throughout the tropical Indo-West Pacific region, including the Indian Ocean, Southeast Asia, northern Australia, and western Pacific islands. Its distribution often overlaps with that of *H. ovalis*, though *H. major* generally occupies slightly deeper or more stable subtidal environments.

Ecology and Habitat The species occurs in shallow subtidal zones on sandy or muddy substrates, commonly in lagoons, sheltered coastal waters, and reef flats. It can tolerate moderate turbidity and reduced light levels and is frequently found mixed with other seagrass species, particularly *Halophila ovalis* and *Halodule spp.*

Hydrocharitaceae

Halophila minor

(Zollinger) Hartog, 1957

LC

NE

Halophila minor is a small, delicate marine angiosperm forming low-growing and often sparse seagrass meadows. The species spreads primarily through slender, creeping rhizomes that grow within soft sandy or muddy sediments and produce fine roots for anchorage. Leaves occur in opposite pairs at each node. Leaf blades are small, elliptic to oblong, generally 1-3 cm in length and distinctly smaller and narrower than those of *Halophila ovalis* and *Halophila major*. Leaves are light to bright green with a fine but visible midrib and several delicate cross veins that are less conspicuous than in H. major. Petioles are short and overall leaf size may vary with environmental conditions such as depth, light availability, and water clarity.

Reproductive Morphology *Halophila minor* is dioecious with male and female flowers borne on separate plants. Flowers are extremely small and produced close to the sediment surface. Pollination is hydrophilous and occurs underwater, facilitated by water movement including tidal currents and gentle wave action. Although sexual reproduction occurs, population persistence and meadow expansion are largely maintained through clonal growth by rhizome extension. Fruits are small, ovoid to globose, and contain several smooth, brown seeds. Seeds contribute to dispersal and recolonization, particularly following disturbance events that fragment existing seagrass beds.

Distribution *Halophila minor* is distributed throughout the tropical Indo-West Pacific, including the Indian Ocean, Southeast Asia, northern Australia, and parts of the western Pacific. Its range often overlaps with *Halophila ovalis* and *Halophila major,* though *H. minor* is generally less abundant and more localized.

Ecology and Habitat The species inhabits shallow subtidal environments on sandy or muddy substrates, commonly in sheltered bays, lagoons, and reef-associated habitats. *Halophila minor* tolerates moderate turbidity and reduced light conditions and is frequently found mixed with other small seagrass species, particularly *Halophila ovalis* and *Halodule spp.*

Hydrocharitaceae

Halophila stipulacea

(Forsskål) Ascherson, 1867

LC

NE

Halophila stipulacea is a small to medium-sized marine angiosperm forming dense, low-growing seagrass meadows. The species spreads extensively through slender, creeping rhizomes that grow within soft sandy or muddy substrates and produce numerous fine roots, providing strong anchorage. Leaves occur in opposite pairs at each node. Leaf blades are elliptic to oblong, typically 2-6 cm in length, with a characteristic serrated or dentate margin, a key diagnostic feature of the species. Leaves are light to dark green and often display fine hairs along the leaf margins and petioles. Cross-veins are present but less conspicuous than in Halophila major. Petioles are short, and leaf morphology may vary in response to environmental conditions such as light availability, depth, and nutrient levels.

Reproductive Morphology *H. stipulacea* is dioecious, with male and female flowers borne on separate plants. Flowers are small and produced near the sediment surface. Pollination is hydrophilous and occurs underwater, facilitated by water movement including tidal currents. Both sexual reproduction and clonal growth contribute to population maintenance. The species is capable of rapid vegetative expansion, which enhances its ability to colonize new habitats. Fruits are ovoid and contain several small, brown seeds. Seeds contribute to dispersal and enable establishment in newly available or disturbed habitats, supporting the species' high colonization potential.

Distribution *H. stipulacea* is native to the Red Sea and western Indian Ocean, but has expanded its range extensively. It has invaded the Mediterranean Sea via the Suez Canal and, more recently, the Caribbean Sea, where it is now widely established. Its current distribution spans tropical and subtropical regions of the Indian Ocean, Mediterranean, and western Atlantic.

Ecology and Habitat The species inhabits shallow subtidal to deeper waters, occurring on sandy or muddy substrates in lagoons, sheltered bays, reef flats, and deeper offshore environments. *H. stipulacea* tolerates a wide range of environmental conditions, including reduced light, high salinity, and moderate nutrient enrichment, which contributes to its invasive success.

Hydrocharitaceae

Thalassia hemprichii

(Ehrenberg) Ascherson, 1871

LC

NT

Thalassia hemprichii is a medium to large-sized marine angiosperm forming extensive, dense meadows in tropical coastal waters. It spreads primarily via robust, creeping rhizomes, which can penetrate soft sandy or muddy substrates to anchor the plant and support clonal expansion. Leaves occur in two ranks and are strap-shaped, 15-50 cm long and 0.8-2.5 cm wide, with a smooth surface and parallel venation. The leaf margins are entire, and new leaves emerge continuously from the rhizome apex. Petioles are short and sheathing at the base.

Reproductive Morphology *T. hemprichii* is dioecious, with male and female flowers on separate plants. Flowers are small and located near the sediment surface. Pollination occurs underwater (hydrophilous), primarily via tidal currents and water movement. Sexual reproduction produces seeds, while clonal growth via rhizomes ensures meadow expansion and maintenance. Fruits are elongated to ellipsoid, containing several small brown seeds. Seeds can disperse over short distances via water currents and contribute to recolonization of disturbed areas.

Distribution *T. hemprichii* is widely distributed across the tropical Indo-Pacific region, including the East African coast, Red Sea, South and Southeast Asia, northern Australia, and the western Pacific islands.

Ecology and Habitat The species occurs in shallow subtidal to intertidal zones, favoring sandy to muddy substrates. It is commonly found on reef flats, lagoons, and sheltered coastal areas. Its dense meadows provide critical habitat for fish, invertebrates, and mega-herbivores such as sea turtles and dugongs. *T. hemprichii* tolerates moderate turbidity and nutrient enrichment.

Hydrocharitaceae

Enhalus acoroides

(Linnaeus f.) Royle, 1839

LC

NT

Enhalus acoroides is a coarse marine herb. Vegetative propagation occurs through thick, creeping rhizomes measuring approximately 10-15 mm in diameter and brown in color. The species forms extensive mono-specific stands due to vigorous rhizome growth. Leaves are large and strap like, measuring 30-150 cm in length and 0.7-1.7 cm in width and range in color from bright to dark green. Leaf sheaths are compressed, up to 15 cm long, whitish and translucent. Marginal nerves persist after leaf decay and appear blackish, a diagnostic feature of the species.

Reproductive Morphology Male inflorescences are borne on peduncles 5-10 cm long. The spathe bract is broadly ovate lanceolate, approximately 5 x 3 cm, slightly keeled with the keel and nerves bearing numerous long, rough hairs, the margins are characteristically curled. Male flowers possess thin pedicels 3-12 mm long, which break off about 0.3-0.5 mm below the flower. Sepals are approximately 2 x 1 mm and white, while petals are 1.25-1.75 mm long and also white.

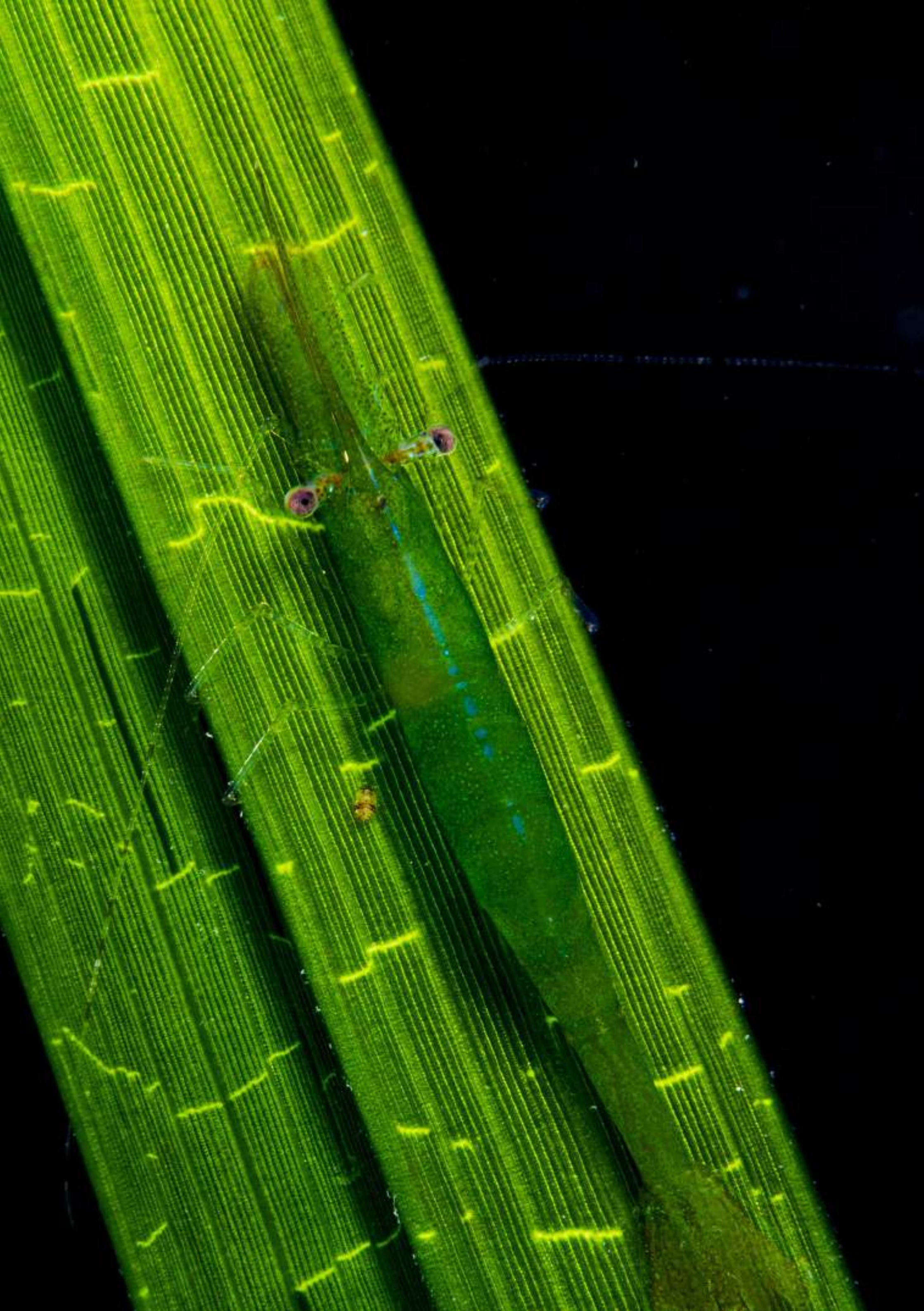
Female inflorescences are borne on much longer peduncles, typically 40-50 cm or longer that enabling flowers to reach the water surface. The spathe bract measures 4-6 x 1-2 cm, bears many long rough hairs, and has non-curled margins. Female flowers have oblong sepals approximately 1 x 0.5 cm, with rounded apices and recurved margins. Petals measure 4-5 x 0.3-0.4 cm, are white with a reddish apex. The ovary is densely covered with long, fringe-like hairs, and the stigmatic branches are 10-12 mm long and densely papillose.

Fruits are large, measuring 2.5-7 x 2.2-3 cm, and range in color from green to dark brown or blackish at maturity. Each fruit contains 8-14 seeds. Seeds are brown, measuring approximately 10-15 x 12 mm.

Distribution *E. acoroides* is widely distributed along the coasts of the Indian Ocean and western Pacific. In Africa, it occurs from northern Kenya southwards to Mozambique, including Madagascar and the Seychelles. The species is also present in South and Southeast Asia, including Sri Lanka.

Ecology and Habitat This species occurs along sheltered coastlines in shallow marine waters, typically on sandy or muddy substrates. It is frequently found on mudbanks adjacent to mangrove ecosystems and may form dense monospecific meadows or occur in association with other seagrasses, most commonly *H. ovalis*. *E. acoroides* occurs at depths of up to 6 m; however, flowering generally takes place only where plants are briefly exposed during extreme low tides or where the inflorescences are able to reach the water surface.

Above Right: Female flower
Above Left: Male flower
Below Right: Opened up fruit
Below Left: Fruit



Cymodoceaceae

Cymodocea rotundata

Ascherson and Schweinfurth, 1870

LC

NT

Cymodocea rotundata is a small to medium-sized tropical seagrass species that forms low, continuous meadows in shallow coastal waters. It spreads through slender, creeping rhizomes that grow horizontally within sandy or muddy substrates and produce numerous fibrous roots, providing firm anchorage and effective sediment stabilization. The plant often forms mixed meadows with other tropical seagrasses, contributing to habitat complexity in nearshore environments.

Leaves arise in opposite pairs at each node of the rhizome. Leaf blades are narrow, strap-shaped, typically 5-15 cm long, with rounded apices and smooth margins, which distinguish this species from the closely related *Cymodocea serrulata*. Leaves are light to dark green with fine longitudinal veins, and the petioles are short. Leaf size and density may vary with depth, water clarity, and nutrient availability.

Reproductive Morphology *Cymodocea rotundata* is dioecious, with male and female flowers occurring on separate plants. Flowers are small, inconspicuous, and produced near the sediment surface, remaining protected within the leaf sheaths. Pollination is hydrophilous and takes place underwater, aided by water movement and local currents. Sexual reproduction contributes to genetic diversity and long-term population resilience, particularly in stable meadows. However, clonal growth through rhizome extension is the primary mode of meadow expansion and local persistence, enabling rapid recovery following physical disturbance.

Fruits are small, ovoid to slightly elongated and develop close to the sediment surface. Each fruit contains one to a few seeds enclosed within a firm pericarp, which protects the developing embryo from physical damage and desiccation. Seeds contribute to dispersal at local and regional scales, particularly during strong currents or storm events. Seedling establishment is most successful in stable sandy substrates, supporting recolonization of disturbed areas and maintenance of meadow continuity.

Distribution *Cymodocea rotundata* is widely distributed throughout the tropical Indo-West Pacific region. Its range includes the eastern coast of Africa, the Red Sea, Indian Ocean islands, Southeast Asia, northern Australia, and many western Pacific Island systems. The species is common in coastal waters of Sri Lanka and the broader South Asian region, where it forms important seagrass meadows in lagoons and sheltered bays. Its distribution is closely associated with warm, shallow tropical marine environments with suitable sandy or muddy substrates.

Ecology and Habitat This species typically inhabits shallow subtidal and intertidal zones, particularly in lagoons, sheltered bays, reef flats, and calm nearshore waters. It grows best on sandy to muddy substrates with moderate water movement and good light availability, although it can tolerate slight turbidity. *Cymodocea rotundata* plays a significant ecological role by stabilizing sediments, reducing coastal erosion, and providing feeding and nursery habitats for fish, invertebrates, and juvenile marine organisms. Its meadows contribute to nutrient cycling and support high biodiversity in tropical coastal ecosystems.

Cymodoceaceae

Cymodocea serrulata

(R. Brown) Ascherson and Magnus, 1870

LC

NE

Cymodocea serrulata is a medium-sized tropical seagrass that forms dense, continuous meadows in shallow coastal areas. Using creeping rhizomes and fibrous roots, it anchors firmly to sandy or muddy substrates, effectively stabilising sediment. Often found alongside other tropical species, it enhances the structural complexity of nearshore habitats. Leaves emerge in opposite pairs from rhizome nodes. These strap shaped blades (10–30 cm long) feature distinct serrated margins and pointed tips, distinguishing them from *Cymodocea rotundata*. While usually light to dark green with clear veins, leaf size and canopy height fluctuate based on depth, light, and nutrients.

Reproductive Morphology *Cymodocea serrulata* is dioecious, bearing small, inconspicuous male and female flowers on separate plants near the sediment surface. Protected by leaf sheaths, pollination is hydrophilous and occurs underwater, facilitated by water movement and local currents. While sexual reproduction boosts genetic diversity and long-term resilience, vegetative propagation via rhizome extension is the primary driver for local expansion and rapid recolonisation after disturbances. The ovoid fruits develop near the seabed, each containing seeds encased in a protective pericarp to withstand mechanical damage. These seeds enable dispersal during storms or strong currents. Successful seedling establishment in stable sandy or muddy substrates ensures meadow continuity and the recovery of disturbed habitats.

Distribution The species is common in coastal waters of Sri Lanka and the broader South Asian region, where it forms extensive meadows in lagoons, sheltered bays, and reef-associated environments. Its distribution is closely linked to warm, shallow marine habitats with suitable soft substrates.

Ecology and Habitat This species inhabits shallow subtidal and intertidal zones, particularly lagoons, sheltered bays, reef flats, and calm nearshore waters. It grows best on sandy to muddy substrates with good light penetration and moderate water movement, although it can tolerate moderate turbidity. *Cymodocea serrulata* plays an important ecological role by stabilizing sediments, reducing coastal erosion, and providing nursery and feeding habitats for fish and invertebrates. Its meadows contribute to nutrient cycling, organic matter production, and the maintenance of high biodiversity in tropical coastal ecosystems.

Cymodoceaceae

Halodule uninervis

(Forsskål) Ascherson, 1882

LC

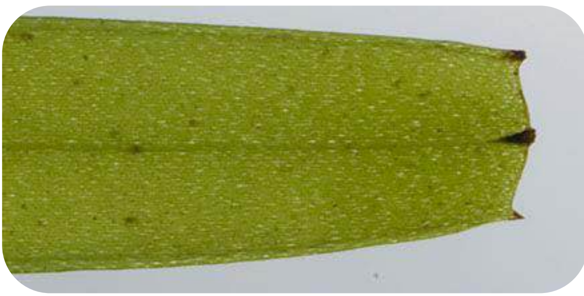
NT

Halodule uninervis is a small, fast growing tropical seagrass species that forms low, sparse to moderately dense meadows in shallow coastal waters. It spreads through slender, creeping rhizomes that extend horizontally within sandy or muddy substrates and produce fine fibrous roots, providing anchorage and initial sediment stabilization. The species often colonizes disturbed or newly available substrates and commonly occurs in mixed meadows with other tropical seagrasses.

Reproductive Morphology *H. uninervis* is dioecious, with male and female flowers occurring on separate plants. Flowers are minute and produced near the sediment surface, remaining enclosed within leaf sheaths. Pollination is hydrophilous and occurs underwater, facilitated by water currents and tidal movement. Fruits are small and ovoid, developing near the sediment surface. Each fruit generally contains a single seed enclosed within a firm pericarp, which provides protection to the developing embryo. Seeds contribute to dispersal at local and regional scales, particularly during strong tidal flows or storm events. Seedling establishment is most successful on stable sandy or muddy substrates, supporting recolonization of disturbed habitats and the maintenance of meadow structure.

Distribution *H. uninervis* is widely distributed throughout the tropical Indo-West Pacific region, including the eastern coast of Africa, the Red Sea, Indian Ocean islands, South and Southeast Asia, northern Australia, and many western Pacific Island systems.

Ecology and Habitat This species typically inhabits shallow subtidal and intertidal zones, particularly lagoons, estuaries, sheltered bays, and calm nearshore waters. It grows best on sandy to muddy substrates with good light availability and moderate water movement, although it can tolerate higher turbidity and fluctuating environmental conditions compared to many larger seagrass species. *Halodule uninervis* plays an important ecological role as a pioneer species by stabilizing sediments and facilitating the establishment of later-successional seagrass species. It provides feeding grounds for herbivores such as green turtles and dugongs and serves as nursery habitat for juvenile fishes and invertebrates. Its meadows contribute to nutrient cycling and enhance coastal ecosystem productivity.



Cymodoceaceae

Halodule pinifolia

(Miki) Hartog, 1964

LC

NE

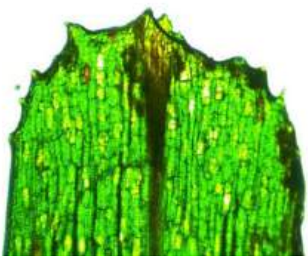
Halodule pinifolia is a small, fine-leaved tropical seagrass species that forms low, sparse to moderately dense meadows in shallow coastal waters. It spreads through slender, creeping rhizomes that grow horizon-tally within sandy or muddy substrates and produce fine fibrous roots, providing anchorage and initial sediment stabilization. The species commonly forms mixed meadows with other tropical seagrasses and often occurs in sheltered nearshore environments.

Leaves arise from short vertical shoots connected to the rhizome. Leaf blades are very narrow, linear, and needle like in appearance, typically 3-12 cm long, giving the plant a delicate morphology compared to other *Halodule* species. The leaf apices are simple and rounded or slightly pointed, lacking the trident-shaped tip characteristic of *Halodule uninervis*. Leaf size and density vary with depth, light availability, and nutrient conditions.

Reproductive Morphology *Halodule pinifolia* is dioecious, with male and female flowers occurring on separate plants. Flowers are minute, inconspicuous, and produced near the sediment surface, remaining enclosed within the leaf sheaths. Pollination is hydrophilous and occurs underwater, facilitated by water movement and local currents. Fruits are small, ovoid, and develop near the sediment surface. Each fruit usually contains a single seed enclosed within a firm pericarp, which protects the developing embryo from mechanical damage and environmental stress.

Distribution *Halodule pinifolia* is distributed throughout the tropical Indo-West Pacific region, including South and Southeast Asia, northern Australia, and parts of the western Pacific.

Ecology and Habitat *Halodule pinifolia* plays an important ecological role as an early colonizing species by stabilizing newly deposited sediments and facilitating the establishment of larger, late-successional seagrasses. Its meadows provide habitat for small invertebrates and juvenile fishes and contribute to nutrient cycling in shallow coastal ecosystems.



Cymodoceaceae

Syringodium isoetifolium

(Ascherson) Dandy, 1939

LC

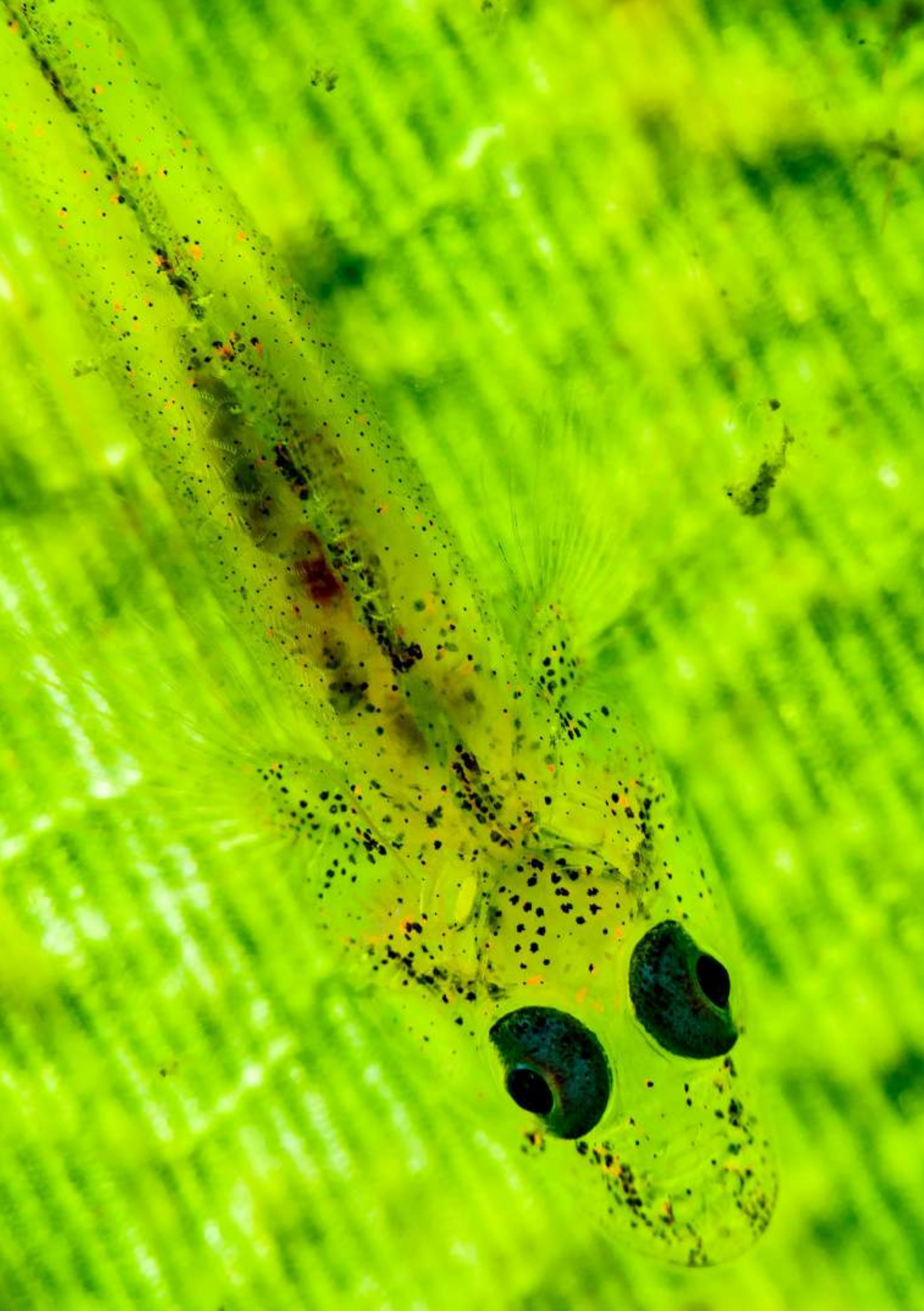
NT

Syringodium isoetifolium is a medium sized tropical seagrass species forming dense, continuous meadows in shallow coastal waters. It spreads through creeping rhizomes embedded in sandy or muddy substrates and produces fibrous roots that provide strong anchorage and effective sediment stabilization. The species commonly forms mixed meadows with *Cymodocea* and *Halodule* species, enhancing habitat complexity in nearshore environments. Leaves arise from short vertical shoots connected to the rhizome. Leaf blades are cylindrical, smooth, and spaghetti-like in appearance, typically 10-30 cm long, with rounded apices and internal air spaces that enhance buoyancy and light exposure. The distinctive tubular leaf morphology clearly differentiates this species from other tropical seagrasses with flat leaf blades. Leaf length and density vary with depth, water clarity, and nutrient availability.

Reproductive Morphology *Syringodium isoetifolium* is dioecious, with male and female flowers produced on separate plants. Flowers are small and inconspicuous, developing near the sediment surface within leaf sheaths. Pollination is hydrophilous and occurs underwater, facilitated by water movement and tidal currents. Fruits are small, ovoid to slightly elongated and develop close to the sediment surface. Each fruit contains one to a few seeds enclosed within a firm pericarp, which protects the developing embryo from physical damage and environmental stress. Seeds facilitate dispersal at local and regional scales, particularly during periods of strong water movement and storm events. Successful seedling establishment occurs primarily in stable sandy substrates, supporting recolonization of disturbed areas and maintenance of meadow continuity.

Distribution *Syringodium isoetifolium* is widely distributed throughout the tropical Indo-West Pacific region, including the eastern coast of Africa, the Red Sea, Indian Ocean islands, South and Southeast Asia, northern Australia, and many western Pacific Island systems. The species is common in coastal waters of Sri Lanka and the broader South Asian region, where it forms extensive meadows in lagoons, sheltered bays, and reef-associated environments. Its distribution is closely linked to warm, shallow tropical marine habitats with suitable sandy or muddy substrates.

Ecology and Habitat This species typically inhabits shallow subtidal and intertidal zones, particularly lagoons, sheltered bays, reef flats, and calm nearshore waters. It grows best on sandy to muddy substrates with good light availability and moderate water movement, although it can tolerate mild turbidity. *Syringodium isoetifolium* plays a major ecological role by stabilizing sediments, reducing coastal erosion, and providing nursery and feeding habitats for fish, invertebrates, and juvenile marine organisms. Its dense meadows support high epiphytic diversity and contribute significantly to primary productivity and carbon sequestration in tropical coastal ecosystems.



Ruppiaceae

Ruppia maritima

Linnaeus, 1753

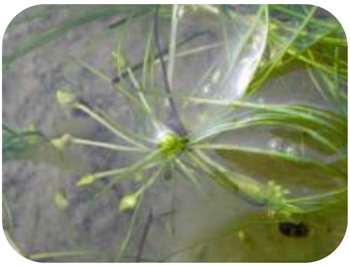
LC

LC

Ruppia maritima is a submerged aquatic angiosperm forming low growing, often patchy meadows in shallow coastal and brackish water environments. The plant possesses slender, creeping rhizomes that grow horizontally within soft muddy or sandy sediments and produce fine roots for anchorage. The rhizomatous growth form enables rapid vegetative spread and local persistence in dynamic coastal habitats. Leaves are alternate and filiform (thread-like), measuring approximately 5-20 cm in length, with smooth margins and no distinct midrib. The leaves are highly flexible and adapted to water movement, reducing mechanical damage in shallow waters. Leaf length and density vary according to salinity, nutrient availability, water depth, and turbidity.

Reproductive Morphology *Ruppia maritima* is predominantly monoecious, with male and female flowers borne on the same individual. Flowers are highly reduced and produced on elongated peduncles that can reach the water surface.

Pollination occurs at or near the water surface (epihydrophilous pollination), where pollen is transported by surface currents and capillary forces. Both sexual reproduction (by seeds) and asexual reproduction (by rhizome elongation and fragmentation) contribute significantly to population maintenance, genetic diversity, and recolonization after disturbance. The fruit is a small, ovoid to pear-shaped drupe containing a single seed with a hard seed coat. Seeds are capable of long-term persistence in sediments, forming seed banks that enhance population resilience following disturbances such as salinity fluctuations, desiccation, and physical damage to seagrass beds. Dispersal occurs by water currents and through ingestion and transport by waterbirds.



Distribution and ecology *Ruppia maritima* have a cosmopolitan distribution and is one of the most widely distributed seagrass species globally. It occurs in tropical, subtropical, and temperate coastal regions, including the Indo-West Pacific, Mediterranean Sea, Red Sea, Atlantic coasts of Europe and Africa, the Americas, and Australia. The species is commonly found in estuaries, lagoons, coastal ponds, and sheltered nearshore environments.

This species inhabits shallow coastal waters, estuaries, coastal lagoons, and brackish to hypersaline environments. It exhibits exceptional tolerance to salinity variation, ranging from nearly freshwater conditions to hypersaline lagoons, making it highly adaptable to fluctuating estuarine conditions. *Ruppia maritima* plays a key ecological role by stabilizing sediments, enhancing water clarity, and providing food and habitat for fish, invertebrates, and migratory waterbirds. It is an important primary producer and nursery habitat in estuarine ecosystems.

Glossary

Alismatales: An order of flowering plants containing several major seagrass families (including Hydrocharitaceae).

Allochthonous: Originating from a place other than where it is found; referring to carbon or nutrients brought into the meadow by external wave or current action.

Angiosperms: Flowering plants that produce seeds enclosed within a fruit; seagrasses represent the only fully submerged marine angiosperms.

Anoxic: An environment heavily depleted of or entirely lacking oxygen, typical of deep marine and lagoon sediments.

Autotrophy: The biological process by which organisms (like seagrasses) synthesize their own food from inorganic substances using light.

Benthic: Relating to or occurring at the bottom of a body of water, including the sediment surface and sub-surface layers.

Biofilms: A complex, thin layer of microorganisms (like diatoms and bacteria) that adhere to and grow on submerged surfaces such as seagrass leaves.

Biotic Dispersal: The spread or transport of seeds or pollen facilitated by living organisms, such as crustaceans, sea turtles, or dugongs.

Blue Carbon: The carbon captured by the world's coastal ocean ecosystems, primarily stored long-term in the sediments underlying seagrass meadows, salt marshes, and mangroves.

Clonal Growth: Asexual reproduction achieved through the horizontal extension of rhizomes, generating genetically identical daughter shoots (ramets).

Denitrification: The microbially facilitated process of reducing nitrates/nitrites into harmless nitrogen gas, removing excess nutrients from the ecosystem.

Detritivores: Organisms that obtain nutrients by consuming detritus (decomposing plant and animal matter).

Dioecious: A reproductive strategy where male and female flowers are borne on completely separate individual plants.

eDNA (Environmental DNA): Trace DNA released by organisms into their environment (e.g., seawater) that is collected and sequenced to monitor biodiversity.

Endophytes: Microorganisms, such as fungi or bacteria, that live entirely within the internal tissues of plants without causing apparent disease.

Epibenthic: Organisms that live on the surface of the bottom sediments in an aquatic environment.

Epiphyte: An organism (such as microalgae, small crustaceans, or biofilms) that grows upon the surface of a plant, typically seen coating seagrass blades.

Eutrophication: The excessive enrichment of a water body with minerals and nutrients (usually nitrogen and phosphorus), frequently inducing rapid algal blooms and subsequent oxygen depletion.

Halos: Distinct, barren patches of sand cleared around reefs or seagrass beds due to the intense foraging behavior of concentrated herbivores (e.g., sea urchins).

Hydrophily (Hydrophilous Pollination): A specialized form of pollination where pollen is dispersed and transported entirely by water currents.

Hypoxia: A condition of low dissolved oxygen concentrations in a water body, often leading to die-offs of marine life.

Infauna / Infaunal: Aquatic animals that live within the bottom substratum or burrow into the sediments beneath the water.

Meiofauna: Microscopic benthic invertebrates that live in both marine and fresh water environments, typically dwelling in the interstitial spaces between sediment grains.

Monoecious: A reproductive characteristic where both male and female reproductive structures are found on the same individual plant.

Monocotyledons: A class of flowering plants characterized by having a single cotyledon (embryonic leaf) within the seed; all seagrasses are monocotyledons.

Phenotypic Plasticity: The ability of a single genotype to produce different physical traits (like thicker leaves or deeper roots) in response to differing environmental conditions.

Polyphyletic: A grouping of organisms derived from more than one common ancestor; indicating that seagrasses evolved their marine traits independently multiple times.

Porewater: The water filling the interstitial spaces between sediment particles in the seabed.

Potamogetonales: An order of aquatic flowering plants to which several important seagrass families belong.

Ramets: Independent, but genetically identical individual shoots that are part of a larger clonal plant colony, formed via vegetative propagation.

Refractory Carbon: Organic carbon that resists microbial degradation and remains stably trapped in sediments over long geological periods.

Rhizome: A continuously growing, horizontal underground stem that puts out lateral shoots and adventitious roots, forming the structural foundation of a seagrass meadow.

Viviparous: A reproductive mechanism where seeds or embryos germinate and develop into seedlings before detaching from the parent plant.

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Index

PROJECT GREENER WAVE

The **PROJECT GREENER WAVE**, initiated under the Youth Climate Ambassador 2025 programme, is an initiative dedicated to restoring sea grass ecosystems in Sri Lanka. Central to the project is a laboratory-based sea grass culture system, which serves as the initiative for restoring these critical underwater plants. In addition, community-based awareness programmes were conducted to educate communities about the ecological significance of sea grass ecosystems and the importance of protecting them.

This comprehensive guide is part of the Greener Wave Project and serves as a detailed visual and descriptive reference for sea grass species in Sri Lanka, their distribution patterns, ecological roles, and the challenges they face. Designed for researchers, coastal managers, educators, and students, the guide also provides insights into conservation practices and encourages informed, collective action to safeguard these ecosystems for future generations.

The Youth Climate Ambassador 2025 programme is a flagship initiative led by the British Council Sri Lanka, in partnership with the Earth Lanka Youth Network and Sevanatha. It is designed to identify, train, and empower young leaders across the country to take proactive climate action at the community, local, and national levels. Thru this programme, participants gain the knowledge, skills, and platforms to drive environmental awareness, implement sustainable projects, and influence policy decisions, fostering a generation of informed, committed, and impactful climate advocates.

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