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CHAPTER 5

Seagrass ecosystems in Malaysia

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Abstract: Seagrass meadows are widely distributed along the shallow coasts of Malaysia and provide important ecological functions that supports biodiversity and coastal livelihoods. Malaysia also supports 17 species of seagrass, with highest recorded species richness in southern Peninsular Malaysia and eastern Sabah (14 species), although national estimates of the extent of seagrass meadow remain uncertain due to uneven survey coverage and limited long-term monitoring efforts. Available evidence indicates permanent losses and major contractions of seagrass meadows associated primarily with coastal development, seabed filling, dredging, and declining water quality. The protection of seagrass is still mostly indirect and often incidental, with management responses being reactive and species-driven, with seagrass commonly protected indirectly through Marine Parks and broader coastal conservation frameworks rather than integrated into coastal planning and management. The Sibu-Tinggi Archipelago, Johor and Kampung Kebagu, Sabah case studies illustrated in this study highlights the contrasting conservation outcomes and importance of sustained research and preventive management.

INTRODUCTION

Seagrass meadows occur widely along Malaysia's shallow coasts, forming highly productive ecosystems that support fisheries, coastal livelihoods, and marine biodiversity. They are found in estuaries, lagoons, nearshore flats, and around islands, where they are closely linked to mangroves and coral reefs as part of connected coastal systems. These meadows provide nursery and feeding habitat for fish and invertebrates and support gleaning and small-scale fisheries on which many coastal communities depend. They also serve as critical habitat for endangered megafauna such as dugongs and green turtles.

Malaysia spans two major marine regions—the Sunda Shelf and the western edge of the Coral Triangle—contributing to relatively high seagrass diversity compared to many countries in the region. Despite this ecological importance, seagrass meadows remain unevenly documented and weakly integrated into coastal planning and management. Clear information on their distribution, condition, and trajectories is therefore essential for assessing the current state of Malaysia's coastal ecosystems and informing decisions that prevent irreversible loss.

At the national scale, assessment of seagrass remains constrained by uneven mapping and limited long-term monitoring, yet available evidence shows that permanent losses and major contractions have already occurred. Coastal development, seabed filling, dredging, and declining water quality are the most consistent pressures, while conservation responses remain largely reactive and fragmented.

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SITUATIONAL ANALYSIS

Distribution and extent

Seagrasses occur along much of Malaysia's coastline in shallow, sheltered waters with soft substrates and adequate light, and are absent from rocky or high-energy coasts (Figure 1). They form both intertidal and subtidal meadows across coastal settings including estuaries and deltas, semi-enclosed lagoons, reef-associated flats, open coastal flats, and offshore shoals (e.g. Bujang *et al.* 2006; Ooi *et al.* 2011b).

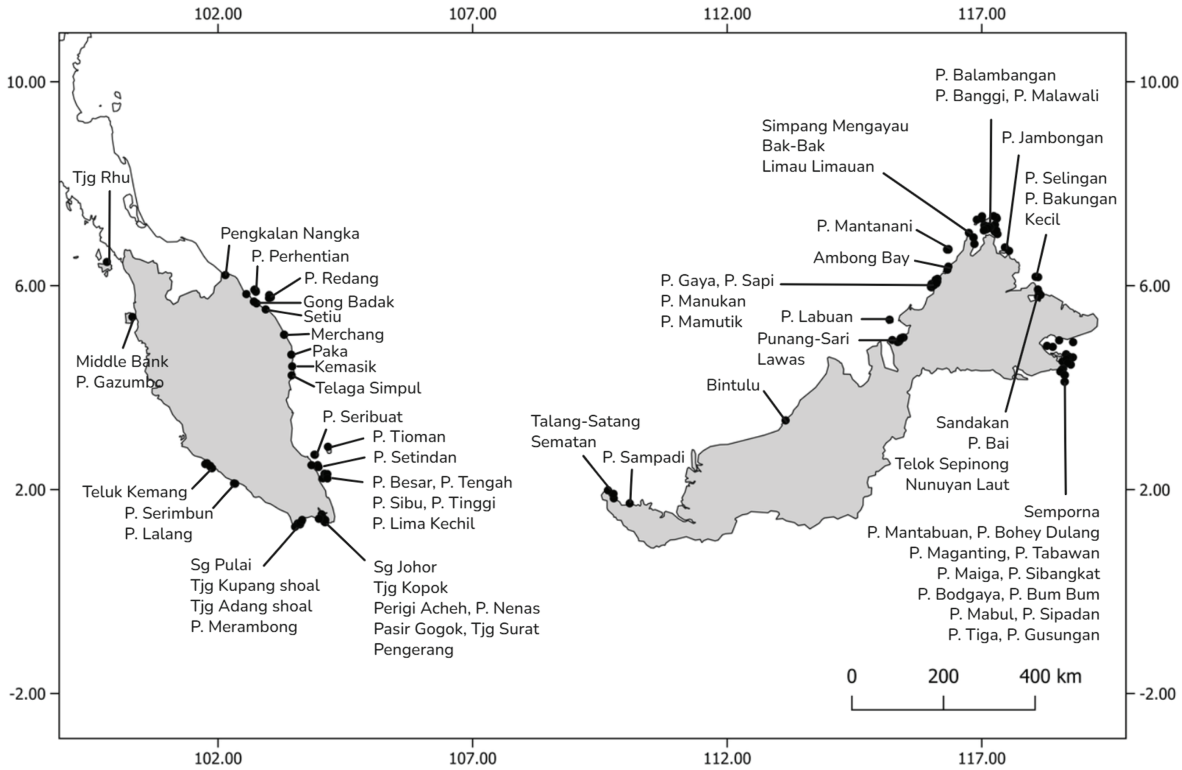

Figure 1. Map of verified seagrass occurrence records in Malaysia, showing 205 point locations compiled from 59 peer-reviewed papers and technical reports published between 2000 and 2025. Areas without points reflect gaps in survey coverage and data availability rather than confirmed absence of seagrass. "P." denotes Pulau (Malay for "island").

National-scale mapping remains incomplete. The most recent verified estimate of approximately 49 km^2 (Sudo *et al.* 2021) almost certainly underrepresents true national extent, particularly in Sarawak. In contrast, substantially larger figures reported in global datasets (e.g. 5,581 km^2 in Thorhaug *et al.* 2020) lack Malaysia-specific validation.

Seagrass meadows in Malaysia vary widely in size, with a small number of well-documented sites providing important anchors for national understanding. The largest documented meadow occurs in the Sibu Archipelago (Johor), where a continuous subtidal system covers approximately 12.88 km^2 (Heng *et al.* 2022). Among intertidal systems, the most extensive meadow is found in the Lawas region of Sarawak, estimated at around 2 – 3 km^2 (Bujang *et al.* 2006). In Sabah, significant seagrass areas have been mapped around Banggi Island, where multiple subtidal sites together support approximately 4.15 km^2 of seagrass (Rajamani and Marsh 2015). Beyond these locations, seagrass mapping

has been spatially uneven and largely focused on intertidal habitats, with subtidal meadows remaining a major knowledge gap due to the need for in-water surveys. A national intertidal seagrass mapping programme funded by Yayasan PETRONAS, initiated in 2025, is expected to substantially improve coverage and area estimates for Peninsular Malaysia and Sabah.

Species richness and diversity

Located within the Indo–West Pacific, one of the global centres of seagrass diversity, Malaysia supports a relatively high diversity of seagrass species, with 17 species recorded nationally (Table 1). Species richness varies regionally, reflecting differences in coastal geomorphology, water clarity, and survey effort. The south coast of Peninsular Malaysia and east coast of Sabah show the highest recorded richness, each supporting up to 14 species. In contrast, Sarawak exhibits lower recorded richness, reflecting limited survey coverage rather than confirmed absence.

At the site level, areas of high richness are concentrated in Johor and Sabah. The Sibu–Tinggi archipelago supports up to 12 species (Ooi *et al.* 2011b, 2017), while the Sungai Pulai estuary has recorded 10 – 12 species, but with evidence of species loss over time (Bujang and Zakaria 2014; Che Alias *et al.* 2024). In East Malaysia, Pulau Banggi and Pulau Gaya (Sabah) support around 10 species, while Lawas (Sarawak) records approximately eight species (Bujang *et al.* 2006; Ahmad-Kamil *et al.* 2013; Rajamani and Marsh 2015).

Most Malaysian seagrass species are classified as Least Concern (Table 1); however, *Halophila beccarii* is listed as Vulnerable due to habitat degradation, and emerging evidence of decline in *Enhalus acoroides* indicates growing conservation concern despite being in the Least Concern category (IUCN 2024).

Ecological Functions and Services

Seagrass meadows function as important nursery and feeding habitats for fish and invertebrates, supporting nearshore fisheries and coastal food webs. Malaysian seagrass meadows are used by commercially important demersal and nearshore fishes, including emperors (Lethrinidae) and threadfin breams (Nemipteridae), and support high densities of juvenile fishes, reinforcing their role as nursery grounds contributing to fisheries productivity (Arshad *et al.* 2006; Ho *et al.* 2018; Ho 2019).

Seagrass meadows also contribute to coastal environmental quality by reducing turbidity, stabilising sediments, and improving nearshore conditions (Japar Sidik and Bujang 2006; Lamb *et al.* 2017). Structurally large species such as tape seagrass (*Enhalus acoroides*) play an important role in sediment stabilisation in shallow systems, including in Penang (Nur Asilah 2020). Malaysian seagrass meadows further contribute to blue carbon storage, although available estimates are limited and likely conservative (Rozaimi *et al.* 2017).

In addition, seagrass meadows are key foraging habitats for endangered megafauna such as dugongs and green turtles, and support coastal livelihoods through intertidal gleaning and small-scale fisheries, particularly for women (Affendi *et al.* 2005; Ponnampalam *et al.* 2015; Heng *et al.* 2022; Nishizawa *et al.* 2023; David *et al.* 2024). Socio-economic valuation suggests substantial livelihood and non-market benefits, conservatively estimated at at least US$57,000 per hectare per year in Sungai Pulai, although such assessments remain geographically limited (Rahman and Yaakub 2020).

Table 1. Seagrass species in Malaysia by region. IUCN Red List Categories in increasing order of extinction risk - LC Least Concern, NT Near Threatened, VU Vulnerable.

No.	Family/Species	IUCN Red List Category	West Peninsular Malaysia	East Peninsular Malaysia	South Peninsular Malaysia	West Sabah	East Sabah	North Sabah	Sarawak
	Family Hydrocharitaceae								
1	*Enhalus acoroides* (Linnaeus *f.*) Royle	LC	√	√	√	√	√	√	√
2	*Thalassia hemprichii* (Ehrenb.) Aschers.	LC	√	√	√	√	√	√	√
3	*Halophila beccarii* Aschers.	VU		√	√				√
4	*Halophila decipiens* Ostenfeld	LC	√	√	√		√	√	√
5	*Halophila major* (Zoll.) Miquel	LC		√	√		√	√	
6	*Halophila minor* (Zoll.) den Hartog	LC		√	√	√	√	√	√
7	*Halophila ovalis* (R. Br.) Hook. *f.*	LC	√	√	√	√	√	√	√
8	*Halophila nipponica* J. Kuo.	NT			√				
9	*Halophila spinulosa* Aschers.	LC	√	√	√		√	√	
10	*Halophila tricostata* M.Greenway	LC					√		
	Family Cymodoceaceae								
11	*Cymodocea rotundata* Ehrenb. & Hempr. ex Aschers.	LC	√	√	√	√	√	√	√
12	**Oceana serrulata* (R. Br.) Byng & Christenh.	LC	√	√	√	√	√	√	√
13	*Halodule pinifolia* (Miki) den Hartog	LC	√	√	√	√	√	√	√
14	*Halodule uninervis* (Forssk.) Aschers.	LC	√	√	√	√	√	√	√
15	*Syringodium isoetifolium* (Ashers.) Dandy	LC	√	√	√		√	√	
16	*Thalassodendron ciliatum* (Forssk.) den Hartog	LC					√		
	Family Ruppiaceae								
17	*Ruppia maritima* Linnaues	LC	√						
	Total Species		12	13	14	8	14	12	10
	Total Species by Region			15			14		10

*Previously *Cymodocea serrulata* (R. Br.) Aschers. Magnus.

STATUS AND TRENDS

The national status of seagrass ecosystems in Malaysia remains difficult to resolve due to uneven spatial coverage and limited long-term observations. Nevertheless, there is clear evidence that seagrass meadows have been permanently lost at multiple locations. Entire meadows have been eliminated following coastal development, dredging, sand mining, and land reclamation, with documented losses in Johor, Terengganu, Kelantan, and Negeri Sembilan (Bujang *et al*. 1999, 2016; Zakaria *et al.* 2025). These records demonstrate that seagrass loss in Malaysia is real, substantial, and often irreversible.

In addition to complete losses, several large meadows have undergone substantial contraction, including reductions by half and more at Pengkalan Nangka Lagoon (Kelantan), Telaga Simpul (Terengganu), and Tanjung Adang Laut (Johor), as well as marked declines at Paka Lagoon (Terengganu) and the Punang–Sari Lawas River Estuary (Sarawak), driven by combinations of coastal development, sediment disturbance, and natural sand dynamics (Bujang and Zakaria 2014; Hossain *et al.* 2015; Zakaria *et al*. 2025).

At the same time, seagrass meadows can exhibit pronounced variability within annual cycles, particularly in monsoon-influenced systems that experience light limitation and sediment dynamics. Studies from both intertidal and subtidal environments show that meadow extent and cover can fluctuate markedly within a single year without necessarily indicating sustained decline. Seasonal contraction and partial recovery have been documented in subtidal meadows of the Sibu–Tinggi archipelago and in intertidal systems in Tanjung Kopok (Johor) and Lawas (Sarawak) (Ahmad-Kamil *et al.* 2013; Ooi and Lim 2019; Heng *et al.* 2022; Ooi *et al.* 2024a), underscoring the need to distinguish seasonal variability from persistent loss when interpreting monitoring data.

Drivers of change and pressures

In Malaysia's intertidal systems, the strongest evidence of seagrass loss is linked to human-driven drivers, particularly coastal development, dredging, and seabed infilling (Table 2). In Sungai Pulai (Johor), shoreline modification and dredging have caused long-term reductions in seagrass extent through altered sediment transport, burial, and reduced light availability (Bujang and Zakaria 2014; Hossain *et al.* 2019), processes known to constrain recovery following disturbance (Ooi *et al.* 2011a). Similar land-based pressures occur in Sabah, where catchment disturbance and infrastructure development have increased sediment inputs and reduced light availability, including within protected areas (Freeman *et al.* 2008).

Natural forcing also shapes intertidal dynamics. At Kampung Kebagu (Sabah), seagrass cover declines during the Northeast Monsoon but recovers during calmer periods, indicating short-term variability (Hassan *et al.* 2025), although episodic extreme events such as the 2015 Sabah earthquake and repeated exposure to adverse conditions have since been associated with more persistent loss in nearby systems such as Usukan Bay.

Water-quality degradation further compounds stress. Elevated nutrients, turbidity, and pollutants are associated with declining seagrass condition at Sungai Johor, Lawas (Sarawak), and parts of Sabah (Freeman *et al.* 2008; Ahmad-Kamil *et al.* 2013; Ooi *et al.* 2024a). Localised physical disturbance, particularly boat anchoring and propeller scarring, damages shoots and rhizomes and disproportionately affects large, slow-growing species such as *Enhalus acoroides*. Additional damage may occur when leaves are manually torn to prevent propeller entanglement, further reducing canopy integrity.

Subtidal meadows such as Pulau Sibu (Johor), within a marine protected area, are shaped primarily by monsoon-driven hydrodynamics, with waves and currents driving cycles of contraction and re-establishment (Ooi *et al.* 2014; Ooi and Lim 2019; Heng *et al.* 2022). In parts of Sabah, destructive fishing practices, including blast fishing, remain an additional pressure on nearshore seagrass habitats (Showen *et al.* 2018).

Table 2. Summary of major drivers of seagrass change in Malaysia, the pressures through which they act, and observed ecological effects at representative sites.

Driver	Pressure	Key Sites	Observed Effects
Coastal development & land reclamation	Dredging, infilling, direct habitat removal, altered sediment transport	Johor: Sungai Pulai (Merambong, Tanjung Adang Laut, Tanjung Adang Darat)	Long-term loss of intertidal seagrass extent
Catchment disturbance & land-use change	Sediment runoff, turbidity, reduced light availability	Johor: Sungai Pulai; Sungai Johor Sabah: Tunku Abdul Rahman Park	Seagrass loss or delayed recovery due to light limitation
Poor water quality management	Elevated nutrients and industrial pollutants	Johor: Tanjung Kopok; Perigi Acheh Sarawak: Lawas	Reduced seagrass cover, shortened canopy height, algal dominance
Boating and vessel traffic	Physical damage from anchoring and propeller scarring	Johor: Pulau Sibu (subtidal, MPA)	Localised scarring and loss of seagrass cover and biomass
Monsoon climate variability	Strong waves and currents causing physical disturbance	Johor: Pulau Sibu (subtidal, MPA)	Seasonal to multi-year contraction and re-establishment
Episodic extreme events	Acute sediment discharge and turbidity following natural disturbances	Sabah: Usukan Bay (post-2015 earthquake)	Localised seagrass loss associated with short-term sediment loading

CONSERVATION AND MANAGEMENT OVERVIEW

Seagrass conservation in Malaysia has evolved through a series of overlapping initiatives rather than a coordinated national framework. Early work focused on inventory and use, while later studies—particularly those linked to dugong research—brought seagrass into conservation discussions (Affendi *et al.* 2005; Ponnampalam *et al.* 2015; Heng *et al.* 2022) and, as recently seen in Pahang, triggered immediate restrictions on tourism (Ooi *et al.* 2024b). Despite this, translation into formal, lasting protection has been limited by legislative and governance constraints.

At present, seagrass is still mostly protected indirectly, with about 15% of mapped meadows falling within Marine Parks or Ramsar sites (Sudo *et al.* 2021). While seagrass has gained some recognition through broader ecosystem-based planning frameworks, including marine protected areas and the Important Marine and Coastal Areas programme (WWF Malaysia & MSMS 2024), protection is often incidental, and management responses tend to be reactive and species-driven rather than part of routine planning and regulation.

Notably, community-based monitoring has raised the profile of seagrass and generated useful site-level knowledge, particularly in Johor meadows since the late 2000s. However, these efforts remain weakly linked to formal management and regulatory processes, limiting their influence on planning and regulatory decisions.

Knowledge gaps

Despite growing research attention, significant knowledge gaps continue to constrain effective seagrass conservation and management in Malaysia.

1. Spatial data gaps and uneven geographic coverage

Seagrass distribution data remain spatially incomplete and geographically uneven, with major gaps in Sabah and Sarawak despite known occurrences. Existing maps are largely derived from site-specific or opportunistic surveys—mostly in Johor—limiting confidence in national-scale estimates of meadow extent, richness, and representativeness.

2. Limited long-term data to assess seagrass condition and trends

Malaysia lacks sustained, standardised data frameworks to track seagrass condition over time. Consequently, long-term trends in meadow condition, species composition, and responses to interacting pressures remain poorly understood. Most monitoring efforts have been short-lived, constraining the detection of cumulative change and comparison of trajectories across sites.

3. Limited data on ecosystem functions and services to humans

Although the ecological importance of seagrass meadows is widely recognised, empirical data on functions of direct policy relevance—such as fisheries support, coastal protection, and carbon sequestration—remain limited. Socio-ecological dimensions, including livelihood dependence, gendered use, and cultural values, are unevenly documented and rarely integrated with biophysical datasets.

4. Limited scientific evidence to guide seagrass restoration

Seagrass restoration has gained rapid momentum as a preferred response to meadow loss, often in the absence of Malaysia-specific scientific evidence to guide practice. Key uncertainties remain around site suitability, physical constraints, and long-term persistence in tropical multi-species meadows, compounded by the lack of sustained post-restoration monitoring. In this context, ad hoc restoration efforts, which commonly involve removal of plant material from existing meadows and are undertaken without ecological guidance, risk harming donor sites and adding pressure to remaining seagrass rather than supporting recovery.

Case studies

The following case studies illustrate contrasting pathways of seagrass conservation in Malaysia: one shaped by long-term research informing conservation recognition, and another documenting rapid loss in a highly exposed system.

Sibu-Tinggi Archipelago, Johor, Peninsular Malaysia

The shallow waters of the Sibu–Tinggi archipelago off Mersing support some of the largest subtidal seagrass meadows in Peninsular Malaysia. Pulau Sibu alone supports a continuous meadow of approximately 12.9 km^2, the largest recorded nationally, while Pulau Tinggi supports a second large meadow of about 3 km^2 (Ooi *et al.* 2011b; Heng *et al.* 2022). Unlike the intertidal systems more commonly studied in Malaysia, these are permanently submerged forereef meadows occurring mainly at depths of about 3 to 6 metres, close to the lower light limits for seagrass growth (Ooi 2012).

The meadows are dominated by small, fast-growing species such as *Halophila ovalis* and *Halodule uninervis*, which are preferred forage for dugongs. Long-term research has identified the archipelago as an important dugong feeding ground, with repeated use by individuals including mother-calf pairs (Affendi *et al.* 2005; Ponnampalam *et al.* 2015; Heng *et al.* 2022).

Ecological studies show that these subtidal meadows are highly sensitive to disturbance. Because they occur near their light thresholds, they undergo cycles of contraction during turbid periods and partial recovery when conditions improve, while even shallow burial of centimetres can cause rapid local loss (Ooi *et al.* 2011a, 2014; Ooi and Lim 2019). As a result, disturbance can have lasting spatial effects even when overall meadow extent appears stable.

Sustained research in the Sibu–Tinggi archipelago has directly informed conservation planning, contributing to its recognition under Malaysia's Important Marine and Coastal Area (MyIMCA) framework (Ooi and Adam 2024). This case illustrates how long-term ecological evidence can support proactive identification of nationally significant seagrass systems.

Kampung Kebagu, Sepanggar Bay, Kota Kinabalu, Sabah

Kampung Kebagu in Sepanggar Bay once supported one of the most extensive remaining intertidal seagrass meadows near Kota Kinabalu. The shallow meadow was exposed to both monsoonal forcing and coastal pressures, and earlier surveys recorded up to seven seagrass species, including *Enhalus acoroides*, *Cymodocea* spp., *Thalassia hemprichii*, *Halodule uninervis* and *Halophila* spp. (Phang 2000; Bujang *et al.* 2006; Thomas 2023).

Monitoring conducted in 2023 documented pronounced seasonal fluctuations in seagrass cover linked to monsoon cycles, alongside an overall decline in meadow condition and loss of *T. hemprichii* and *H. pinifolia* (Hassan *et al.* 2025). Cover decreased substantially during the Northeast Monsoon, recovered during calmer periods, and then declined sharply again by early 2024. Severe seabed erosion and prolonged exposure followed, and by late 2024 the meadow was largely lost. By 2025, only small, patchy remnants of *H. uninervis* and *H. ovalis* remained, with no clear signs of recovery.

At Kampung Kebagu, the combination of shallow depth, tidal exposure, and repeated extreme weather left little scope for recovery once the meadow was lost. This case highlights how exposed intertidal seagrass systems can cross irreversible thresholds when climate -driven stress interacts with local pressures.

CHALLENGES AND OPPORTUNITIES

Seagrass management in Malaysia is shaped by fragmented institutional responsibility across agencies responsible for fisheries, environment, coastal development, and marine protected areas, alongside the absence of a nationally coordinated seagrass inventory and long-term monitoring framework. As a result, national estimates of seagrass extent remain uncertain, the capacity to detect long-term change is limited, and large areas of Sabah and Sarawak remain poorly surveyed despite confirmed seagrass occurrence.

Research and monitoring efforts are largely project-based and short-term, with limited coordination among government agencies, universities, and non-governmental organisations. Monitoring conducted under Environmental Impact Assessment (EIA) and Environmental Management Plan (EMP) requirements is not always easily accessible, reducing continuity and uptake into planning and management decisions.

Despite their ecological importance, seagrass meadows remain weakly recognised in national policy and coastal planning. They are rarely treated as priority habitats in environmental impact assessment or marine spatial planning, and where protection exists it is often incidental, leaving many meadows exposed to pressures from coastal development, seabed filling, dredging, and declining water quality.

At the same time, new opportunities are emerging. Growing interest from industry and private funders, linked to increasing recognition of seagrass as a climate-relevant ecosystem, could support longer-term monitoring and help address key data gaps if channelled through coordinated frameworks. Community-based monitoring and local ecological knowledge also offer practical ways to strengthen conservation by complementing scientific surveys, particularly where institutional capacity is limited.

Policy recommendations

In Malaysia, seagrass conservation needs to be preventive and planning-led, rather than driven by reactive, project-by-project responses. These recommendations emphasise a precautionary approach and coordinated decision-making to avoid irreversible seagrass loss:

1. Apply precautionary limits on seabed filling/land reclamation affecting seagrass

Given strong evidence of sustained seagrass loss linked to seabed filling (land reclamation) and associated dredging, particularly in estuarine and intertidal systems, states should apply time-bound or site-specific moratoria on seabed filling affecting seagrass meadows until adequate baseline data, cumulative impact assessments, and clear avoidance options are available. These measures are likely to face resistance in development-intensive states, but local evidence indicates that once seagrass is buried or fragmented, recovery at meaningful scales is unlikely.

2. Prioritise avoidance of high-value seagrass and define clear no-go areas

Where development is proposed near seagrass, planning should prioritise avoidance of high-value meadows and minimise unavoidable impacts, with restoration or offsets treated only as last-resort measures. No-go areas should include large continuous meadows, sites supporting threatened megafauna, and seagrass areas critical for ecological connectivity, sediment stabilisation, and long-term carbon storage.

3. Make seagrass explicit in coastal planning and EIA decision rules

Seagrass meadows should be explicitly recognised as priority coastal habitats in national and state coastal plans, Environmental Impact Assessment (EIA) guidance, and marine spatial planning layers, so they are considered early in development decisions rather than incidentally or after impacts occur.

4. Address water quality and sediment inputs as core seagrass pressures

Seagrass conservation should be explicitly linked to catchment and coastal water-quality management, recognising that sedimentation, turbidity, and nutrient inputs are major drivers of seagrass decline beyond the meadow itself.

5. Fund long-term, standardised monitoring and cumulative assessment

A nationally endorsed monitoring framework should be established and supported over multiple years to distinguish seasonal variability from sustained decline and to enable cumulative impact assessment in development hotspots, integrating spatially explicit seagrass data from multiple sectors using standard methods and scheduled updates so outputs are directly usable in planning and EIA processes.

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