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CHAPTER 21

State of nature conservation of mangroves in Malaysia

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Abstract: Malaysia's mangroves are ecologically rich and socioeconomically vital coastal ecosystems, not only supporting biodiversity, but also fisheries, shoreline protection, and climate regulation. This chapter reassesses their status since 1991, highlighting improved knowledge, expanded protection, and increased recognition of ecosystem services, including the now "popular" blue carbon. Despite restoration progress, mangroves continue to decline due to multiple anthropogenic threats, including urbanisation, agriculture and aquaculture expansion, pollution, and climate change, with recent losses outpacing gains from restoration. Current challenges include inconsistent mapping, and ineffective restoration practices and governance. Moving forward, integrated management, ecosystem-based restoration, community stewardship, and coherent national policies are essential to ensure resilient, biodiversity-rich and most importantly, functional mangrove ecosystems for Malaysia's sustainable future.

INTRODUCTION

Mangroves occupy a narrow niche at the land-sea interface that is both ecologically and economically important. In Malaysia, mangrove ecosystems have long supported coastal livelihoods, fishery production, sustainable forestry (i.e., in Matang Mangrove Forest Reserve – MMFR), shoreline stability, and a rich coastal biodiversity. In the 1991 *State of Nature Conservation* (SoNC) assessment, Ong and Gong (1991) described Malaysia's mangroves as being "*extremely productive… (yet) being reclaimed or extirpated for alternative use at an alarming rate*". They highlighted widespread clearing of mangroves for infrastructure development (e.g., airports, ports and reservoirs), agriculture, aquaculture (especially for tiger prawn *Panaeus monodon*) and timber products (e.g., woodchip, poles and charcoal). In addition, fragmented governance hampered the gazettement of mangroves as protected areas, and there were fundamental gaps in our understanding of the ecological processes and values of Malaysian mangroves (Ong and Gong 1991). At that time, mangroves covered ca. 2% of Malaysia's total land area (650,000 ha), with losses in Peninsular Malaysia estimated at 20% over the past two decades. No mangroves have been gazetted for conservation, i.e. as national parks (Ong and Gong 1991).

More than three decades later, Malaysia remains among the top mangrove nations globally, though the anthropogenic pressures identified in 1991 persist in new and evolving forms. Encouragingly, ecological functions are better understood, there is a new-found momentum in mangrove restoration and mangroves have entered national and international agendas on climate change and biodiversity conservation. However, continued mangrove loss, inconsistencies in mapping (which affects governance), fragmented institutional mandates, and the uneven quality of restoration still undermine conservation gains. In this 2025 *State of Nature Conservation*, we reassess the status, values, pressures, governance, and future pathways for mangroves in Malaysia. We compare national trends to global trajectories presented in the *State of the World's Mangroves* (Leal and Spalding 2024), while explicitly revisiting and responding to the unanswered questions posed by Ong and Gong (1991).

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EXTENT, DISTRIBUTION AND STATUS

Malaysia is home to the third and sixth largest extent of mangrove habitat worldwide according to estimates from Mangrove Forests of the World (Hamilton and Casey 2016) and Global Mangrove Watch (Bunting *et al.* 2022), respectively. In Southeast Asia, our mangrove extent is second only to Indonesia (Hamilton and Casey 2016; Bunting *et al.* 2018). Recent remote-sensing estimates of our national mangrove coverage ranges from 469,000 ha in *Mangroves of the World*, to 552,000 ha in *Global Mangrove Watch* and 587,000 ha in *Status of Mangroves in Malaysia* (Omar 2024). These discrepancies likely arise from differences in classification approaches, spatial resolution, and treatment of degraded or regenerating stands. Mangroves are unevenly distributed across the country, with east Malaysia hosting more than 60% of the country's mangroves. Major mangrove complexes are dominated by deltaic and estuarine systems, mainly distributed in Lower Kinabatangan-Segama Wetlands in Sabah, Rajang-Belawai-Paloh delta and Kuching Wetlands National Park in Sarawak, Matang in Perak, Klang Islands Mangrove Forest Reserve in Selangor, Sungai Merbok Mangrove Forest Reserve in Kedah, and Sungai Pulai Mangrove Forest Reserve in Johor.

Since the early 1990s, Malaysia has experienced a net decline in mangrove forest cover, with national estimates indicating persistent loss in recent years. Global datasets suggested a sharp decline in the rate of loss as compared to the last century, with approximately only 3 – 6% of mangroves being lost over 2000 – 2012 (Hamilton and Casey 2016; Richards and Friess 2015). However, these apparent gains in slowing loss rates should not be interpreted as a signal of security, as Malaysia is clearly not out of the woods yet. Recent national data pointed towards a 7% mangrove loss over just six years (2017 – 2023), with 80% of this loss being recorded in Sabah alone due to urbanisation, industrialisation and residential expansion (Omar 2024). Though global patterns demonstrate that losses are increasingly counterbalanced by localised gains due to natural sediment accretion, landward migration, and mangrove restoration (Leal and Spalding 2024), in Malaysia the overall decline in mangrove forest cover outweighed the gains (Omar 2024). Reversing this trajectory will require urgent action to reduce ongoing human pressures, improve land-use planning and prioritise ecosystem restoration (Friess *et al.* 2020).

The silver lining is that the protection of mangroves in Malaysia has expanded considerably since the 1990s. Unlike in the 1991 SoNC assessment, prominent mangrove areas in the country are now protected under a diverse designation, including forest reserves, Ramsar sites, wildlife sanctuaries, and national and state parks (Table 1). According to *Status of Mangrove in Malaysia*, 94% of mangroves are gazetted as Permanent Reserved Forests in Malaysia under the National Forestry Act 1984 (Omar 2024). Malaysia now hosts six Ramsar sites with mangrove ecosystems (Table 1), recognised as "Wetlands of International Importance", with Kuala Gula–Matang area proposed as the country's 8th Ramsar site (Azhari and Hassan 2021). Furthermore, two mangrove areas are included in the Kilim Karst Geoforest Park and the Penang Hill Biosphere Reserve, designated under the UNESCO Global Geopark and UNESCO Man and Biosphere Programmes, respectively. Collectively, these designations reflect strong and growing national and international recognition of the ecological and cultural importance of mangroves in Malaysia. Though a welcomed development that signified a pivotal mindset change (from production to protection), formal designation does not necessarily equate to effective conservation. Mangrove loss and degradation continue to occur within PFRs, driven mostly by development pressures at boundaries (Wong *et al.* 2020; Lucas *et al.* 2021; Omar 2024). Furthermore, Malaysia lacks a consolidated national mangrove protected-area map, resulting in inconsistencies across Federal reports, State inventories, and global databases. Hence, while Malaysia has made meaningful progress in formally protecting mangroves, the conservation status of mangroves ultimately depends not on coverage alone, but on ecosystem integrity and governance coherence.

Table 1. Prominent protected areas in Malaysia where mangroves are a primary or significant habitat.

State	Protected area	Approximate area (ha)	State-level	International -level
Kedah	Sungai Merbok Mangrove Forest Reserve	4,000 ha	√	
	Kilim Karst Geoforest Park (Langkawi UNESCO Global Geopark) / Kisap Forest Reserve 500-million-year-old coastal karst ecosystem coexisting with mangroves.	10,000 ha (includes mangroves)	√	√
Penang	The Penang Hill Biosphere Reserve A model for harmonising urban development with conservation from the hilltop to the sea (including mangrove ecosystem situated within Penang National Park).	12,000 ha (includes mangroves)	√	√
Perak	Matang Mangrove Forest Reserve Gazetted in 1906; world's best managed mangrove production forest.	40,000 ha	√	
Selangor	Kuala Selangor Nature Park / Malawati Forest Reserve Collaboratively managed by state government and Malaysian Nature Society.	300 ha	√	
	Klang Islands Mangrove Forest Reserve		√	
Johor	Pulau Kukup Johor National Park (Ramsar site) One of the largest uninhabited mangrove islands in the world.	600 ha	√	√
	Tanjung Piai Johor National Park (Ramsar site) Southernmost mangroves of mainland Eurasia.	500 ha	√	√
	Sungai Pulai Mangrove Forest Reserve (Ramsar site) The largest intact riverine mangrove system in Peninsular Malaysia.	9,000 ha	√	√

Sabah	Kota Kinabalu Wetland Centre (Ramsar site) Recognised as a State Cultural Heritage Site	20 ha	√	√
Sarawak				
	Lower Kinabatangan–Segama Wetlands (Ramsar site) The largest contiguous mangrove area in the Southern Sulu Sea.	79,000 ha	√	√
	Sepilok Laut Mangrove Forest Reserve	4,300 ha	√	
	Maruap Mangrove Forest Reserve	31,000 ha	√	
	Kuching Wetlands National Park (Ramsar site)	7,000 ha	√	√
	Rajang Mangroves National Park Malaysia's largest deltaic mangrove national park.	9,000 ha	√	
	Bako National Park	3,000 ha (includes mangroves)	√	
	Maludam National Park	43,000 ha (includes mangroves)	√	

BIODIVERSITY VALUES AND ECOSYSTEM SERVICES

Recognition of biodiversity values of mangroves have expanded tremendously since the 1991 SoNC assessment. Perspectives have sharply pivoted from viewing mangroves primarily as production forests, with largely anecdotal evidence on their benefits to local fisheries (Ong and Gong 1991), to the current comprehensive understanding of their biodiversity values and the wide range of ecosystem services they provide (Figure 1).

Malaysia lies within the global epicentre of mangrove diversity (i.e., the Indo-West Pacific biogeographic region) and is home to one of the most species-rich mangrove floras and fauna in the world. More than 40 true mangrove species can be found in Malaysian mangroves (Lee *et al.* 2015), including globally threatened and range-restricted taxa such as *Bruguiera* × *hainesii* and *Sonneratia griffithii* (Polidoro *et al.* 2010). Furthermore, Malaysian mangroves provide crucial habitat for a wide array of terrestrial, avian, coastal and marine fauna, including marine megafauna (e.g., dolphins, rays, crocodiles, and dugongs) and endangered terrestrial species (e.g., proboscis monkey *Nasalis larvatus* in Bornean mangroves). In addition, Malaysian mangroves form critical nodes along the East Asian–Australasian Flyway, offering feeding and roosting habitats for migratory shorebirds and waterbirds of international conservation concern, including the endangered oriental darter *Anhinga melanogaster* and Nordmann's greenshank *Tringa guttifer* (Zakaria and Rajpar 2015). For this reason, key mangrove areas are designated as Important Bird and Biodiversity Areas

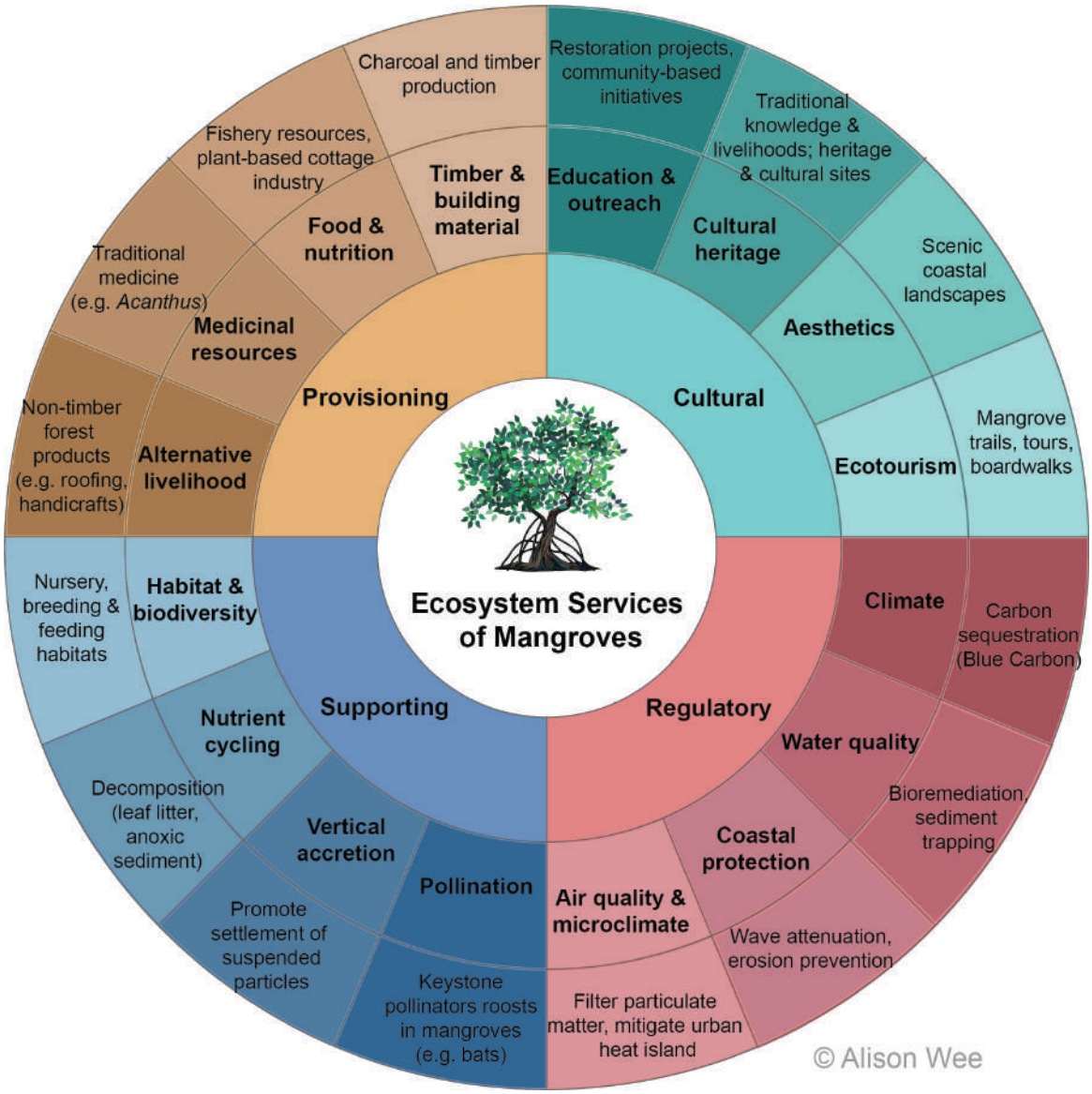

Figure 1. Ecosystem services of mangroves, particularly in the context of Malaysia.

(IBAs) (i.e., Teluk Air Tawar-Kuala Muda Wetlands in Penang) and Ecologically or Biologically Significant Marine Areas (EBSA) (i.e., the mangrove belt of the north Selangor coast, and Bako-Buntal Bay in Sarawak), as well as the Important Marine Mammal Areas (IMMAs) (i.e., Matang Mangroves and Coastal Waters; Similajau-Kuala Nyalau Coastline; Kuching Bay; Satun-Langkawi Archipelago; and Mersing Archipelago).

The ecological (and economical) importance of Malaysian mangroves is further underscored by their high productivity and strong functional linkages to coastal fisheries (Chong *et al.* 2007). Since the 1990s, research has firmly established mangroves as essential nursery, feeding, and refuge habitats for commercially important fishery species, including penaeid prawns (*Penaeus* spp.), mud crabs (*Scylla* spp.), and a wide range of finfish taxa (Sasekumar *et al.* 1992; Azmir *et al.* 2019; Mustafa Kamal *et al.* 2022). This aligns with global estimates that mangrove supports an annual abundance of ~800 billion fishes, prawns, bivalves and crabs (zu Ermgassen *et al.* 2024), with four million small scale fishers depend

directly on mangrove-associated resources worldwide (zu Ermgassen *et al.* 2020). In recognition of the provisioning services provided by mangrove habitats, Malaysia hosted the Third International Symposium on Mangroves as Fish Habitat in 2018, with the goal of "Connecting the Hemispheres" of scientists, researchers, industry professionals, economists, educators, and government officials (Bulletin of Marine Science 2018). Besides provisioning for fishery resources, mangroves in Malaysia, specifically the MMFR, are also globally renown for over a century of silviculture for charcoal production and construction. Established in 1902, the MMFR operates on 30-year rotational cycles with natural regeneration and enrichment planting, supplying charcoal and poles, while retaining continuous forest cover (Ismail *et al.* 2020; Lucas *et al.* 2021). The perpetuity of silviculture practices in MMFR validates the 1991 SoNC's argument that mangroves can also be conserved through rational use. However, MMFR's singular success has not been widely replicated elsewhere in Malaysia, and it remains a unique model for commercial-scale exploitation of mangrove trees with a long management history (Chen *et al.* 2024).

The importance of mangroves in coastal protection became particularly evident following the 2004 Indian Ocean tsunami, which marked a turning point in Malaysia's appreciation of mangroves beyond provisioning functions. Post-disaster assessments demonstrated that intact mangrove forests significantly reduced wave energy and prevented the loss of human lives and property damage, thus reinforcing their role as natural coastal defences (Kathiresan and Rajendran 2005). In recognition of this, the then Ministry of Natural Resources and Environment launched the "Tree Planting Program with Mangroves and Other Suitable Species Along National Coastlines" in 2005, that planted a total of nine million seedlings of mangroves and other coastal tree species across 3820 ha of coastal areas as of September 2025 (BERNAMA 2025; Ministry of Natural Resources and Environment 2014). In parallel, Malaysian mangroves have gained global prominence as important blue carbon ecosystems, with aboveground and belowground carbon stock ranging from 60 to 180 Mg C ha^{-1}, and from 290 to 470 Mg C ha^{-1}, respectively (Lee *et al.* 2025). Though promising, Malaysia's blue carbon financing mechanism is still in its infancy, with blue carbon projects being initiated in only Sabah and Johor now. The overall recognition of regulatory services provided by mangroves have propelled mangrove restoration initiatives in Malaysia, led not only by the government, but also the public and private sectors.

HUMAN PRESSURES

Human pressures on Malaysian mangroves have always been a tug-of-war between nature conservation and economic development. The pressures themselves have evolved since the 1991 SoNC assessment, though the resulting impacts remain largely the same, i.e. mangrove cover loss, degradation, and fragmentation. Generally, outright large-scale clearing has slowed in many areas. Instead of wholesale deforestation, contemporary pressures are increasingly chronic and cumulative, with compounding effects of altered hydrology, habitat fragmentation, pollution, and sea-level rise. As highlighted in the 1991 SoNC, conversion of mangroves for aquaculture emerged as a major threat in the late 1980s and early 1990s, particularly shrimp farming in the pursuit of the so-called "*pink gold*" (Ong and Gong 1991; Warne 2011; Mangrove Action Project 2018). Large-scale conversion to aquaculture has slowed in recent years; encroachment into mangrove areas are now often illegal operations. However, we are left to grapple with the devastating impacts of abandoned, disease-ridden or under productive aquaculture ponds, alongside the challenges of rehabilitating them back to mangrove habitats due to unsuitable hydrological, topographical and soil conditions (e.g., Tangah *et al.* 2020). In the early 21st century, the dominant driver of mangrove loss has shifted to agriculture, particularly mangrove conversion to oil palm plantations. Southeast Asia lost over 100,000 ha of mangroves between 2000 and 2012,

with oil palm identified as one of the leading agricultural replacement land uses (Richards and Friess 2015). This is especially acute in coastal Sabah and Sarawak where plantation expansion is concentrated (Yan *et al.* 2020). Together, land conversion for aquaculture and agriculture purposes accounted for >50% of mangrove loss in Malaysia (Richards and Friess 2015), signifying cultivation as the single largest threat to mangroves.

Simultaneously, urbanisation and coastal infrastructure development have intensified since the 1991 SoNC assessment, particularly in Peninsular Malaysia. Mangroves have been cleared for ports (e.g., Senari Port in Sarawak), industrial estates (e.g., Pulau Indah in Selangor), tourism (e.g., Kuantan River waterfront in Pahang) and residential areas (e.g., Kudat district in Sabah). Notably, there are several land reclamation projects at various stages of implementation that directly impact mangroves, including Forest City in Johor, Penang South Islands, and Kedah Coastal Extension. Such large-scale projects pose wide-ranging and irreversible threats to mangroves, not only in the form of direct habitat loss, but also indirect processes such as altered coastal hydrodynamics and disrupted sediment flow (Chee *et al.* 2017). Furthermore, coastal urbanisation disproportionately affects fringing and estuarine mangroves, as it creates manmade physical barriers to the landward migration of mangroves driven by sea level-rise, a phenomenon known as "coastal squeeze" (Lovelock and Reef 2020). Without significant changes in land use planning, urbanisation will persist as a threat to mangroves in Malaysia as human populations pushes further into forested land. In contrast to the increasing threats of urbanisation, mangrove loss and degradation due to timber harvesting has greatly reduced since the 1990s. This is particularly apparent in the wood chip industry that once led to the destruction of vast mangrove areas – 15,000 ha over 25 years in Sarawak and 70,000 ha over 15 years in Sabah – but has since ceased as the operations were no longer economically viable (Chong 2006). Furthermore, permanent forest reserves in Malaysia (including almost all mangrove forests) are currently under a 15-year moratorium on monoculture plantations, with the Selangor state government imposing a 25-year moratorium since 2010 (Murughan *et al.* 2026). Logging is generally prohibited, and when it does occur, is largely limited to illegal harvesting and clearing (for agriculture, aquaculture and settlement), and to areas where alternative livelihoods are limited.

The emerging threats on mangroves of the early 21st century are arguably pollution and climate change, not so much because these pressures are new, but because our understanding of their scale, mechanisms, and long term impacts has deepened substantially. We now have a better understanding of how indirect pressures, such as sediment runoff (Mohd Kamal *et al.* 2025), industrial effluents (El-Turk *et al.* 2019), untreated sewage (Magam *et al.* 2016), and marine debris accumulation (Abd. Rahim *et al.* 2025), could impact the mangroves from upstream and beyond. These pressures result in multiple negative consequences in mangroves, including the impairment of benthic productivity and processes, disruption of trophic linkages, degradation of water quality, tree mortality and stunted growth, and the bioaccumulation of pollutants in the food web. In addition to land-base pressures, Malaysian mangroves are facing a growing threat from the sea. Climate change is accelerating sea level rise, which can outpace sediment accretion and root growth, leading to mangrove drowning (Friess *et al.* 2023). Alarmingly, with the absence of landward migration (i.e., coastal squeeze), some mangroves in Kelantan, Terengganu and Sabah could be submerged and lost by the turn of the next century (Lovelock *et al.* 2015). Globally, over 60% of mangrove loss is attributed to direct and indirect human activities, often acting synergistically rather than independently (Leal and Spalding 2024). Understanding the vulnerability of mangrove ecosystems to indirect pressures from their surroundings prompted a more systemic view of these processes, aptly encapsulated in the synonymous concepts of "mountains-to-mangroves", "ridge-to-reef", "catchment-to-coast" and "source-to-sea" (e.g., Salomons *et al.* 2005). Unfortunately, this integrated perspective has yet to be adopted in the governance of mangroves in Malaysia.

CHANGING PERCEPTION AND ACTION

In the 1991 SoNC assessment, Ong and Gong advocated for the "rational sustainable use" of mangrove forests for silviculture and to support coastal fisheries. This demonstrates that while the ecological and economical values of mangroves were recognised, the perception of mangroves were largely human-centric and utilitarian. Indeed, our long-standing experience with mangrove silviculture, epitomised by the century-old MMFR in Perak, shaped our then perception that a good way to conserve mangroves was through rational use on a sustainable yield basis (Ong and Gong 1991). MMFR demonstrated that mangroves, unlike many other tropical forest types, could be managed productively without ecosystem collapse, provided that rotation lengths, regeneration processes and hydrological regimes were respected (Chen *et al.* 2024). In this sense, MMFR serves as both a national and global benchmark for sustainable mangrove forestry. The rational use perspective – expanded to include contributions to coastal fisheries – also serve as an argument against mangrove conversion to other competing (more lucrative) land use types (Ong and Gong 1991).

Since then, the mangrove management landscape in Malaysia has shifted towards a paradigm that emphasises restoration and ecosystem rehabilitation. Large scale mangrove planting campaigns have become a prominent feature of national and state initiatives, exemplified by the "Tree Planting Programme with Mangroves and Other Suitable Species Along National Coastlines" that has been running since 2005. Replanting of mangrove species under this program mostly focused on the west coast of Peninsular Malaysia, Sabah and southern Sarawak (Figure 2). In addition, private and public institutions, in collaboration with state Forestry Departments and the Ministry of Natural Resources and Environmental Sustainability, have collectively planted more than 360,000 mangrove seedlings under the national initiative "100 Million Tree Planting Campaign (2021 – 2025)" within the Greening Malaysia Programme (100 Juta Pokok, n.d.). Besides governmental agencies, several non-profit organisations have emerged as champions of mangrove restoration in Malaysia, including the Malaysian Nature Society, Global Environment Centre, WWF-Malaysia, Wetlands International Malaysia and the Global Mangrove Alliance Malaysia chapter. While these efforts have raised public awareness for mangrove conservation, leading to overall positive outcomes (Friess *et al.* 2020), there is growing recognition that planting effort alone does not equate to conservation success.



Figure 2. Map showing planting locations under the "Tree Planting Program with Mangroves and Other Suitable Species Along National Coastlines". Adapted from e-pesisir (Malaysia Space Agency, n.d.).

Consistent with findings in the State of the World's Mangroves (Leal and Spalding 2024) and supported by evidence from Malaysia, many planting initiatives suffered from fundamental ecological shortcomings. Monospecific planting, dominated by *Rhizophora* spp., often fails in sites where natural hydrological conditions are unsuitable; poor site selection results in high seedling mortality; and short term project metrics obscures the importance of long term functional recovery (Leal and Spalding 2024). Furthermore, monitoring, reporting and verification of restoration success is largely absent, limiting our abilities to improve on failures and replicate successes. Perhaps this is why Malaysia is still struggling to achieve a net gain in mangrove cover despite the mass mobilisation of resources and manpower for restoration.

Instead of a tunnel vision focusing on sheer planting numbers alone, mangrove restoration in Malaysia should adopt a more holistic approach that emphasises on planning, adaptive management and community engagement (Beeston *et al.* 2023). Specifically, restoration initiatives must align with the principles of Ecological Mangrove Restoration (EMR), which prioritises the restoration of natural hydrology, sediment dynamics, and species zonation before active planting. Based on this framework, the most important question any restoration initiative should ask is actually "Can my site be restored?" Without this initial thought process, mangrove restoration risks being "*syok sendiri*" (self-congratulatory) with questionable long-term success. Besides promoting habitat recovery and natural regeneration, a key goal of the EMR is for restored mangroves to closely resemble native floristic composition (Figure 3). Therefore, mangrove replanting should veer away from monoculture plantation and prioritise a multi-species stand, to ensure long-term productivity and ecological resilience (Li *et al*. 2025). To take this one step further, ecosystem restoration is typically more successful when restoration stocks have higher genetic diversity or are locally adapted (da Silva *et al.* 2025). In pursuit of planting numbers, mangrove restoration in Malaysia have long relied on the use of non-locally sourced seedlings, with the most common supplier being nurseries located in Kuala Sepetang near MMFR (pers. comm.). However, recent evidence suggests that this may result in artificial genetic mixing among populations, implicating the natural genetic structure of mangroves in Peninsular Malaysia (Mugundha-Kumar *et al.* 2026). Hence, it is imperative that future restoration initiatives prioritise local seedlings to conserve the naturally occurring genotypes. Lastly, the quantification of restoration outcome should focus on functional recovery instead of mere structural recovery (forest cover). Emerging technologies, such as environmental DNA (Wee *et al.* 2023) and bioacoustics (Rahim *et al*. 2025), have shown promising progress in tracking functional guilds and community dynamics in mangroves. Together, these changes can move mangrove restoration in Malaysia from symbolic action toward resilient, functionally intact coastal ecosystems.

More recently, Malaysian mangroves gained a new level of valuation through their recognition as blue carbon ecosystems (Lee *et al.* 2025). This represents yet another profound shift in the perception of mangroves, from sources of timber to long term carbon sinks. Mangroves sequester and store disproportionately large quantities of carbon as compared to other terrestrial ecosystems, particularly within their deep, anoxic sediments. Hence, mangroves are regarded as an important nature-based solution for climate change (Alongi 2020). As such, mangrove restoration projects now serve three simultaneous objectives – ecosystem restoration, biodiversity conservation and carbon sequestration. Recognising blue carbon as a potent strategy to achieve net zero emissions, ASEAN launched the Blue Carbon and Finance Profiling Project in 2025 to integrate blue carbon strategies into national and regional development plans (ASEAN 2025). Following this, the federal government of Malaysia started exploring the creation of a Blue Carbon Credit Trading Platform in the country, in collaboration with the Sabah Maju Jaya Secretariat and the Sabah State Forestry Department (Ministry of Finance Malaysia 2025). As the State with the largest mangrove area, Sabah has positioned itself as a leader in blue carbon in Malaysia – it hosted the Sabah

International Blue Economy Conference in 2024, put forth a Sabah Mangrove Action Plan (2024 – 2033) and will become the Blue Economy Hub for Malaysia. The inaugural blue carbon initiatives are set to be in Sabah and Johor. These are all promising developments that point towards a stronger stewardship of mangrove ecosystems catalysed by the blue carbon agenda. However, this growing emphasis on blue carbon also warrants caution. If not grounded in transparent governance and rigorous monitoring, blue carbon initiatives risk reducing mangroves to carbon commodities, potentially incentivising poorly designed restoration, genetic homogenisation, or the exclusion of local communities. Ensuring that climate finance complements rather than compromises ecosystem integrity will be essential for lasting benefits of the blue carbon agenda.



Figure 3. A multi-species replanted mangrove forest in Johor, which closely resembles the structure and species composition of nearby natural mangrove forests.

Ultimately, the convergence of ecosystem restoration and climate finance presents Malaysia with a rare opportunity to redefine mangrove conservation – not merely as an environmental obligation, but as a strategic vehicle to advance multiple national agendas in sustainable development. To ensure that this opportunity can be realised while balancing social and economic development needs, Malaysia should draw lessons from Sabah and develop a National Mangrove Action Plan. This will ensure that mangrove governance is harmonised across all states and a coherent roadmap and clear targets are established for mangrove conservation.

TOWARD THE NEXT STATE OF NATURE: PATHWAYS TO SUSTAINABILITY

We have come far from where we were during the 1991 SoNC assessment. Where ecological knowledge used to be lacking (as urgently noted by Ong and Gong), we now have a wealth of knowledge on local mangrove biodiversity and ecology, complemented by a thriving research network, i.e. The Malaysian Mangrove Research Alliance and Network (MyMangrove) (Amir *et al.* 2020). Where legal protection of mangroves was once fragmented and unclear, a growing network of nationally and internationally recognised protected areas (e.g. Ramsar, UNESCO programmes) now safeguards these ecosystems. And where Malaysian mangroves were historically valued primarily as production forests, they are

today increasingly recognised for their full suite of ecosystem services – most notably coastal protection, fisheries support, and their critical role as blue carbon sinks. Taken together, this SoNC finds that Malaysia has made substantial progress since 1991, especially in recognising the value of mangroves.

Moving forward, four inter-connected priorities emerge as pathways toward the next SoNC. First, Malaysia must reconcile mangrove extent maps through harmonised national monitoring (supported by consistent ground truthing) that aligns with data platforms such as the Global Mangrove Watch, to track mangrove cover change more accurately and improve governance. Second, restoration success must be redefined by functional recovery, rather than by the number of seedlings planted, aligning practice with EMR principles. Third, mangroves must continue to be recognised for their multifunctional roles (instead of carbon alone) and fully integrated into climate policy, including nationally determined contributions (NDCs), adaptation planning, disaster risk reduction, and blue economy strategies. Finally, long term sustainability depends on empowering coastal communities as stewards, through proper land tenure, inclusive governance, and equitable benefit sharing that align conservation objectives with local livelihoods. Together, these pathways highlight the fact that the next State of Nature Conservation for Malaysian mangroves must move beyond planting and restoration and move toward integrated management – where science, policy, finance, and community stewardship converge to secure resilient mangrove ecosystems for generations to come.

REFERENCES

Anon. 100 Juta Pokok. (n.d.). Penghijauan Malaysia: Kempen Penanaman 100 Juta Pokok , "Pokok Kita, Kehidupan Kita" 2021-2025. https://www.100jutapokok.gov.my/

Abd Rahim, N.H., Satyanarayana, B., Ibrahim, Y.S., Not, C., Idris, I., Jani, J.M. Cannicci, S. and Dahdouh-Guebas, F. 2025. Distribution of marine debris in the mangroves of a semi-enclosed lagoon system. In *Microplastic Pollution,* pp. 167–180. Singapore: Jenny Stanford Publishing. https://doi.org/10.1201/9781003660064-5

Alongi, D.M. 2020. Global significance of mangrove blue carbon in climate change mitigation. *Sci* 2(3): 67. https://doi.org/10.3390/sci2030067

Amir, A.A., Foong, S.Y., Kaur, C.R., Satyanarayana, B., Sharma, S., Ismail, A., Awang, N.A. *et al.* 2020. The strategic establishment of the Malaysian Mangrove Research Alliance and Network (MyMangrove). *Malayan Nature Journal* 72(4): 577–595.

Association of Southeast Asian Nations (ASEAN). 2025, May 21. ASEAN, Japan, and UNDP launch blue carbon and finance profiling project to accelerate sustainable blue economy in Southeast Asia. *ASEAN*. https://asean.org/asean-japan-and-undp-launch-blue-carbon-and-finance-profiling-project-to-accelerate-sustainable-blue-economy-in-southeast-asia/

Azhari, N.E.M. and Hassan, M.F. 2021, June 16. Kuala Gula-Matang Set to be Malaysia's Eight Ramsar Site. *Bernama*. https://www.bernama.com/en/news.php?id=1972375

Azmir, I.A., Amin, S., Esa, Y., Yasin, I.S.M. and Ara, R. 2019. A snapshot study on larval fish diversity in selected mangrove areas of Peninsular Malaysia, Malaysia. *Journal of Academia* 7(2): 112–123.

Beeston, M., Cameron, C., Hagger, V., Howard, J., Lovelock, C.E., Sippo, J., Tonneijck, F.H., van Bijsterveldt, C. and van Eijk, P. 2023. Best practice guidelines for mangrove restoration. Global Mangrove Alliance.

BERNAMA. 2025, September 21. Gov't allocates over RM71 million for mangrove conservation, maintenance – Johari. *Bernama*. https://www.bernama.com/en/news.php?id=2469757

Bulletin of Marine Science. 2018. Mangroves as fish habitat 3. https://bullmarsci.org/MAFH3/about.html

Bunting, P., Rosenqvist, A., Hilarides, L., Lucas, R. M., Thomas, N., Tadono, T., Worthington, T.A., Spalding, M., Murray, N. and Rebelo, L.M. 2022. Global Mangrove Extent Change 1996–2020: Global Mangrove Watch Version 3.0. *Remote Sensing* 14: 3657. https://doi.org/10.3390/rs14153657

Chee, S.Y., Othman, A.G., Sim, Y.K., Adam, A.N.M. and Firth, L.B. 2017. Land reclamation and artificial islands: Walking the tightrope between development and conservation. *Global Ecology and Conservation* 12: 80–95. https://doi.org/10.1016/j.gecco.2017.08.005

Chen, D., Satyanarayana, B., Wolswijk, G., Abd Rahim, N.H., Amir, A.A., Hugé, J. and Dahdouh-Guebas, F. 2024. Historical ecological monitoring and appraisal for extractive uses and other values in Malaysia unveils consequences of regime shifts in 120 years of mangrove management. *Journal for Nature Conservation* 79: 126582. https://doi.org/10.1016/j.jnc.2024.126582

Chong, V.C. 2006. Sustainable utilization and management of mangrove ecosystems of Malaysia. *Aquatic Ecosystem Health & Management* 9(2): 249–260. https://doi.org/10.1080/14634980600717084

Chong, V.C. 2007. Mangroves-fisheries linkages—the Malaysian perspective. *Bulletin of Marine Science* 80(3): 755–772.

da Silva, J.M., Bertola, L.D., DeWoody, J.A., Steeves, T., Sunnucks, P., Vilaça, S.T. and Hoban, S. 2025. Conserving genetic and genomic diversity in accordance with the Global Biodiversity Framework. *Annual Review of Animal Biosciences* 14: 399–428. https://doi.org/10.1146/annurev-animal-030424-070756

ELTurk, M., Abdullah, R., Zakaria, R.M. and Bakar, N.K.A. 2019. Heavy metal contamination in mangrove sediments in Klang estuary, Malaysia: Implication of risk assessment. *Estuarine, Coastal and Shelf Science* 226: 106266. https://doi.org/10.1016/j.ecss.2019.106266

Friess, D.A., Yando, E.S., Abuchahla, G.M., Adams, J.B., Cannicci, S., Canty, S.W., Cavanaugh, K.C. *et al.* 2020. Mangroves give cause for conservation optimism, for now. *Current Biology* 30(4): R153–R154. https://doi.org/10.1016/j.cub.2019.12.054

Friess, D.A., Chen, L., Cormier, N., Krauss, K.W., Lovelock, C.E., Raw, J.L., Rogers, K., Saintilan, N. and Sidik, F. 2023. Mangrove forests and climate change: impacts and interactions. In *Climate Change and Estuaries*, M.J. Kennish, H.W. Paerl and J.R. Crosswell (Eds.), pp. 381–400. Boca Raton: CRC Press. https://doi.org/10.1201/9781003126096-22

Hamilton, S.E. and Casey, D. 2016. Creation of a high spatio-temporal resolution global database. *Global Ecology and Biogeography* 25(6): 729–738.

Ismail, S.M., Amir, A.A., Ariffin, N.H.S. and Latiff, A. 2020. Conservation and management of mangroves in Peninsular Malaysia: A historical perspective. *Malayan Nature Journal* 72(4): 425–439.

Kathiresan, K. and Rajendran, N. 2005. Coastal mangrove forests mitigated tsunami. *Estuarine, Coastal and Shelf Science* 65(3): 601–606. https://doi.org/10.1016/j.ecss.2005.06.022

Leal, M. and Spalding, M.D. 2024. *The state of the world's mangroves 2024*. Global Mangrove Alliance. https://doi.org/10.5479/10088/119867

Lee, S.S., Muhamad, A. and Tong, J. 2015. *Mangrove Guidebook for Malaysia*. Petaling Jaya: Wetlands International Malaysia.

Lee, S.L., Chee, S.Y., Huxham, M., Jamilah, M., Choo, J., Kaur, C.R., Amir, A.A. *et al.* 2025. Blue carbon ecosystems in Malaysia–status, threats, and the way forward for research and policy. *The Journal of Environment & Development* 34(1): 225–265. https://doi.org/10.1177/10704965241284366

Li, Z., Li, Y. and Fan, B. 2025. Diverse restored mangrove stands enhance carbon storage compared to monospecific plantation: a meta-analysis. *Forest Ecology and Management* 578: 122446. https://doi.org/10.1016/j.foreco.2024.122446

Lovelock, C.E., Cahoon, D.R., Friess, D.A., Guntenspergen, G.R., Krauss, K.W., Reef, R., Rogers, K. *et al.* 2015. The vulnerability of Indo-Pacific mangrove forests to sea-level rise. *Nature* 526(7574): 559–563. https://doi.org/10.1038/nature15538

Lovelock, C.E. and Reef, R. 2020. Variable impacts of climate change on blue carbon. *One Earth* 3(2): 195–211. https://doi.org/10.1016/j.oneear.2020.07.010

Lucas, R., Otero, V., Van De Kerchove, R., Lagomasino, D., Satyanarayana, B., Fatoyinbo, T. and Dahdouh-Guebas, F. 2021. Monitoring Matang's mangroves in Peninsular Malaysia through Earth observations: A globally relevant approach. *Land Degradation & Development* 32(1): 354–373. https://doi.org/10.1002/ldr.3652

Magam, S.M., Zakaria, M.P., Halimoon, N., Aris, A.Z., Kannan, N., Masood, N., Mustafa, S. *et al*. 2016. Evaluation of distribution and sources of sewage molecular marker (LABs) in selected rivers and estuaries of Peninsular Malaysia. *Environmental Science and Pollution Research* 23: 5693–5704. https://doi.org/10.1007/s11356-015-5804-9

Malaysian Space Agency (MYSA). (n.d.). e Pesisir: Coastal and marine GIS public portal. https://epesisir.mysa.gov.my/gis/_public/index_public.php

Mangrove Action Project. 2018, April. Map calls for attention to mangrove loss in Pitas, Sabah in Malaysia. *Mangrove Action Project.* https://mangroveactionproject.org/2018/04/map-calls-for-attention-to-mangrove-loss-in-pitas-sabah-in-malaysia/

Ministry of Finance Malaysia. 2025, August 27. Federal government to develop policy guidelines and explore creation of blue carbon credit trading platform. *Ministry of Finance Malaysia.* https://www.mof.gov.my/portal/en/news/press-citations/federal-govt-to-develop-policy-guidelines-and-explore-creation-of-blue-carbon-credit-trading-platform

Ministry of Natural Resources and Environment. 2014. Laporan Kajian Penilaian Outcome Program Penanaman Pokok Bakau dan Spesies-spesies yang Sesuai di Pesisiran Pantai Negara. https://www.mybis.gov.my/pb/1738

Mohd Razali, S., Radzi, M.A., Marin, A. and Samdin, Z. 2022. A bibliometric analysis of tropical mangrove forest land use change from 2010 to 2020. *Environment, Development and Sustainability* 24(10): 11530–11547. https://doi.org/10.1007/s10668-021-01935-7

Mohd Kamal, M.A., Hamid, N.B., Mokhtar, M., Daud, M.E., Kaamin, M., Sahat, S., Mohammad Azmi, M.A., Sanik, M.E. and Thane, S.M. 2025. Impact of sedimentation on mangrove forests in West Coast, Peninsular Malaysia. *Journal of Advanced Research Design* 138(1): 151–161. https://doi.org/10.37934/ard.138.1.151161

Mugundha-Kumar, A., Taguchi, H., Rowntree, J. K., Ishikawa, N., Suyama, Y. and Wee, A.K. 2026. Mangrove restoration should consider the unique genetic structure of the extant populations. *Ecological Research* 41(6): e70135.

Murughan, M., Roslan M.K., Johar, M., Zubaidah, H., Seca, G. and Pakhriazad, H.Z. 2026. Exploring the drivers of forest management certification in Malaysia. *Journal of Tropical Forest Science* 38(1): 65–77. https://doi.org/10.26525/jtfs2026.38.1.65

Mustafa Kamal, A.H., Sinden, A., Idris, M.H., Al-Asif, A.-., Hamli, H., Musa, N., Piah, R.M. *et al.* 2022. Diversity of fisheries in Sarawak, Northwest Borneo: Present status and conservation issues. *Borneo Journal of Resource Science and Technology* 12(1): 32–51. https://doi.org/10.33736/bjrst.4651.2022

Omar, H. 2024. *Status of Mangrove in Malaysia*. Kepong: Forest Research Institute Malaysia.

Ong, J.E. and Gong, W.K. 1991. Mangroves. In *State of Nature Conservation in Malaysia*, R. Kiew (Ed.), pp. 22–28. Petaling Jaya: Malaysian Nature Society.

Polidoro, B.A., Carpenter, K.E., Collins, L., Duke, N.C., Ellison, A.M., Ellison, J.C., Farnsworth, E.J. 2010. The loss of species: mangrove extinction risk and geographic areas of global concern. *PloS One* 5(4): e10095. https://doi.org/10.1371/journal.pone.0010095

Rahim, A.K.H.A., Puan, C.L., Mah, A.N.M.M.A., Zakaria, M., Jamaludin, N. and Wahaf, N.S.A. 2025. Bioacoustic assessment of mangrove health: Influence of habitat characteristics on bird richness. *Biotropica* 57(1): e13427. https://doi.org/10.1111/btp.13427

Richards, D.R. and Friess, D.A. 2016. Rates and drivers of mangrove deforestation in Southeast Asia, 2000–2012. *Proceedings of the National Academy of Sciences* 113(2): 344–349. https://doi.org/10.1073/pnas.1510272113

Salomons, W., Kremer, H.H., Turner, R.K., Andreeva, E.N., Arthurton, R.S., Behrendt, H., Burbridge, P. *et al*. 2005. The catchment to coast continuum. In *Coastal Fluxes in the Anthropocene*, C.J. Crossland, H.H. Kremer, H.J., Lindeboom, J.I.M. Crossland and M.D.A. Tissier (Eds.), pp. 145–200. Berlin: Springer. https://doi.org/10.1007/3-540-27851-6_4

Spalding, M.D. and Leal, M. 2021. *The State of the World's Mangroves*. Global Mangrove Alliance.

Tangah, J., Chung, A.Y. and Chan, H.T. 2020. *Rehabilitation of Mangroves in Sabah: The SFD-ISME Collaboration (2014-2019).* International Society for Mangrove Ecosystems.

Warne, K. 2011. Pink gold and a blue revolution. In *Let Them Eat Shrimp: The Tragic Disappearance of the Rainforests of the Sea*, K. Warne (Ed.), pp. 29–37. Washington, DC: Island Press/Center for Resource Economics. https://doi.org/10.5822/978-1-61091-024-8

Wee, A.K., Salmo Iii, S.G., Sivakumar, K., Then, A.Y., Basyuni, M., Fall, J., Habib, K.A. *et al.* 2023. Prospects and challenges of environmental DNA (eDNA) metabarcoding in mangrove restoration in Southeast Asia. *Frontiers in Marine Science* 10: 1033258. zhttps://doi.org/10.3389/fmars.2023.1033258

Wong, C.J., James, D., Besar, N.A., Kamlun, K.U., Tangah, J., Tsuyuki, S. and Phua, M.H. 2020. Estimating mangrove above-ground biomass loss due to deforestation in Malaysian Northern Borneo between 2000 and 2015 using SRTM and landsat images. *Forests* 11(9): 1018. https://doi.org/10.3390/f11091018

Yan, J., Gao, S., Xu, M. and Su, F. 2020. Spatial-temporal changes of forests and agricultural lands in Malaysia from 1990 to 2017. *Environmental Monitoring and Assessment* 192(12): 803. https://doi.org/10.1007/s10661-020-08765-6

Zakaria, M. and Rajpar, M.N. 2015. Assessing the fauna diversity of Marudu Bay mangrove forest, Sabah, Malaysia, for future conservation. *Diversity* 7(2): 137–148. https://doi.org/10.3390/d7020137

zu Ermgassen, P.S., Mukherjee, N., Worthington, T.A., Acosta, A., da Rocha Araujo, A. R., Beitl, C.M., Castellanos-Galindo, G.A. *et al.* 2020. Fishers who rely on mangroves: Modelling and mapping the global intensity of mangrove-associated fisheries. *Estuarine, Coastal and Shelf Science* 247: 106975. https://doi.org/10.1016/j.ecss.2020.106975

zu Ermgassen, P.S., Worthington, T.A., Gair, J.R., Garnett, E.E., Mukherjee, N., Longley-Wood, K., Nagelkerken, I. *et al.* 2024. The global fish and invertebrate abundance value of mangroves. *bioRxiv* 2024-05. https://doi.org/10.1101/2024.05.02.591889