Assessing the supply side of blue carbon in ICM and other local sites in the East Asian Seas region

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EXECUTIVE SUMMARY

The East Asias Seas (EAS) region hosts a substantial number of Blue Carbon Ecosystems (BCEs), including mangroves, seagrass meadows, salt marshes, seaweed beds, and tidal flats. These ecosystems play critical roles in carbon sequestration, climate regulation, and coastal resilience by sequestering and storing substantial amounts of carbon dioxide (CO_2) and mitigating greenhouse gas emissions. Despite their importance, BCEs continue to face threats from human activities such as aquaculture and coastal development, resulting in significant habitat loss and depletion of carbon stocks.

This supply side study has several objectives: firstly, to confirm the status of BCEs in Integrated Coastal Management (ICM) and other local specific sites in the region . Secondly, to assess current management practices and support systems for BCEs at these sites, identifying gaps and challenges that could inform local capacity-building and Blue Carbon (BC) program development efforts. Lastly, to evaluate interest in expanding and implementing a BC program. To achieve these goals, a survey tool was created and disseminated to the PEMSEA Network of Local Governments (PNLG – 57 contacts) and some of the PEMSEA Network of Learning Centers (PNLC – 48 contacts) members in coordination with the Secretariats of PNLG and PNLC. The survey findings from 20 sites across 6 countries were supported by additional BC-related information gathered from published or unpublished State of Oceans and Coasts (SOC) Reports covering 20 sites in 7 countries.

The survey findings show consistent trends with regional and national studies, highlighting the ecological, economic, and social significance of BCEs. Efforts are underway to manage and safeguard BCEs through various protection measures, supported by laws, regulations, and management plans. However, challenges remain in ensuring these protections, management strategies, and law enforcement efforts are fully effective.

Mangrove forests across 29 sites in seven countries face significant threats including logging, pollution (oil spills, chemicals), climate change, coastal development, and illegal activities like fishing and settlement encroachment. Mangroves contribute to local economies through fisheries and tourism, benefiting coastal communities. Predominantly publicly owned, they are managed with support from governmental agencies and international organizations. Conflicts arise from competing land uses, mitigated by initiatives like Marine Protected Areas (MPAs), Locally Managed Marine Areas (LMMAs), ICM, and Other Effective Area-Based Conservation Measures (OECMs). Regular monitoring and enforcement of local regulations show promise in protecting mangroves, alongside active restoration efforts by governments, Non-Governmental Organizations (NGOs), and academic institutions to enhance resilience and biodiversity.

Seagrass meadows are present across 24 sites in seven EAS countries, facing threats such as pollution, coastal development, climate change, and other human activities. They contribute significantly to local economies through fisheries, tourism, and aquaculture, serving as critical habitats for biodiversity and scientific research. Managed as public lands, approaches include MPAs, LMMAs, and ICM, supported by local regulations.

Salt marshes across seven sites in China face threats from coastal development, pollution, and aquaculture expansion. Economically, they contribute through aquaculture, tourism, and salt production, while playing essential roles in conservation. Management efforts involve protected areas, ongoing monitoring, and extensive restoration activities like vegetation planting and ecological projects.

Seaweed beds are poorly documented in the EAS region, with recognition at only two sites—Guimaras, Philippines, and Bintan, Indonesia. Bintan reveals challenges from climate change and conflicts between shipping and fishing, lacking adequate protection and enforcement. More data are needed to understand their status and importance in the region.

Tidal flats are reported across seven sites in five countries (Table 18), facing pressures from coastal developments like fisheries ports and marina expansions, rising sea levels due to climate change, and pollution from reclamation projects. Tidal flats support fishing, provide livelihoods, facilitate biodiversity research, and attract tourists for recreation. From surveyed sites, it was documented that tidal flats are protected in the forms of MPA, LMMA, OECM, ICM, and Ramsar sites.

Overall, the survey identified four primary categories of gaps and challenges in managing BC ecosystems: issues with governance and enforcement, limitations in capacity and resources, impacts from environmental and climate change factors, and deficiencies in data and knowledge. These are important factors to note when designing and implementing a future BC program.

Regarding interest in developing and implementing BC projects, all respondents expressed interest in developing and implementing BC projects. Various BC projects have been implemented, focusing on conservation, research, monitoring, restoration, and participation in the carbon market. BCE restoration, conservation, and assessments received the highest interest and are followed by more sophisticated initiatives, such as carbon crediting and trading.

The survey conducted offers insights into the current status and management levels of BC initiatives from the supply side within the EAS region. Moving forward, it would be beneficial to conduct another round of supply side survey in collaboration with more partners to gather data, especially from countries and sites that have not responded. While mangrove forests and seagrass meadows were extensively covered in the data collection due to their prominence in the region, there remains a significant opportunity to explore other BCEs such as salt marshes, seaweed beds, and tidal flats, which were underrepresented in the current study. Further survey will contribute to a more comprehensive understanding of the supply side potential in the region.

Integrating findings from the supply side study with concurrent market demand assessment will provide a holistic perspective, highlighting critical gaps that need addressing in future BC initiatives. To advance BC initiatives effectively, PEMSEA could prioritize supporting restoration, conservation, and assessment of BCEs at identified project sites. Finally, expertise in carbon crediting and trading will be essential to maximize the economic benefits derived from these BCEs, ensuring sustainable environmental management practices in the EAS region.

GLOSSARY

Term	Definition
Blue carbon	The carbon dioxide (CO_2) captured and stored by coastal and marine ecosystems
Blue carbon ecosystems	Specific types of coastal and marine habitats that are particularly effective at capturing and storing CO_2 from the atmosphere. In this report, blue carbon ecosystems refer to mangroves, seagrass meadows, salt marshes, seaweed beds, and tidal flats.
Mangroves	Trees and shrubs that grow in coastal intertidal zones and estuarine environments in tropical and subtropical regions around the world. They are characterized by their ability to thrive in saline or brackish water conditions, where freshwater meets the sea.
Mangrove forests	Coastal ecosystems found in tropical and subtropical regions. They are characterized by salt-tolerant trees, shrubs, and other vegetation that thrive in brackish water along coastlines, estuaries, deltas, and lagoons.
Salt marshes	Coastal wetlands that are regularly flooded by seawater during high tides. They are characterized by the presence of salt-tolerant plants such as grasses, herbs, and sedges. They typically occur in temperate and subtropical regions.
Seagrasses	Flowering plants that grow fully submerged in shallow coastal waters. They have roots, stems, and leaves adapted to survive in saline environments.
Seagrass meadows	Extensive areas in shallow coastal waters where seagrasses grow in dense patches or mats. They are found worldwide in coastal areas, from tropical to temperate regions. The term is often used interchangeably with seagrass beds.
Seaweeds	A diverse group of marine algae that grow in various forms, shapes, and sizes in aquatic environments, primarily in saltwater.
Seaweed beds	Areas in the marine environment where seaweeds (marine algae) grow densely and form extensive patches or beds.
Tidal flats	Coastal ecosystems found in intertidal zones, which are areas that are exposed to air during low tide and submerged underwater during high tide. Tidal flats are typically characterized by extensive areas of flat, muddy, or sandy substrates that are regularly inundated by tidal waters. The term is often used interchangeably with mudflats.

1. BACKGROUND

The East Asian Seas (EAS) regionis a global hotspot for blue carbon ecosystems. Many EAS countries are also home to coastal communities vulnerable to the impacts of climate change and declining coastal ecosystem services. There is an opportunity to improve the management of coastal blue carbon ecosystems towards achieving climate change commitments, sustainable development goals, and the well-being of coastal communities. A very important initiative to support the conservation and improvement of the coastal blue carbon ecosystems in the EAS region is the establishment of the PEMSEA Blue Carbon (BC) program.

PEMSEA's BC Program aims to improve the condition of the blue carbon ecosystems (BCEs) in the region and optimize its contribution to the reduction of greenhouse gases and carbon sequestration which in turn will contribute to coastal resilience and habitat restoration. It also aims to improve the local government and community access to additional sources of finance, for example from the private sector and corporations for the scaling-up program for coastal blue carbon ecosystems.

PEMSEA's BC program has the following components, namely: reviewing variousaccounting methodologies used in the region, understanding the supply and demand of blue carbon in the region, and assessing the prospects of blue carbon certification in the region. This particular study looks into the supply side of blue carbon and assesses the readiness of PEMSEA's certified Integrated Coastal Management (ICM) and other sites in the EAS region. The supply-side assessment also aims to assist in identifying capacity-building needs on blue carbon at the local level.

2. STATUS OF BLUE CARBON ECOSYSTEMS IN THE EAST ASIAN SEAS REGION

In the EAS region, BCEs such as mangroves, seagrasses, salt marshes, seaweed beds, and tidal flats are vital coastal habitats that play a significant role in carbon sequestration and storage in addition to their other ecosystem services. They sequester and store large amounts of organic carbon (C_{org}) and carbon dioxide (CO_2) from the atmosphere. This carbon sequestration capability makes these ecosystems highly effective in mitigating climate change by reducing greenhouse gas emissions. Moreover, blue carbon ecosystems contribute to the resilience of coastal areas by protecting against erosion, storm surges, and sea-level rise.

In addition to their role in climate regulation, BCEs provide a wide range of ecosystem services that benefit both the environment and communities. They serve as critical habitats for various plant and animal species, support biodiversity and maintain ecological balance. They also provide valuable ecosystem services such as coastal protection, water filtration, nutrient cycling, and support for fisheries. Furthermore, these ecosystems offer recreational and cultural benefits and contribute to the livelihoods and well-being of coastal communities through activities such as fishing, tourism, and traditional practices (e.g. *tara bandu* in Timor-Leste).

2.1. MANGROVE FORESTS

Mangroves, characterized by their salt-tolerant trees and shrubs, thrive along tropical and subtropical coastlines, particularly in estuaries and tidal zones. Mangroves are distributed across various countries with extensive coastlines, including Indonesia, Malaysia, Thailand, Viet Nam, and the Philippines (Figure 1). In Southeast Asia, the mangrove forest occupies an area of 48,222.25 km² (Bunting et al. 2022). The breakdown of estimated mangrove coverage per country is presented in Table 1.

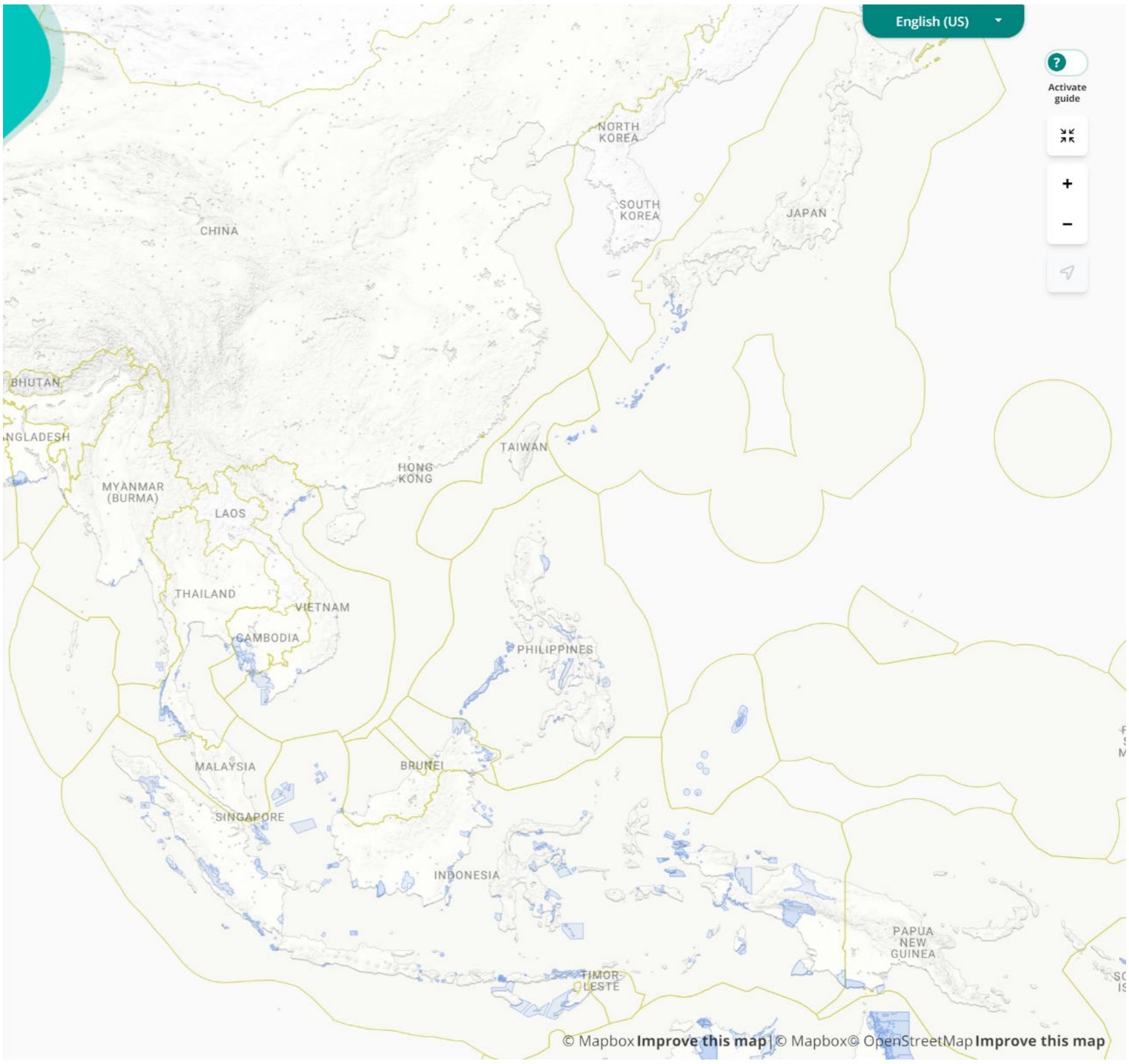

Figure 1. Distribution of mangroves in the EAS region in blue (Global Mangrove Watch, 2024)

Table 1. Mangrove areas in the EAS region

Country	Area (ha)
Brunei Darussalam	35,183.74 (Satyanarayana et al. 2018)
Cambodia	57,132 (Cambodia Ministry of Environment 2018) (0.65% total forest land in Pham and Le Thi, 2019)
China	35,749.25 (Fu et al. 2021)
Indonesia	3.1 million (3% of total Forested land) (Pham and Le Thi, 2019)
Japan	870 (Inoue et al. 2022)
Malaysia	629,038 (3% of total Forested land) (Malaysia's Open Data Portal, 2017 in Pham and Le Thi, 2019)
Philippines	310,593 (4.54% forest land in 2010) (Cabico 2018 in Pham and Le Thi, 2019)
Singapore	659 (Yee et al. 2010)
Republic of Korea	N/A
Thailand	236,500 (Pham and Le Thi, 2019)
Timor-Leste	290 (PEMSEA and Ministry of Agriculture and Fisheries (Timor-Leste), 2019)
Viet Nam	270,000 (Pham and Le Thi, 2019)

According to Richards and Friess (2015), between 2000 and 2012, mangrove forests in the region were lost at an average rate of 0.18% per year, with aquaculture identified as a major pressure, accounting for a total of 30% of mangrove change. The scale of mangrove deforestation is illustrated in Figure 2.

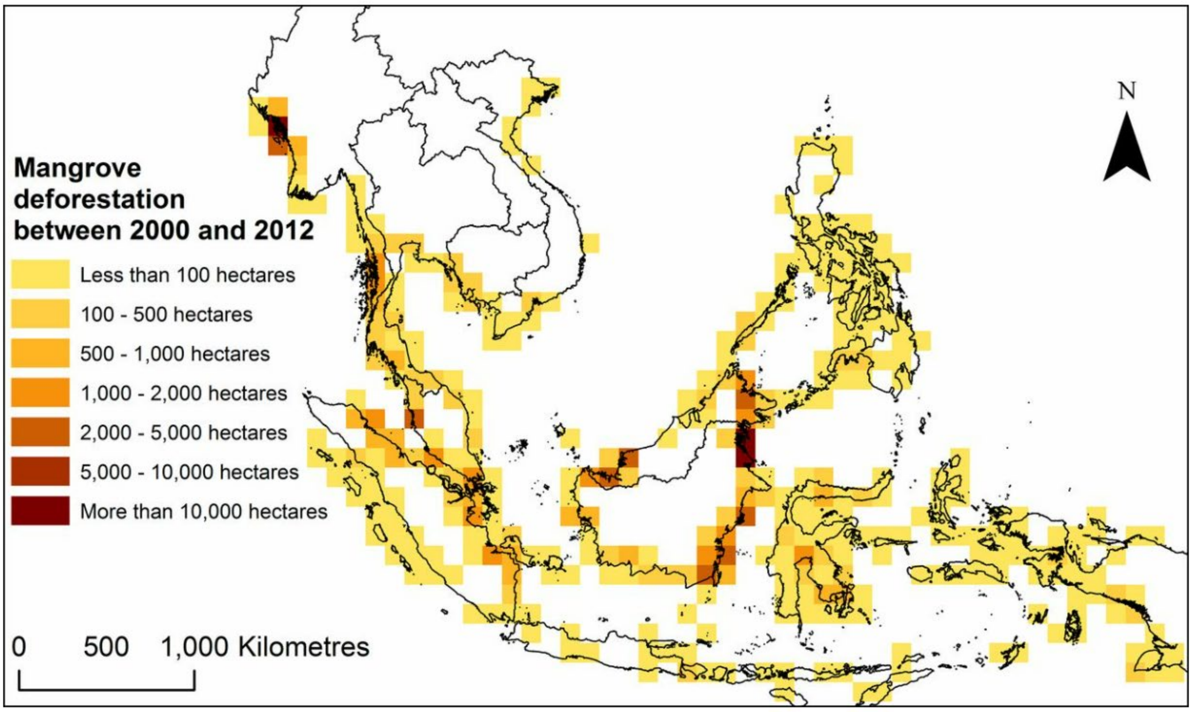

Figure 2. Mangrove deforestation between 2000 and 2021 (Richards and Friess, 2015)

A study conducted by Stankovic et al. (2023) manages to show the summary of biomass Corg stock values from mangrove forests in Southeast Asia (Table 2). Indonesia and Malaysia exhibit the highest variability in Aboveground Carbon (AGC), with values ranging from 0.03 to 742.6 tons per hectare and 12.18 to 231.2 tons per hectare, respectively. The Philippines and Viet Nam also show significant variability, particularly in Belowground Carbon (BGC), ranging from 0.40 to 182.36 tons per hectare and 0.40 to 159.59 tons per hectare, respectively.

Table 2. A summary of biomass C_{org} stock values (Mg C ha^{-1}) in mangrove forests for each country. The stocks are expressed as a range (min-max), as well as average ± standard deviation (SD). Absence of SD in the table means no SD value was available in the literature (Stankovic et al. 2023)

Countries	AGC[1] min – max average ± SD	BGC[2] min – max average ± SD	Total biomass carbon min – max average ± SD	DWC[3] min – max average ± SD	WDC[4] min – max average ± SD	Litter min – max average ± SD
Brunei Darussalam	N/A	N/A	N/A	N/A	N/A	N/A
Cambodia	10–70	1.00–50	N/A	N/A	0.1–10	N/A
Indonesia	0.03–742.6 (168.29 ± 61.21)	0.16–211.2 (26.39 ± 17.72)	0.10–467.4 (24.28)	0.1–34 (8.26 ± 6.30)	N/A	0.98–1.18
Malaysia	12.18–231.2 (367.30)	12.20–18.3 (8.72)	7.04–1009.7 (79.91)	8.1–73.4	N/A	0.56–1.96
Philippines	11.00–559.58 (90.06 ± 34.58)	6.75–182.36 (31.79 ± 13.02)	12.60–125.8	N/A	3.77–5.81	N/A
Singapore	22.06–280.8 (108 0.12 ± 20.31)	3.14–120.7 (27.51 ± 3.70)	160.00–220 (133.15)	N/A	N/A	N/A
Thailand	27.68–310.30 (162.31 ± 21.81)	23.30–40.40 (33.6 ± 9.10)	N/A	N/A	0.8–3	N/A
Timor-Leste	N/A	N/A	N/A	N/A	N/A	N/A
Viet Nam	4.2–311.7 (90.13 ± 15.83)	0.40–159.59 (17.21 ± 3.72)	90–115	0.08–8.4 (3.56 ± 0.19)	N/A	N/A

[1]AGC – aboveground carbon; [2]BGC – belowground carbon; [3]DWC – downed wood carbon; [4]WDC – wood debris carbon

Moreover, Stankovic et al. (2023) show the variability of organic carbon stocks in mangrove sediment across different Southeast Asian countries, highlighting the significant carbon storage potential of mangrove forests in the region (Table 3). They also illustrate that the assessment of carbon sequestration rates was more prevalent for mangrove forests in the area, with the highest figures documented in Indonesia and Thailand, and the lowest in Singapore (Table 4).

Table 3. A summary of the non-extrapolated organic carbon stock in the sediment (Mg ha−1) across different core depths of mangrove forests in Southeast Asia (Stankovic et al. 2023)

Countries	Mangrove Forest	
	Sediment (≤ 100 cm depth) min - max	Sediment (> 100 cm depth) min - max
Brunei Darussalam	N/A	N/A
Cambodia	50–850	N/A
Indonesia	2–575	520–2429.7
Malaysia	5.67–658.4	
Philippines	10.61–559.54	46.77–2014.56
Singapore	8.40–340	
Thailand	5.58–553	462.67–1172.8
Timor-Leste	N/A	N/A
Viet Nam	4.84–884.4	341.9–926.91

Table 4. Carbon sequestration rates (g m^{-2} y^{-1}) in mangrove forests across the EAS region. (Stankovic et al. 2023)

Countries	Mangrove forest min – max
Brunei Darussalam	N/A
Cambodia	N/A
Indonesia	5–1722
Malaysia	20–760
Philippines	N/A
Singapore	70–170
Thailand	100–1263.3
Timor-Leste	N/A
Viet Nam	120–602.7

At the national level, several countries have national mapping programs for their mangroves to understand their national inventory better. In 2021, the Directorate of Soil and Water Conservation, Directorate General of Watershed and Protected Forest Management, Ministry of Environment and Forestry of Indonesia released the National Mangrove Map (Direktorat Konservasi Tanah dan Air, Ditjen PDASRH, 2021). According to the document, the existing mangrove coverage was 3,640,080 ha, comprising 93% dense mangroves, 5% medium-density mangroves, and 2% sparse mangroves (Figure 3).

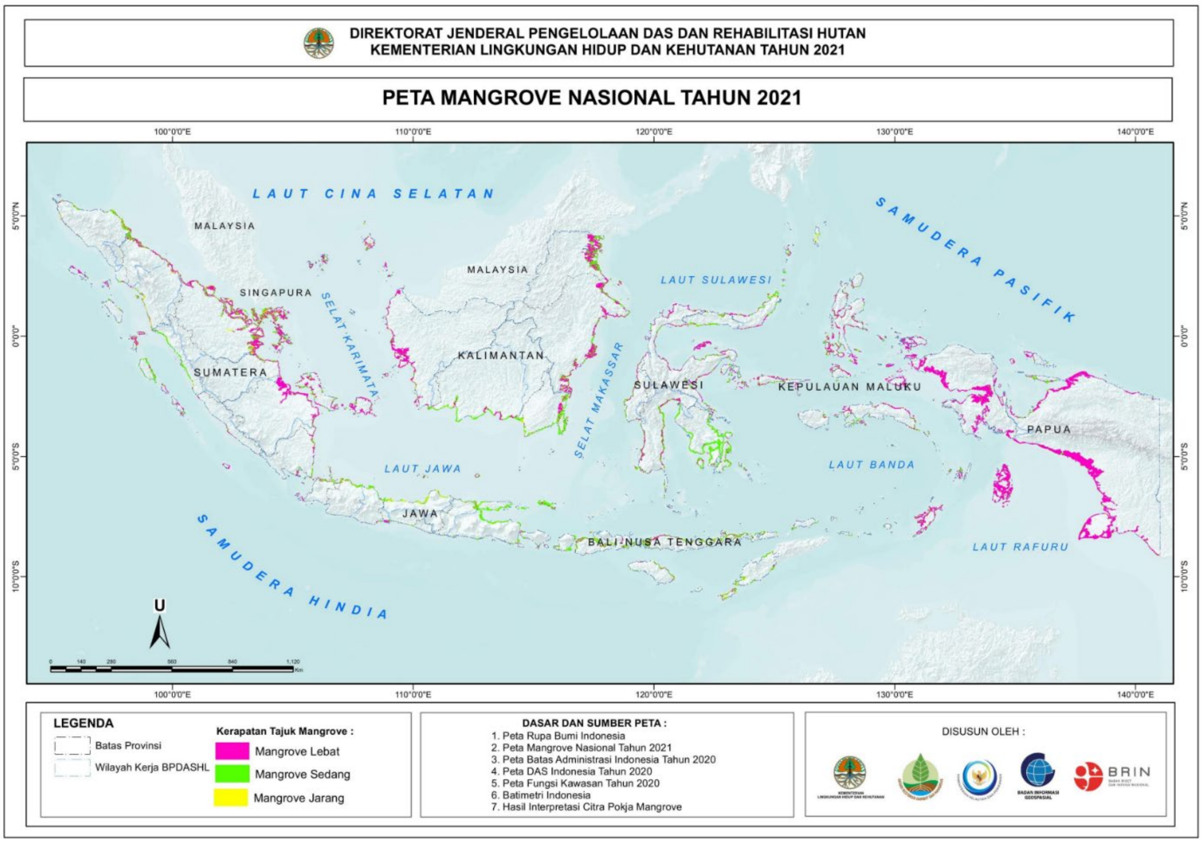

Figure 3. Indonesia's national mangrove map in 2021 (Direktorat Konservasi Tanah dan Air, Ditjen PDASRH, 2021)

In the Philippines, the Department of Environment and Natural Resources (DENR) and the Philippine Space Agency (PhilSA) released the National Mangrove Map 2023 (Figure 4), which will be used to inform decision-making and policy development for the restoration and protection of the country's mangroves. The map underwent ground validation through DENR's citizen science initiative, urging both private and public sectors, including individuals and organizations, to visit coastal barangays. They were encouraged to verify mangrove presence using the ODK Collect app. With a target of over 600 sites and 30,000 validation points nationwide, DENR aims to complete field validation of the mangrove map by June 2024 (DENR 2024).

Figure 4. The Philippines' national mangrove map (source: DENR, 2023)

2.2. SEAGRASS MEADOWS

Seagrasses, flowering plants that form underwater meadows in shallow coastal waters, are widespread in the EAS region, with Indonesia, Malaysia, Thailand, Viet Nam, and the Philippines hosting significant seagrass meadows along their coastlines, in addition to China, Japan and Republic of Korea (Figure 5). The estimated seagrass meadows in Southeast Asia are 24,411.96 km^2 (Stankovic et al. 2023). The seagrass coverage in each country is presented in Table 5.

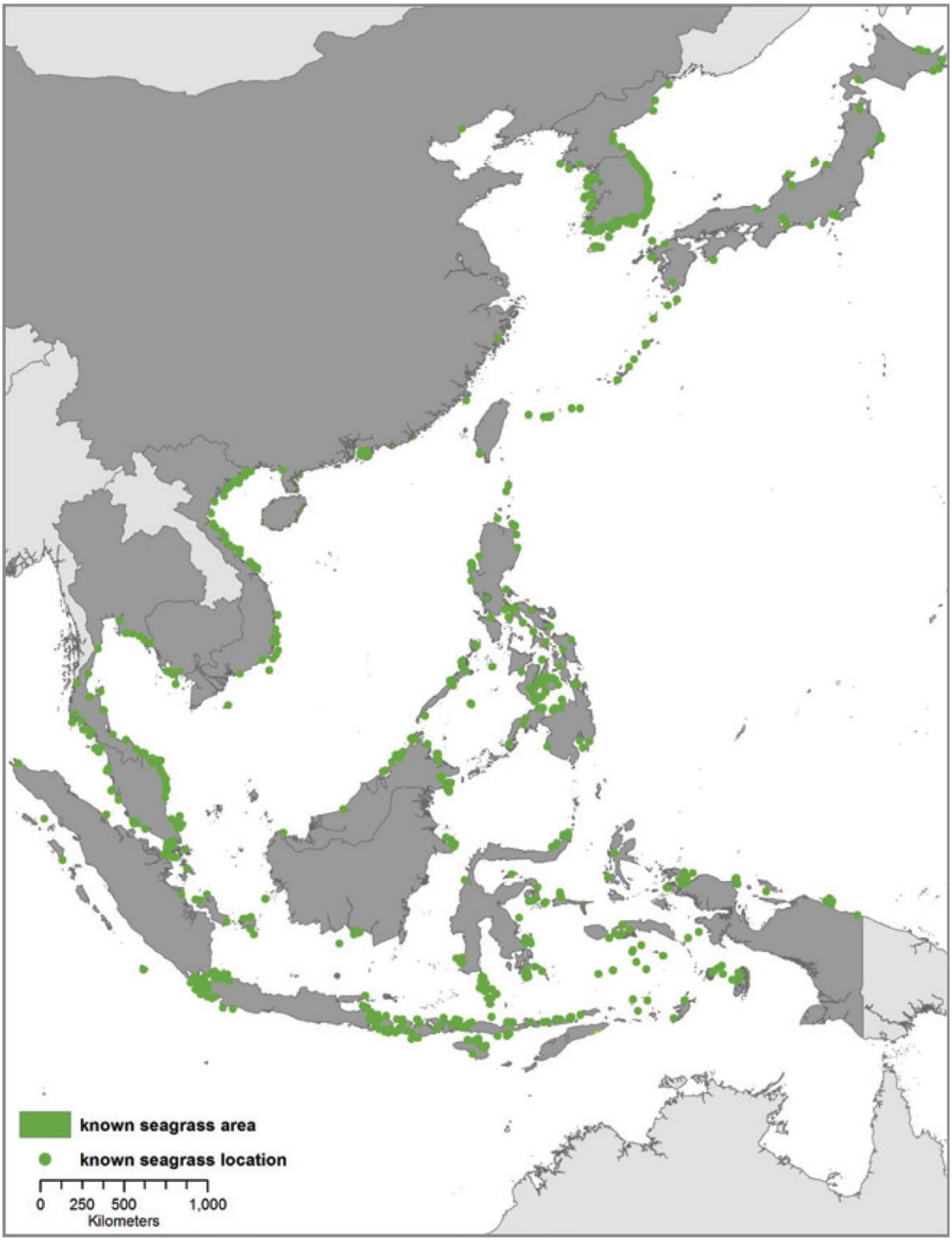

Figure 5. Seagrass meadows that have been mapped in the EAS region (Crooks et al. 2017)

Table 5. Seagrass areas in the EAS region

Country	Seagrass area (ha)
Brunei Darussalam	150 (Sudo et al. 2021)
Cambodia	22,980 (Sudo et al. 2021)
China	7,140 from southern mainland China (Sudo et al. 2021)
Indonesia	293,460 (Sudo et al. 2021)
Japan	2,390 from Ryukyu Islands of Japan (Sudo et al. 2021)
Malaysia	4,900 (Sudo et al. 2021)
Philippines	8,210 (Sudo et al. 2021)
Singapore	200 (Sudo et al. 2021)
Republic of Korea	N/A
Thailand	18,990 (Sudo et al. 2021)
Timor-Leste	1,900 (Sudo et al. 2021)
Viet Nam	15,750 (Sudo et al. 2021)

Between 2000 and 2020, over 60% of seagrass beds experienced a decline (refer to Figure 6), with an average annual decrease of 10.9%, while around 20% of beds saw growth, with an average annual increase of 8.1% in Southeast Asia (including southern mainland China, Taiwan, and the Ryukyu Islands of Japan). This resulted in an overall average annual decline of 4.7% for seagrass beds (Sudo et al., 2021). Moreover, Sudo et al. (2021) report that major human-induced factors such as development, aquaculture, and harmful fishing practices were identified as significant contributors to the decline of seagrass beds in the EAS region.

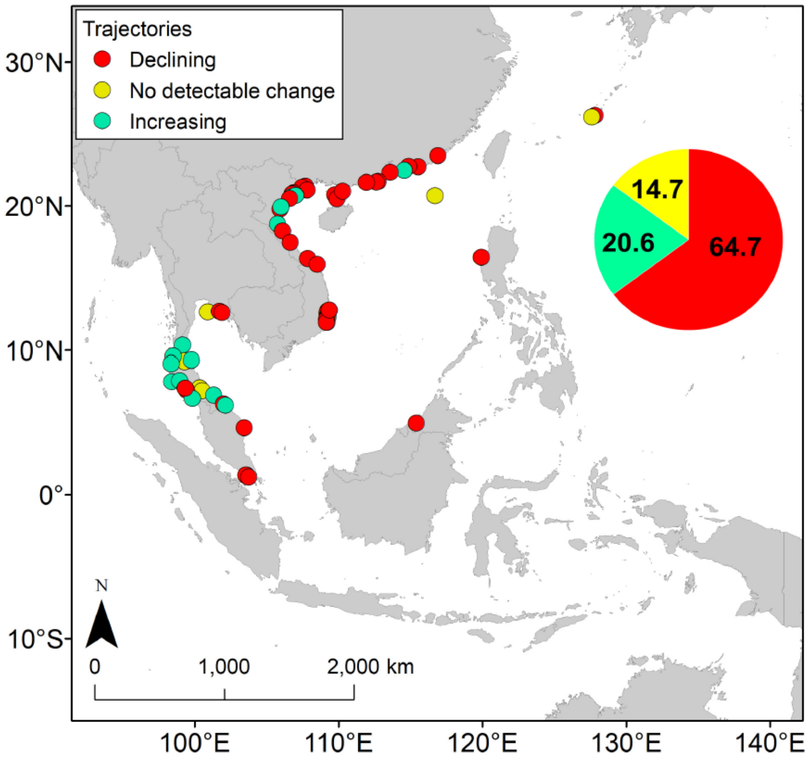

Figure 6. Trajectories of seagrass meadows (Sudo et al. 2021)

Similar to mangroves, Stankovic et al. (2023) compiled country-specific estimates of organic carbon stocks (C_{org}) for seagrass ecosystems across Southeast Asian countries, particularly those in Southeast Asia (Table 6). Thailand exhibits the highest values for both aboveground and belowground carbon stocks. Additionally, the study presents sediment carbon stocks at depths ≤100 cm, highlighting Malaysia and Singapore as having the highest values (Table 7).

Table 6. A summary of biomass C_{org} stock values (Mg C ha−1) in seagrass meadows for each country. The stocks are expressed as a range (min-max), as well as average ± standard deviation (SD). Absence of SD in the table means no SD value was available in the literature (Stankovic et al. 2023)

Country	AGC[1] min – max average ± SD	BGC[2] min – max average ± SD
Brunei Darussalam	N/A	N/A
Cambodia	N/A	N/A
Indonesia	0.01–1.85 (0.65)	0.05–1.84 (1.31)
Malaysia	N/A	N/A
Philippines	(0.77 ± 0.23)	0.59–6.78
Singapore	0.1–1.4	0.10–0.43
Thailand	0.10–9 (0.68 ± 0.31)	(3.05 ± 0.12)
Timor-Leste	N/A	N/A
Viet Nam	N/A	N/A

[1]AGC – aboveground carbon.; [2]BGC – belowground carbon if it was reported as a separate carbon pool

Table 7. A summary of the non-extrapolated organic carbon stock in the sediment (Mg ha−1) across different core depths of seagrass ecosystems in Southeast Asia (Stankovic et al. 2023)

Country	Seagrass Meadows	
	Sediment (≤ 100 cm depth) min - max	Sediment (> 100 cm depth) min - max
Brunei Darussalam	N/A	N/A
Cambodia	N/A	N/A
Indonesia	0.32–65.80[1]	N/A
Malaysia	0.10–201.10	N/A
Philippines	13.95–41.08[2]	N/A
Singapore	4.19–146.60	N/A
Thailand	14.20–205	N/A
Timor-Leste	N/A	N/A
Viet Nam	N/A	N/A

[1] Core reached only up to 67 cm depth; [2] Core reached only up to 50 cm depth

Furthermore, carbon sequestration rates in seagrass ecosystems were derived from a single study conducted in Thailand, indicating a range of 2.97 to 3.09 g m−2 per year. The limited availability of data on flux and sequestration rates, especially within seagrass meadows, underscores a significant knowledge gap across the region.

Indonesia and the Philippines also conducted national mapping for seagrass meadows. Indonesian National Institute of Sciences or LIPI (Sjafrie et al. 2018) released that the potential seagrass beds throughout Indonesia reaches 875,967 ha. However, from this potential, only 293,464 hectares have been validated and verified.

Moreover, the Philippines also has the IAMBlueCECAM or the Integrated Assessment and Modelling of Blue Carbon Ecosystem for Conservation and Adaptive Management Program to help monitor its mangroves and seagrass meadows which is part of Comprehensive Assessment and Conservation of Blue Carbon Ecosystems and their Services in the Coral Triangle (BlueCARES). The initiative was started to create a detailed list of mangrove forests and seagrass areas using remote sensing and on-site measurements. This information helps local officials understand where mangroves are and what types of species are present, which is crucial for better conservation and management of natural resources (Blanco, 2018).

2.3. SALT MARSHES

Salt marshes, coastal wetlands flooded and drained by saltwater brought in by tides, although less prevalent compared to mangroves and seagrasses, are found in countries like China, Republic of Korea, and Japan (Figure 7). A more detailed breakdown of salt marsh areas in the EAS region is provided in Table 8.

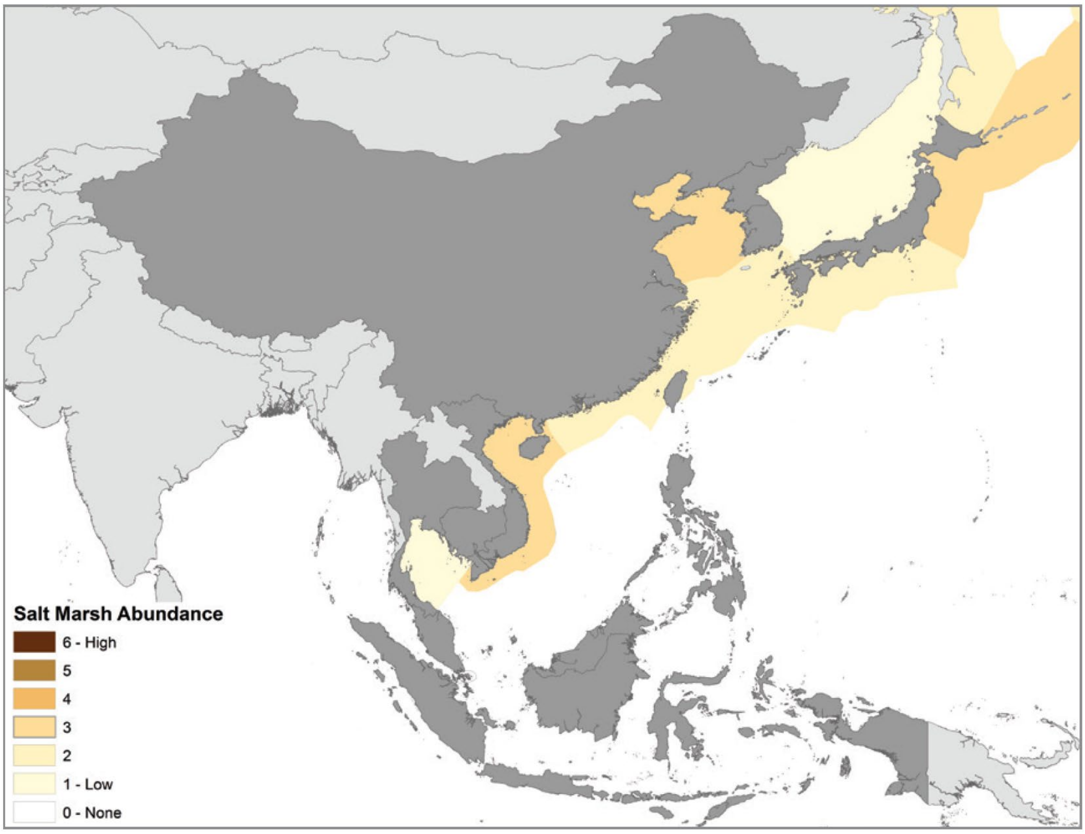

Figure 7. Distribution and relative abundance of salt marshes based on proportion of coastline within a region (Crooks et al. 2017)

Table 8. Salt marsh areas in the EAS region

Country	Salt marsh area (ha)
Brunei Darussalam	N/A
Cambodia	N/A
China	1,241 (Gu et al. 2018)
Indonesia	N/A
Japan	N/A
Malaysia	N/A
Philippines	N/A
Singapore	N/A
South Korea	394.7 (Byun et al. 2019)
Thailand	N/A
Timor-Leste	N/A
Vietnam	N/A

In China, coastal salt marshes have experienced significant depletion. Gu et al. (2018) revealed considerable variation in the extent of coastal salt marshes among regions such as the Liao River Delta, the Yellow River Delta, the middle coast of Jiangsu Province, Chongming Dongtan, and Jiuduansha in Shanghai. Overall, there was a 59% decline in salt marsh extent from the 1980s to the 2010s, although the rate of loss slowed after 2000. The primary cause of salt marsh loss is coastal land reclamation.

A similar trend was observed in the Republic of Korea. Since the 1980s, the Republic of Korea's coastal wetlands have undergone swift degradation and destruction, primarily due to land reclamation and the use of landfills for coastal development. Over the last two decades, from 1987 to 2008, more than 20% of the total tidal flats vanished (Statistics Korea 2010, as cited in Koo et al. 2011).

Despite the declining trend, Li et al. (2022) demonstrate that the value of carbon storage in China's Eastern salt marshes ranged from 7.24 to 104.99 Mg C ha^{-2}. In the Republic of Korea, Byun et al. (2019) show that pristine salt marshes captured more carbon than impacted salt marshes, with values of 19.8 (3.0-34.8) kg C m^{-2} and 14.6 (8.5-23.2) kg C m^{-2} respectively.

2.4. SEAWEED BEDS

Seaweed beds as a carbon sink represent a relatively new field of study, particularly in the EAS region. Japan appears to be the pioneering East Asian country to incorporate seaweed beds, alongside mangroves, seagrass meadows, and tidal flats, in the measurement, verification, and certification of CO_2 absorption.

Tanaka et al. (2020) reported that in the 1990s, the total area covered by seaweed beds was approximately 201,212 hectares. However, by the 2000s, this area had decreased by 22%. This decline was influenced by several factors, such as increasing surface seawater temperatures, excessive grazing by sea urchins and fish, insufficient nutrients and water flow, and aggravated by the construction of coastal breakwaters.

Kuwae et al. (2023) included seaweed beds in their assessment of the annual uptake of atmospheric CO_2 by shallow coastal ecosystems in Japan. The seaweed beds examined in the study included sargassum beds, subarctic kelp beds, and temperate kelp beds situated at depths of less than 20 m and covering areas exceeding 1 ha (Table 9).

Table 9. Estimates of the nationwide annual uptake of atmospheric CO_2 by seaweed beds (Kuwae et al. 2023)

Shallow coastal ecosystem		Area (x 10^4 ha)	Removal coefficient		Uptake rate	
			Mean	Upper limit	Mean	Upper limit
			(tons CO_2/ha/year)		(x10^4 tons CO_2/year)	
Seaweed beds	Sargassum beds	8.8	2.7	5.1	24	45
	Subarctic kelp	2.0	10.3	36.0	21	73
	Temperate kelp beds	6.3	4.2	7.9	26	50
	Total	17.2			71	167

Another study by Sondak et al. (2017) specifically focuses on the use of seaweed aquaculture beds (SABs) as potential CO_2 mitigation effort from commercial seaweed production in China, India, Indonesia, Japan, Malaysia, Philippines, Republic of Korea, Thailand, and Viet Nam. Seaweeds are effective carbon sinks due to their large biomass and longer turnover times compared to phytoplankton. They also contain recalcitrant carbon that is not easily degraded, and through photosynthesis, they reduce partial pressure of CO_2 in seawater while sequestering significant amounts of carbon, making them valuable for biomass production and CO_2 sequestration throughout their lifespan. The study estimated the algal harvests, annual carbon absorption, and potential CO_2 sequestration by SABs in 2014 (Table 10).

Table 10. Estimates of algal harvests, annual carbon absorption, and potential CO_2 sequestration by SABs (Sondak et al. 2017)

Country	Algae harvested (t dw y^{-1})	Estimated C assimilation (t dw y^{-1})	Potential CO_2 sequestration (t dw y^{-1})
China	1,281,949	384,585	1,411,425
Indonesia	897,146	269,124	987,758
Japan	34,330	10,299	37,397
Malaysia	24,533	7,360	27,011
Republic of Korea	108,203	32,461	119,131
Philippines	154,958	46,487	170,608
Viet Nam	1,433	430	1,577

Lastly, Kwan et al. (2022) conducted a study on seaweed carbon stock using Singapore as a case study. The study found that the annual range of seaweed biomass carbon is estimated to be 450 Mg C yr^{-1} or 0.77 Mg C ha^{-1} yr^{-1}, mainly from *Ulva* and *Sargassum*.

2.5. TIDAL FLATS

Tidal flats are a globally widespread coastal ecosystem that occur at the interface between land and sea (Figure 8). Although tidal flats are prevalent in coastal areas worldwide, their global distribution and current status are not well documented, which poses challenges for effectively managing, protecting, and restoring coastal ecosystems globally. Murray et al. (2019) attempted to produce the first analysis of the global distribution and change of tidal flats and the study discovered that the ecosystems are declining in area and highly threatened by human activities.

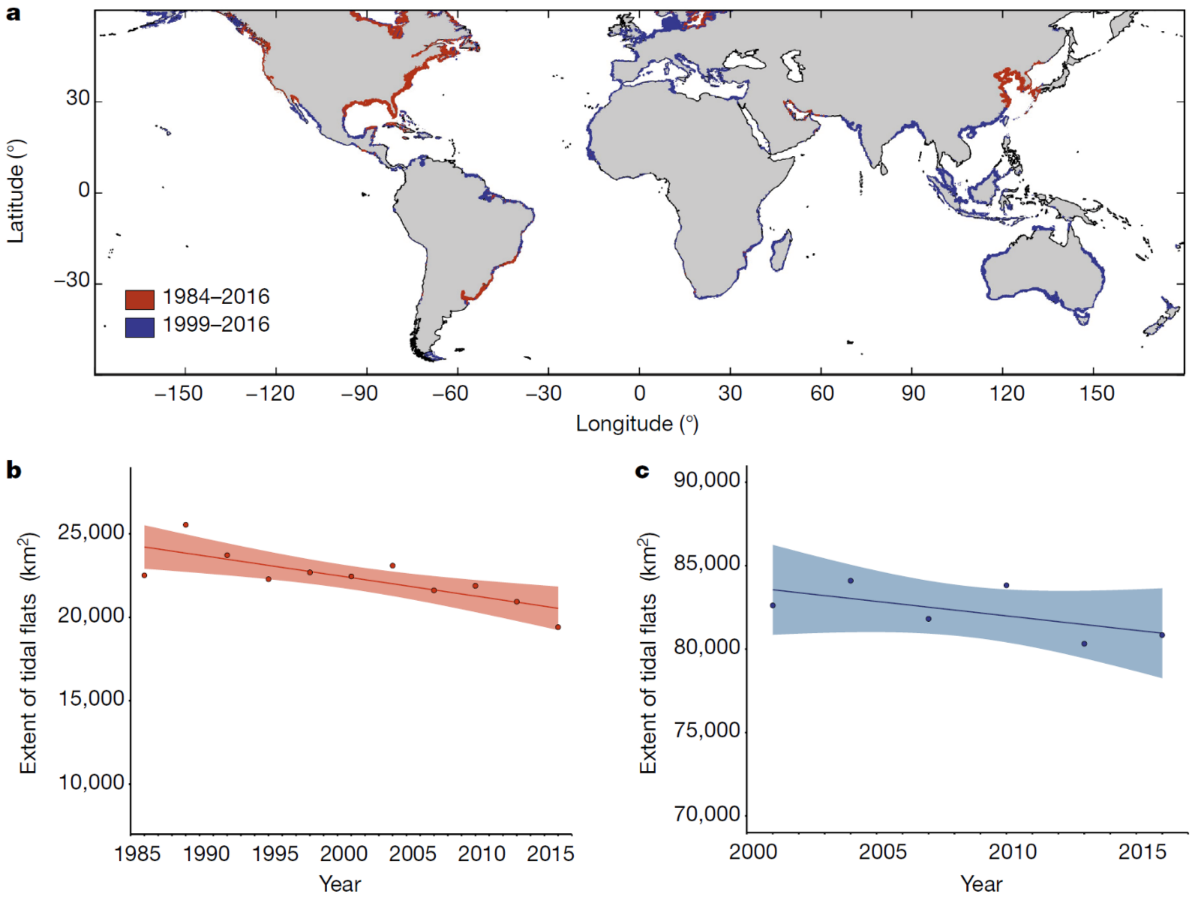

Figure 8. Global trajectory in the extent of tidal flats. a) The global coverage of the trajectory analyses, showing areas in which the development of consistent time-series data over 1984-2016 (orange) and 1999-2016 (orange and blue) was possible. b) Change in extent of tidal flats in 17.1% of the mapped area, 1984-2016 (linear regression, $P = 0.00437$). c) Change in extent of tidal flats in 61.3% of the mapped area, 1999-2016 (linear regression, $P = 0.1794$). Shading in b and c indicates the standard error of the linear model (Murray et al. 2019)

Prior to the global assessment, Murray et al. (2014) conducted a study to track the rapid loss of tidal wetlands in the Yellow Sea across three countries – China, DPR Korea, and the Republic of Korea at three time periods (mid-1950, early 1980s, and late 2000s) (Figure 9). The study found out that 28% of tidal flats present in the 1980s had vanished by the late 2000s, equivalent to an annual loss rate of 1.2%. Furthermore, comparisons with historical maps indicate that as much as 65% of tidal flats have been lost over the past fifty years.

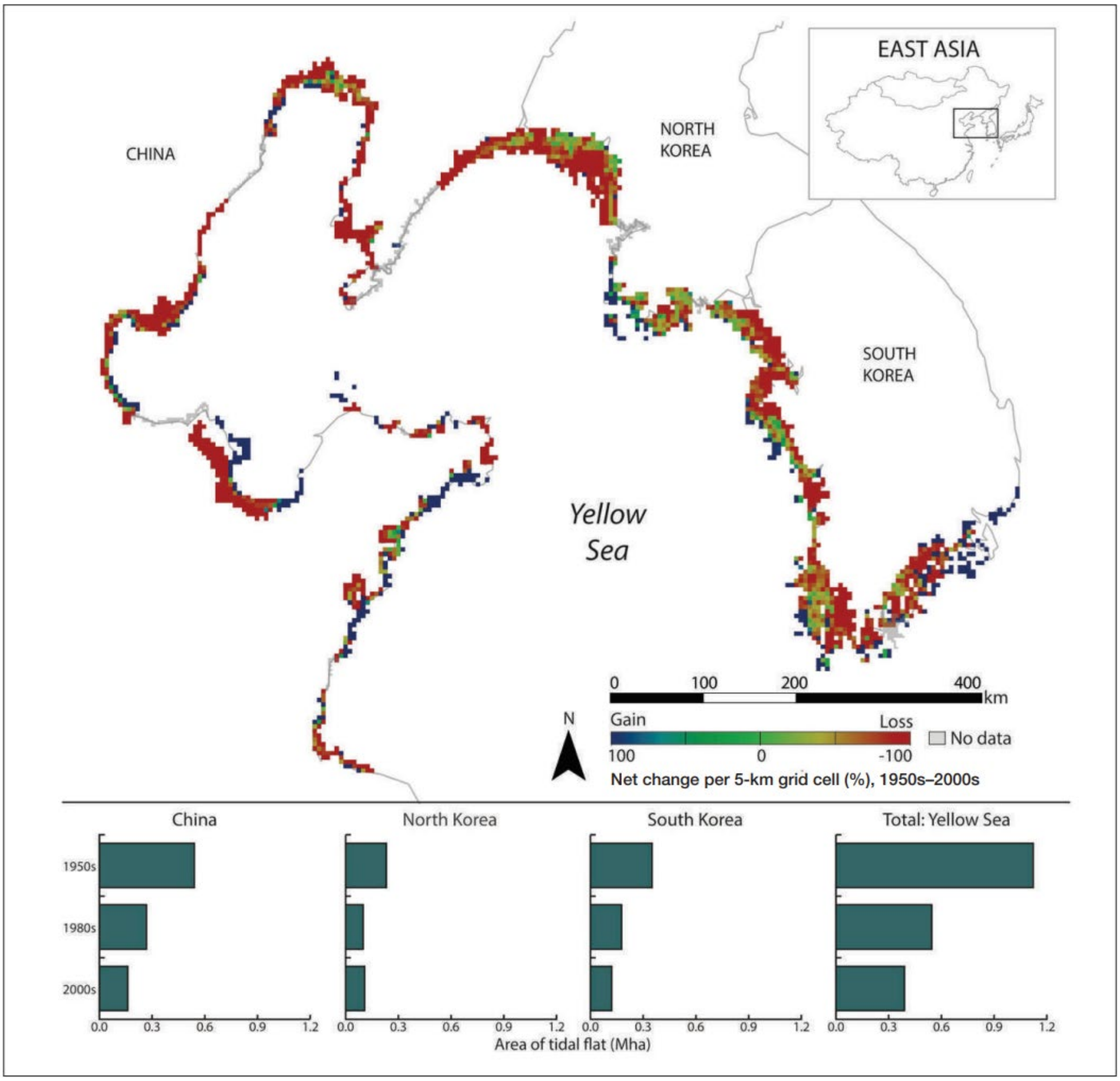

Figure 9. Change in tidal flats in the Yellow Sea between the 1950s and the 2000s, mapped at a 5-km grid resolution. Net change between the two time periods is shown on a color ramp from blue (total gain) to red (total loss) (Murray et al. 2014)

Chen et al. (2020) investigated the carbon storage and sequestration rate in tidal flats along the coast of China. Their research revealed that sediment carbon densities in Chinese tidal flats were generally low (<0.01 g cm^{-3}), yet carbon sequestration rates ranged from 35 to 361 g C m^{-2} yr^{-1}, comparable to rates observed in vegetated coastal areas globally. Moreover, tidal flats in coastal China store 78.07 Tg C (100 cm depth), representing nearly 80% of the carbon deposited in the entire coastal tidal zone.

Finally, in Japan, Kuwae et al. (2023) also estimated the nationwide annual uptake of atmospheric CO_2 by tidal flats. The tidal flats shall have a maximum width of at least 100 m, an area of at least 1 ha, and a mobile substrate (gravel, sand, sandy mud, or mud). The results of the study are presented in Table 11.

Table 11. Estimates of the nationwide annual uptake of atmospheric CO_2 by tidal flats (Kuwae et al. 2023)

Shallow coastal ecosystem	Area (x 10^4 ha)	Removal coefficient		Uptake rate	
		Mean	Upper limit	Mean	Upper limit
		(tons CO_2/ha/year)		(x10^4 tons CO_2/year)	
Tidal flats	4.7	2.6	2.6	12	12

3. BLUE CARBON SITE SURVEY

In 2023, PEMSEA developed a draft site survey tool to assist in determining the status, management and site readiness of BCEs and if there are potential sites in the EAS region that can be designated as pilot sites of the BC program. The supply side assessment can also assist in identifying gaps and capacity-building needs at the local level.

The draft was further refined in 2024 through several methods – literature review (AGEDI 2014, Schindler Murray et al. 2023, UNEP and CIFOR 2014, and Weaver et al. 2022) and internal review by PEMSEA's technical staff between February and April 2024. The final survey tool is shown in Appendix 1.

The refined survey tool was designed with three primary objectives. Firstly, it aims to validate information regarding the status of BCEs in the region against the site level. Secondly, it seeks to provide insights into existing management levels and supporting frameworks for BCEs at the site level, including identifying gaps and challenges in BCE management—these will be useful for designing necessary capacity building at the local level. Lastly, the tool aims to gauge interest in further developing and implementing a BC program.

A BC Site survey using the refined tool was conducted between the end of April and the beginning of June 2024. The tool, along with a filled-in example, was disseminated to the PEMSEA Network of Local Governments (PNLG – 57 contacts) and some of the PEMSEA Network of Learning Centers (PNLC – 48 contacts) members in coordination with the Secretariats of PNLG and PNLC. The survey scope primarily focused on PEMSEA ICM sites with the potential inclusion of new site recommendations from PNLC members.

By the first week of June 2024, 20 completed checklists were received from 6 countries and 20 sites. The results from the survey were supplemented by BC-related information extracted from published or unpublished State of Oceans and Coasts (SOC) reports from 7 countries and 20 sites (Table 12). The list of respondents is shown in Appendix 2.

Table 12. Sources of completed checklists and SOC reports

No.	Country	Site	Source
1	Cambodia	Kampot	Survey
2		Koh Kong	Survey
3		Preah Sihanouk	Survey
4		Kep	SOC (unpublished, 2018)
5	China	Changyi	Survey
6		Dongying	Survey

7		Quanzhou	Survey
8		Haikou	SOC (unpublished, 2020)
9		Jinzhou	SOC (unpublished, 2017)
10		Laoting	SOC (unpublished, 2020)
11		Lianyungang	SOC (unpublished, 2020)
12		Qingdao	SOC (unpublished, 2020)
13		Qingdao Blue Valley	SOC (unpublished, 2020)
14		Xiamen	SOC (unpublished, 2020)
15	Indonesia	Bali	Survey
16		Bintan	Survey
17		Jakarta	Survey
18		Manado	Survey
19		Tangerang	Survey
20		Bontang	SOC (unpublished, 2019)
21		Lombok Timur	SOC (unpublished, 2019)
22		Sukabumi	SOC (unpublished, 2019)
23	Philippines	Bataan	Survey
24		Batangas	Survey
25		Catanduanes	Survey
26		Cavite	Survey
27		Guimaras	Survey
28		Macajalar Bay	SOC (unpublished, 2018)
29		Oriental Mindoro	SOC (unpublished, 2019)
30		Romblon	SOC (unpublished, 2020)
31	Republic of Korea	Ansan	SOC (published)
32		Masan Bay	SOC (published)
33	Thailand	Chanthaburi	SOC (unpublished, 2020)
34		Rayong	SOC (unpublished, 2020)
35		Trat	SOC (unpublished, 2020)
36	Timor-Leste	Dili	Survey
37		Manatuto	Survey
38		Liquica	SOC (unpublished)
39	Viet Nam	Danang	Survey
40		Quang Nam	Survey

The survey has some limitations. Firstly, there were limited responses received, so information had to be supplemented using the SOC reports. Secondly, the SOC reports themselves provide limited information relevant to BC. SOC is a comprehensive tool used to assess and monitor the health of marine and coastal environments in the EAS region. It employs a standardized set of measures to evaluate critical aspects of coastal areas, such as governance, environment, and local economic impact. Policymakers can use SOC to identify emerging issues, track progress, and assess the effectiveness of management efforts. However, since SOC is not specifically tailored for a BC program, the depth and breadth of BC-related information available is somewhat restricted.

4. BLUE CARBON SITE FINDINGS

4.1. RESOURCES USES AND MANAGERS, PROGRAMS AND MANAGEMENT EFFORTS

4.1.1. Mangrove forests

Status

Twenty-nine of 40 sites from seven surveyed countries stated that they have mangrove forests (Table 13). The size of the mangrove forests ranges from 62 hectares in Benoa Bay, Bali, Indonesia, to 62,000 hectares along the coast of Koh Kong and its Peam Krosop Wildlife Sanctuary, Cambodia. Some sites from SOC reports may have incomplete information (i.e. missing area and/or rate of the mangrove forests).

Table 13. Countries and sites with mangrove forests

No.	Country	Site	Area (ha)	Rating of BCE State (1 to 5)
1	Cambodia	Kampot	1,960	3
2		Kep	1,005	N/A
3		Koh Kong	62,000	4
4		Preah Sihanouk	1,350	3
5	China	Quanzhou	7,045	4
6		Haikou	2,601	4
7	Indonesia	Bali	62	2
8		Bintan	10,001	2
9		Bontang	N/A	N/A
10		Jakarta	414	3
11		Lombok Timur	1,494	N/A
12		Manado	12,750	2.5
13		Sukabumi	108	N/A
14		Tangerang	220	1.8 (from an average of 9 subsites ranging score between 1 and 3)
15	Philippines	Bataan	356.77	3
16		Batangas	622.898	5
17		Catanduanes	1,995	3
18		Cavite	500	5
19		Guimaras	395.6	2
20		Macajalar Bay	215.6	N/A
21		Oriental Mindoro	2,684	N/A
22		Romblon	9,130.25	N/A
23	Thailand	Chanthaburi	13,194.74	3
24		Rayong	N/A	N/A
25		Trat	9,553.368	3
26	Timor-Leste	Dili	200	3
27		Liquica	N/A	N/A
28		Manatuto	1,743.56	3
29	Viet Nam	Quang Nam	124	2

Twenty sites assessed the conditions of their mangrove forests, which varied from 2 to 5 (Table 13, Figure 10). These scores correspond to different conditions: 1 indicating poor, 2 indicating fair, 3 indicating good, 4 indicating very good, and 5 indicating excellent. The average score for the mangroves is 3.1, suggesting that overall, the mangroves are in relatively good condition.

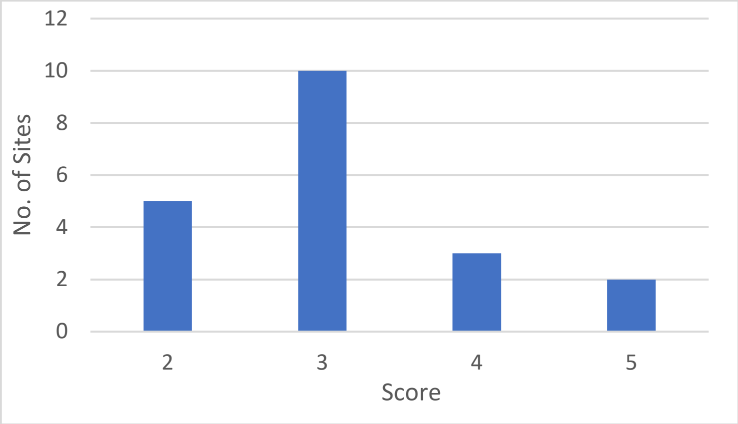

Figure 10. States of mangroves in the EAS region

Issues and Threats

Regarding current issues and threats faced by the ecosystem, respondents and reports indicate that logging/deforestation and pollution are the most threatening issues, followed by climate change, coastal development, and illegal activities (such as illegal fishing, logging, or settlement). Pollution may result from oil spills, marine debris, and harmful chemicals from agriculture. Land conversion due to aquaculture and privatization has also been identified as emerging threats (Figure 11).

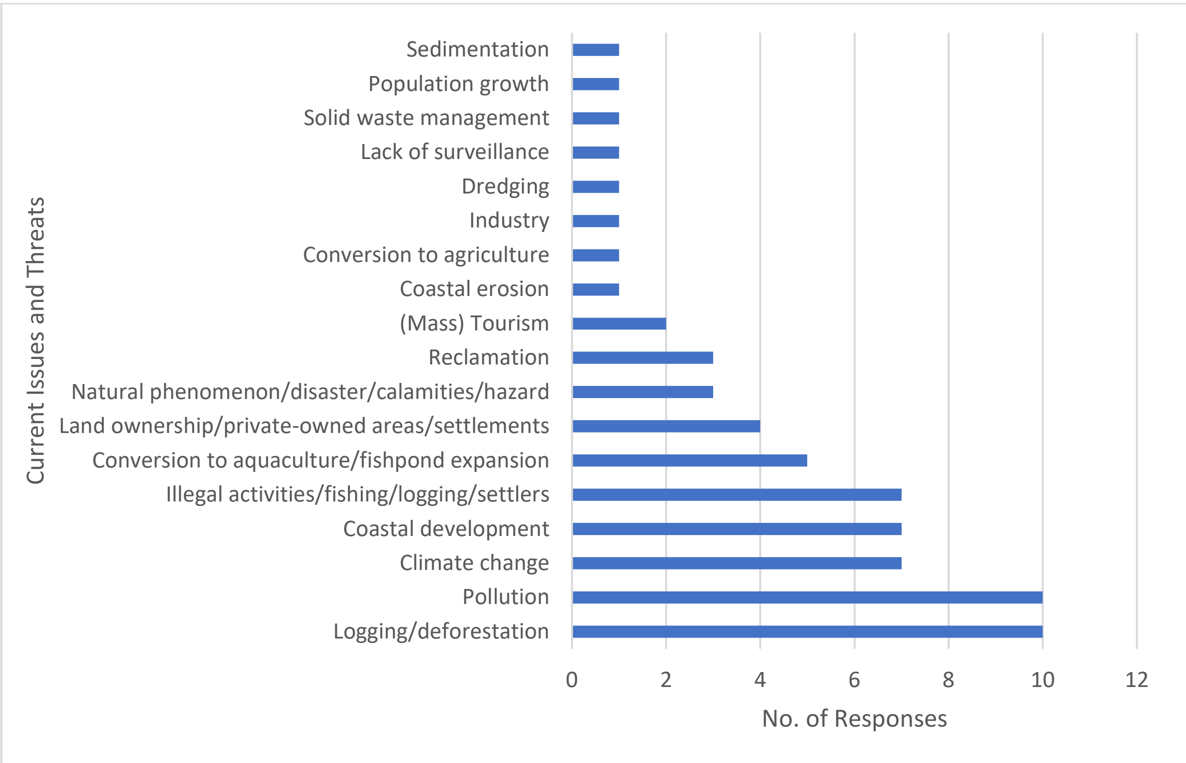

Figure 11. Current threats faced by mangrove forests

Use, Activities and Income Generation

Many activities occur within the mangrove forests, as shown in Figure 12. Tourism, including mangrove tours, bird watching, and ecotourism, is the most common form of utilization. Fishing ranks second, followed by aquaculture in the forms of fish ponds, salt farming, and crab fishing. Some respondents and reports also identify the use of mangroves for education/research facilities and as conservation or heritage sites.

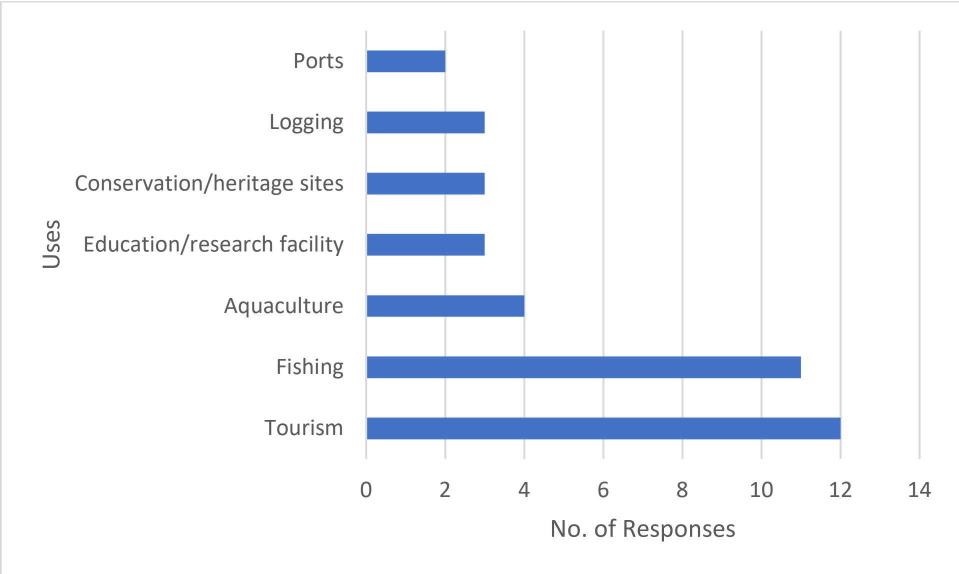

Figure 12. Current uses occur within mangrove forests

From 20 responses, the majority of the respondents (19 out of 20) indicated that mangrove forests generate income for their areas. The income mostly comes from capture fisheries (crabs, fish, shrimp, cockles, clams, oysters), user fees (from tourism), mangrove planting, charcoal production, boating, and funding support/assistance (Figure 13). Current users are mainly coastal communities (40%) and fisherfolk (27%) who rely on the ecosystem, followed by tour operators (21%), as tourism is one of the sources of income (Figure 14).

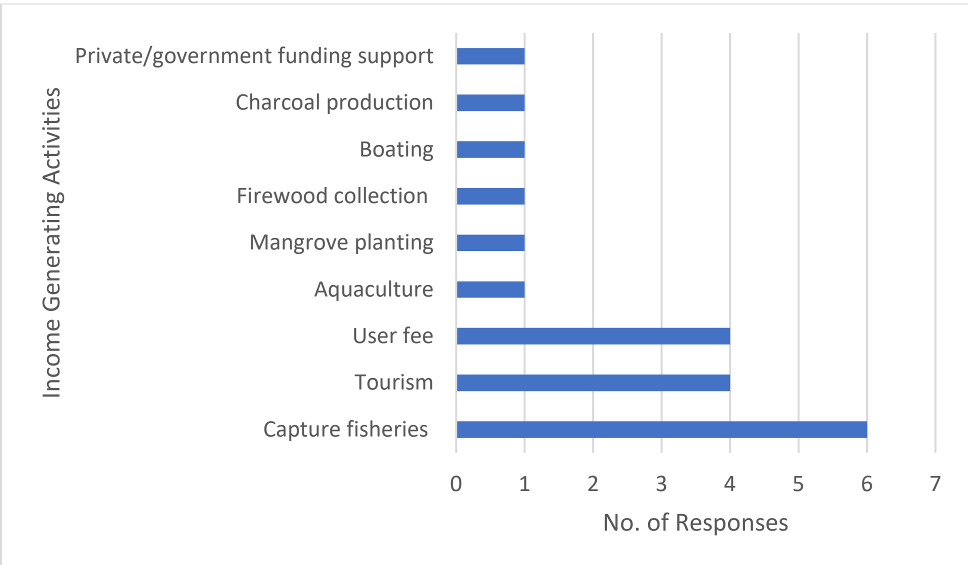

Figure 13. Income generating activities within mangrove forests

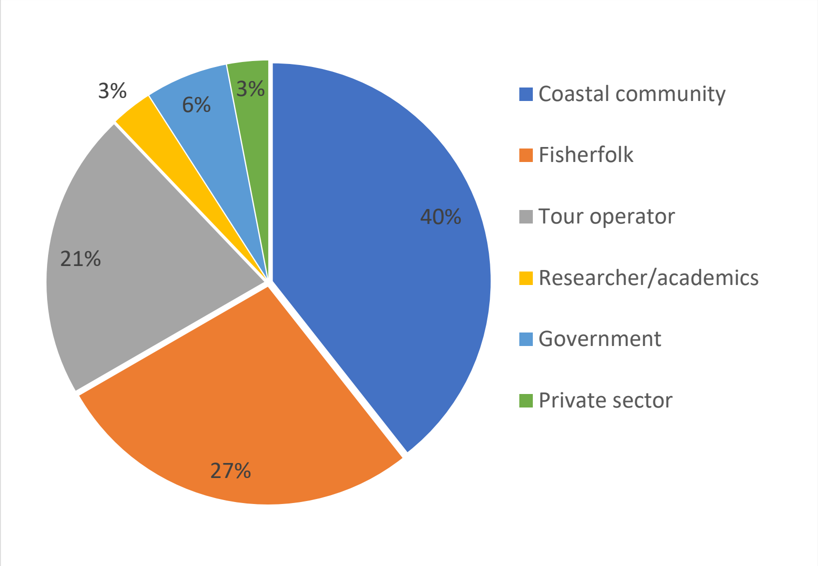

Figure 14. Current users within mangrove forests

Resource Users

The mangrove forests are mostly owned by the public, making up 75% of the total. Communities own 15%, and private individuals or businesses own 10% (Figure 15). This shows that most of the land is managed by the government, with smaller parts owned by local communities and private owners.

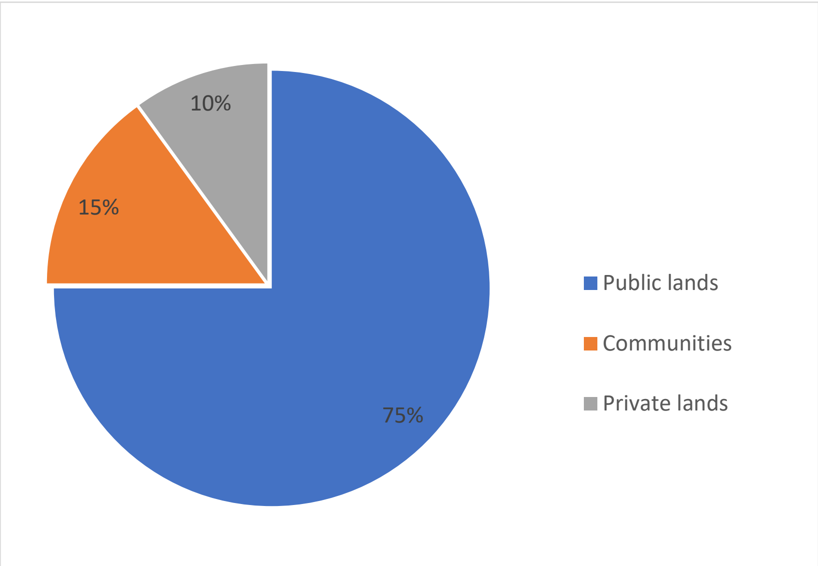

Figure 15. Ownership of mangrove forests

The management of mangrove forests involves diverse stakeholders categorized into governmental agencies and departments such as the Hoi An City People's Committee, Commune People's Committee, Fisheries Administration, and various environmental and agricultural departments. Support is provided by international organizations and Non-Governmental Organizations (NGOs) like UNDP, PEMSEA, Conservation International, USAID, ATSEA-2, and the Coral Triangle Center. Furthermore, community and local management groups include coastal and mangrove communities, Local Government Units (LGU), Locally Managed Marine Areas

(LMMA), and entities like People's Organizations (POs), Municipal Agriculture Offices (MAO), and Marine Protected Area (MPA) authorities, ensuring grassroots involvement and sustainable practices.

With various uses and users, almost half of the responses (44%) indicated that conflicts often occur in the areas. These conflicts typically arise between business and public uses, as well as from illegal activities such as illegal logging and encroachment by settlers. Privatization, particularly through emerging tourism and aquaculture (which involves converting mangrove forests into fish ponds), has also been a significant cause of conflicts.

Management Programs and Support

The responses indicated that 18 out of 23 mangrove forests are under some form of protection and management. Some types of protection and management considered in this report are MPA, LMMA, ICM, and Other Effective Area-Based Conservation Measures (OECMs).

MPAs are designated regions within the marine environment that are legally safeguarded and managed with the goal of achieving conservation objectives. These areas have clearly defined boundaries and regulations that control human activities to different extents, all aimed at preserving marine ecosystems, habitats, and species.

LMMAs are marine zones where local communities and stakeholders play a direct role in managing and conserving marine resources. These areas often integrate traditional knowledge and practices, striving to achieve a balance between conservation efforts and sustainable use of marine resources. LMMAs may or may not have formal legal protection measures in place.

ICM is a process that promotes the sustainable management of coastal areas by integrating environmental, social, and economic considerations. It involves comprehensive planning and management approaches that address multiple uses and stakeholders in coastal areas, emphasizing holistic management to balance conservation with economic development. As emphasized and documented by PEMSEA, ICM can have various activities from pollution reduction and waste management; water use and supply management; habitat protection, restoration, and management; to disaster management, among others.

Lastly, OECMs are areas that achieve significant biodiversity conservation outcomes through methods other than formal MPA designation. These measures may involve sustainable management by local communities, voluntary conservation agreements, or areas where conservation benefits arise naturally from ecosystem functions. Unlike MPAs, OECMs do not always have legal protection measures in place but contribute significantly to biodiversity conservation efforts.

The results show that MPA is considered the most common method of protecting and managing mangrove forests (65%), followed by ICM (18%) and LMMA (12%). Meanwhile, OECM, as a newer classification, has the smallest representation (6%) (Figure 16). This result indicates that MPAs are widely adopted, while ICM and LMMA also play important roles, involving communities and holistic coastal strategies. Lastly, OECM, though newer and less common, is emerging for biodiversity conservation and sustainable management in mangroves. In some countries, these terminologies may have distinctions, while in others, there might be overlaps. For example, in the Philippines, LMMAs are equivalent to local MPAs.

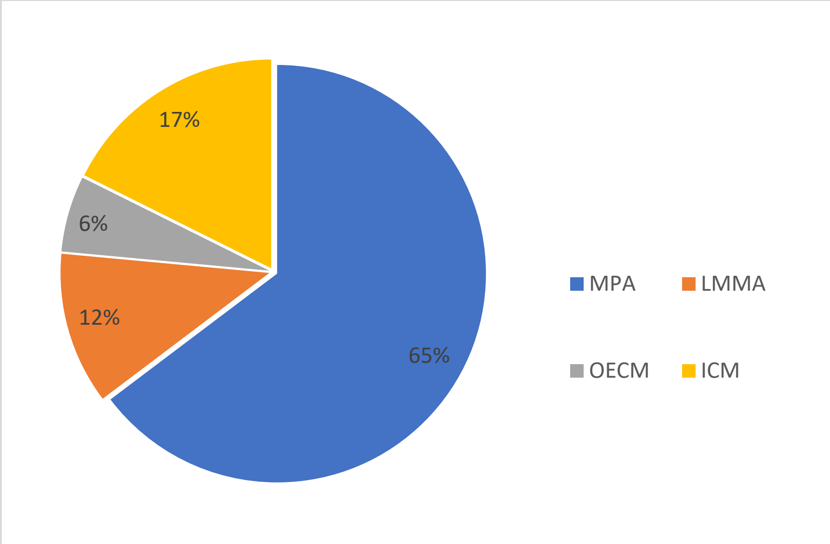

Figure 16. Forms of protection and management for mangrove forests

Thirteen out of 18 responses showed that mangrove forests have local laws or regulations that support their protection, such as the Tara Bandu tradition in Timor-Leste. The majority of the responses indicated that these rules were effectively enforced (Table 14). This indicates a promising trend toward protecting mangrove forests.

Table 14. Local laws/regulations and their enforcement for mangrove forests

Presence of local laws/regulations	No. of Response	Enforcement of local laws/regulations	No. of Response
Yes	13	Yes	9
		No	4
No	5		

Fourteen out of 21 responses indicated that there are regular monitoring efforts to assess the status of the ecosystems. In the Philippines, some of the entities that conduct regular monitoring (e.g. annual mangrove monitoring) are the Bureau of Fisheries and Aquatic Resources, the Department of Environment and Natural Resources (DENR), local universities (e.g. Romblon State University), while the Oriental Mindoro Resource Monitoring Team (ORMT) coordinates efforts involving the Provincial Agriculture Office, Coastal Resources Management Division, municipal Coastal Resources Management Coordinators, Bantay Dagat groups, and non-governmental organizations. Meanwhile, non-targeted assessment methods such as METT to measure MPA management effectiveness and SMART patrols, as well as projects focused on marine environmental quality in coastal waters, can also provide information on the mangrove status. Lastly, fisheries Inspection may further contribute to monitoring efforts, ensuring compliance and sustainability in fishing practices in mangrove areas.

The majority of the responses (18 out of 21) indicated that there are mangrove restoration efforts. In Macajalar Bay, Philippines, several mangrove planting activities have been initiated across various sectors, yet some were not coordinated with local governments, leading to planting in unsuitable areas and subsequently low survival rates. Efforts are underway to rehabilitate mangrove forests and engage communities, supported by organizations like Mangroves for the Future (MFF), CORIN, UNDP, Marine Conservation Cambodia (MCC), Asian Development Bank Greater Mekong Subregion (ADB GMS) project, SEAFDEC-Sida, and UNEP in Kep Province, Cambodia. Specific case studies include initiatives in Cibitung, Tegalbuleud, Ciemas, Simpenan, and Surade in Sukabumi, Indonesia aimed at increasing mangrove areas. In Haikou City, China, projects such as mangrove reforestation and the Dongzhaigang Mangrove Wetland Reserve focus on afforestation, ecological measures, pest control, scientific research, monitoring, and law enforcement, achieving protection outcomes. Finally, restoration projects like the Blue Bay initiative in China are actively implemented to enhance mangrove forests nationwide.

On previous or current projects related to mangroves, 17 out of 19 responses said that there are previous or current projects either donor or government-supported. In Cambodia, various initiatives aim to conserve and restore mangroves with support from donors and the government. In Kep, the IUCN MFF project, alongside MCC efforts, focuses on sustainable management and restoration. Similarly, in Koh Kong, government-supported programs prioritize the protection of mangrove forests. Preah Sihanouk benefits from the Coastal and Marine Biodiversity Conservation Areas (CCCA) program, with collaborative efforts from Fauna & Flora International (FFI), Fisheries Action Coalition Team (FACT), and Wildlife Alliance (WEA) to enhance mangrove resilience. Moving to China, Quanzhou City's "Blue Bay" Comprehensive Restoration Action is bolstered by national government backing, complemented by an ICM System Level 2 Certification. In Indonesia, Bali previously received Japan International Cooperation Agency (JICA) funding, now transitioning to government support, while Bintan's Peatland and Mangrove Restoration Agency of Republic of Indonesia (BRGM) initiative in 2021 emphasizes mangrove conservation. Jakarta's local government leads efforts, supported by initiatives from Manado involving Sam Ratulangi University (UNSRAT), Indonesia Climate Change Trust Fund (ICCTF), YAPEKA, Wildlife Conservation Society (WCS), and Alliance of North Sulawesi Traditional Communities (ALMANUSTRA). In the Philippines, Wetlands International Philippines supports Bataan's conservation efforts, while Catanduanes benefits from local government and NGO collaborations. Cavite's National Greening Program targets mangrove rehabilitation, and in Guimaras, University of the Philippines Visayas conducts vital research. Oriental Mindoro, with CI's 2018 mangrove assessment, and Romblon's Bureau of Fisheries and Aquatic Resources (BFAR) and Romblon State University collaborations, show extensive efforts. In Timor-Leste, PEMSEA and university research support projects in Dili and Manatuto.

Regarding experts working in these areas, 14 out of 16 responses indicated that they have mangrove experts in their areas. In Cambodia's Koh Kong province, mangrove conservation efforts benefit from expertise within the Provincial Department of Environment and the Department of Agriculture and Fishery. Meanwhile, in Preah Sihanouk, there are experts from FFI and WEA. In China, Quanzhou's mangrove restoration efforts are guided by the First Institute of Oceanography (FIO) under the Ministry of Natural Resources (MNR), contributing technical leadership to marine ecological restoration projects. In Indonesia, Bali's research endeavors are supported by local researchers embedded in various project teams, focusing on biodiversity and ecosystem health. Bintan benefits from the expertise of Raja Ali Haji Maritime University in marine research and conservation. In Manado, UNSRAT leads initiatives, combining academic research with practical conservation actions. In Cavite, Cavite State University expertise supports the National Greening Program's mangrove restoration efforts. In Guimaras, University of the Philippines Visayas experts contribute valuable research insights, while in Timor-Leste's Dili and Manatuto, experts from National University of Timor-Leste (UNTL) and University of Timor-Leste (UNITAL) collaborate closely with local communities and government agencies to foster sustainable mangrove management practices.

4.1.2. Seagrass meadows

Status

Twenty-four out of 40 sites across seven surveyed nations reported the presence of seagrass meadows (Table 15). The extent of these mangrove forests varies widely, ranging from 2.4 hectares in Batangas, Philippines, to 25,250 hectares in Kampot, Cambodia. A response from Cantaduanes, Philippines mentioned that there is no data on seagrass coverage, but the seagrass coverage is expected to be wider than mangroves.

Table 15. Countries and sites with seagrass meadows

No.	Country	Site	Area (ha)	Rating of BCE State (1 to 5)
1	Cambodia	Kampot	25,250	3
2		Kep	3,095	N/A
3		Koh Kong	3,993	3
4		Preah Sihanouk	1,360	3
5	China	Dongying	100	3
6	Indonesia	Bintan	2,158.92	3
7		Bontang	2,127	N/A
8		Jakarta	533.96	3
9		Manado	11,200	3
10	Philippines	Bataan	N/A	2
11		Batangas	2.4	5
12		Catanduanes	N/A (expected to be wider than mangroves)	4
13		Cavite	3	1
14		Guimaras	981.19	2
15		Oriental Mindoro	1,196	N/A
16		Romblon	11,060.33	N/A
17	Thailand	Chanthaburi	426.72	N/A
18		Rayong	117.12	N/A
19		Trat	142.56	3
20	Timor-Leste	Dili	13,174.75	1
21		Liquica	N/A	N/A
22		Manatuto	170	3
23	Viet Nam	Danang	10	1.5 (an average of 2 sites)
24		Quang Nam	1,060	1

Seventeen locations evaluated the status of their seagrass with scores ranging from 1 (poor) to 5 (excellent) (Table 11, Figure 17). The average score for the mangroves is 2.6, indicating that, on the whole, the seagrass meadows are relatively in good health. Meanwhile, seven sites could not rate the state of their seagrass meadows.

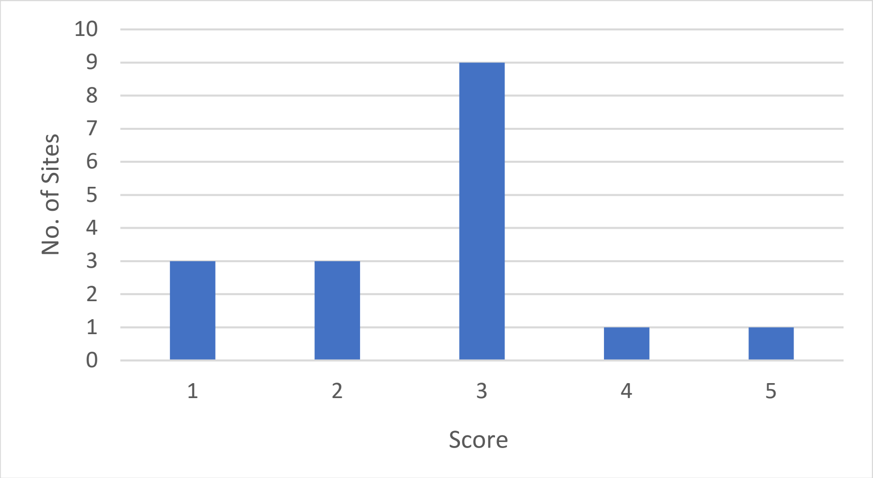

Figure 17. States of seagrass meadows in the EAS region

Issues and threats

Due to its vicinity to the land, seagrass meadows are usually affected by activities on land such as sedimentation and pollution. Seagrass meadows worldwide are under threat from various sources (Figure 18). Pollution from industrial and agricultural runoff, sewage, red tides, and oil spills affects 10 locations, while coastal development, like port expansions, also impacts 10 areas. Climate change, including seasonal changes and rising sea levels, affects 7 sites, and boating activities such as anchoring are a concern in 5 locations. Tourism affects 4 areas, and natural disasters like typhoons impact 3 sites. Sedimentation, turbidity, aquaculture, illegal fishing, invasive species, dredging, reclamation, gleaning, and sea sand mining contribute to threats in fewer locations. Protecting these vital ecosystems requires urgent and coordinated conservation efforts.

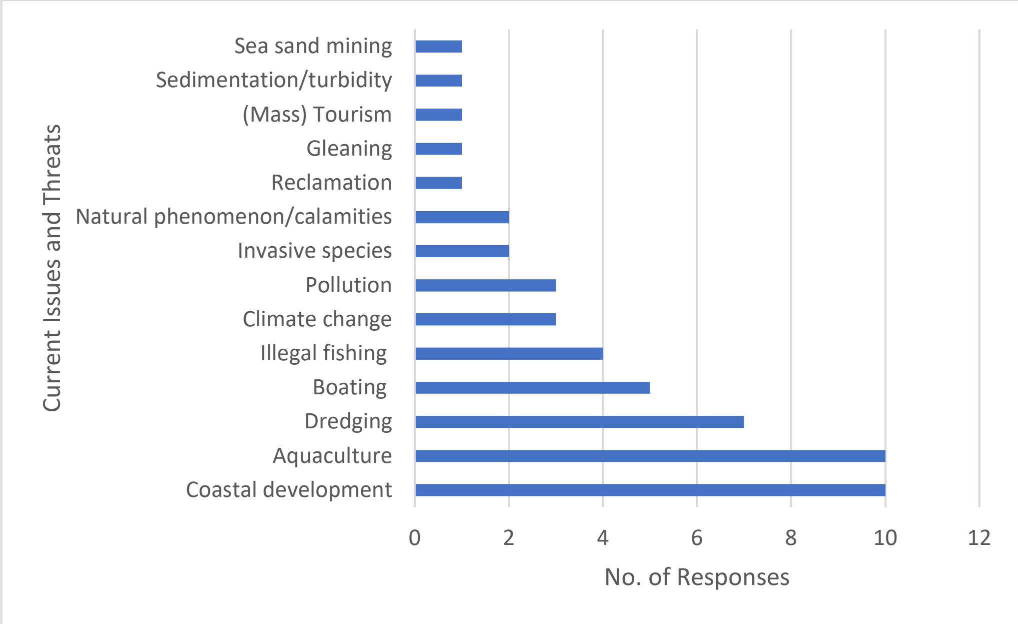

Figure 18. Current threats faced by seagrass meadows

Use, Activities and Income Generation

Seagrass meadows are utilized for various purposes around the EAS region (Figure 19). Fishing is the most common activity, observed in 12 locations, highlighting their importance for fisheries. Tourism activities are significant in 7 areas, showing these environments' recreational value. Aquaculture, including seaweed farming and crab baiting, occurs in 4 locations, contributing to local economies. Direct harvesting or gleaning is reported in 2 locations, while 2 sites are designated conservation areas aiming to protect these habitats. In addition, seagrass meadows support education and research in 1 location, serving as valuable learning environments for scientific study and conservation efforts.

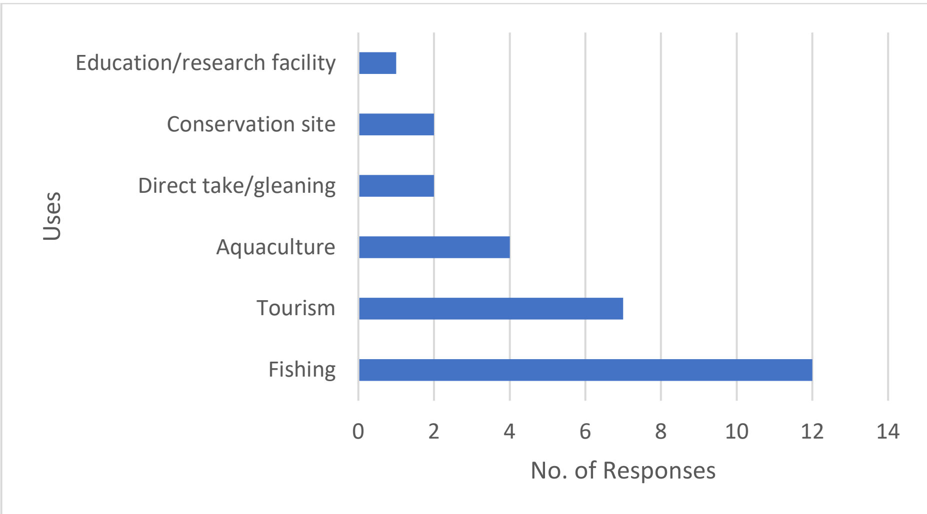

Figure 19. Current uses occur within seagrass meadows

Fourteen out of 16 responses stated that the seagrass meadows in their areas generate income that mainly comes from fishing and tourism (Figure 20). Seagrass meadows generate income primarily through fishing activities across multiple locations. In addition to supporting traditional fishing practices, some areas also benefit from activities like seaweed farming and the sale of edible shellfish. Tourism plays a role in generating income in coastal areas where seagrass habitats enhance beach tourism. Overall, while the income generated from seagrass meadows varies, fishing remains a consistent source of livelihood for coastal communities and sectors reliant on marine resources.

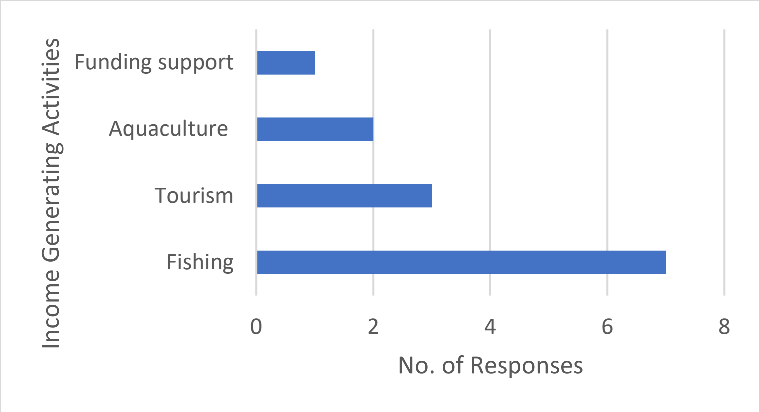

Figure 20. Income generating activities within seagrass meadows

Resource Users

Seagrass meadows are used by a variety of coastal communities and stakeholders (Figure 21). Fisherfolk are the primary users, relying on these habitats for fishing. Coastal communities, including residents and fishermen, utilize seagrass for economic and subsistence purposes. Some areas also involve seaweed farmers who cultivate within these ecosystems. Researchers, academics, and government agencies monitor and manage these habitats for conservation and sustainable use. Tour operators and others involved in coastal tourism also benefit from the recreational and educational value of seagrass areas.

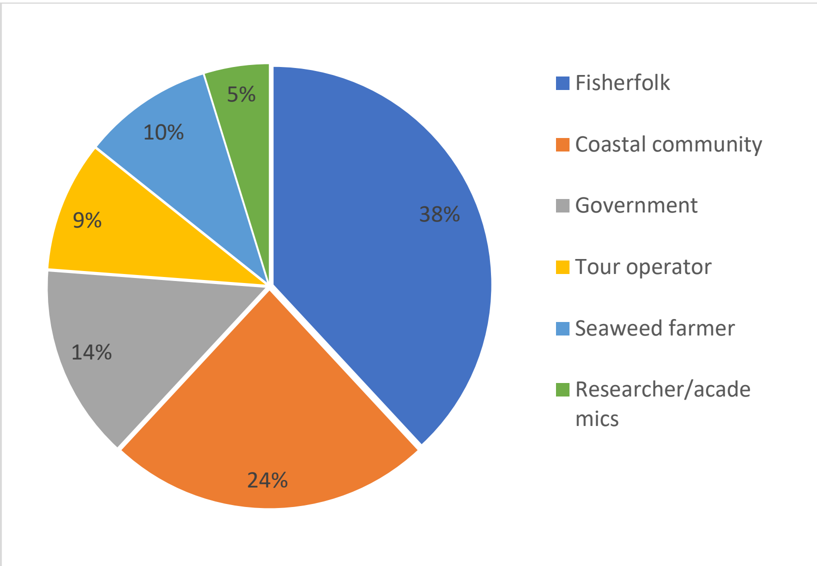

Figure 21. Current users within seagrass meadows

All responses (totaling 15) stated that seagrass meadows in their areas are considered public lands. Nonetheless, the responses show that managing seagrass meadows involves collaboration between governments at both local and national levels. Local governments, including departments, provincial, and municipal bodies like People's Organizations (POs), Municipal Agriculture Offices (MAO), and Municipal Environment and Natural Resources Offices (MENRO), work alongside national agencies. These national bodies set policies, provide funding, and support conservation efforts. Additionally, MPA authorities such as Cu Lao Cham MPA and the Yangtze River Delta National Nature Reserve play key roles in protecting seagrass habitats from environmental threats. Academics, NGOs, LMMA, and private companies also contribute through research, advocacy, and corporate responsibility, forming a collaborative network dedicated to safeguarding seagrass meadows.

Almost half of the responses (6 out of 14) indicate potential conflicts in seagrass meadows arising from conflicting interests and territorial disputes. Tourism competes with fisheries for space and resources, disrupting fishing practices and local livelihoods. Boating activities, irrespective of tourism, disturb seagrass habitats and conflict with fishing vessels. Illegal fishing, which is not always related to tourism, depletes fish stocks and undermines conservation efforts. Coastal development encroaches on seagrass areas, altering ecosystems and increasing pollution. Encroachment in MPAs is another potential cause of conflicts within seagrass meadows.

Management Programs and Support

Seagrass meadows are protected and managed through diverse approaches (Figure 22). The majority (58%) are under MPA management such as Cu Lao Cham, Prek Kampong Smach Marine Fishery Management Area (MFMA), Koh Rong Archipelago Marine Park, and Ream National Park in Cambodia; Bontang MPA in Indonesia; Atauro MPA in Timor-Leste; Avila Marine Sanctuary in the Philippines; and Yellow River Delta Nature Reserve in China. LMMA such as Stung Hav Conservation Area and Prek Thnoat and Koh Tauch Communes in Cambodia involve local communities in sustainable resource management. ICM initiatives in places like Guimaras, the Philippines integrate conservation with coastal development.

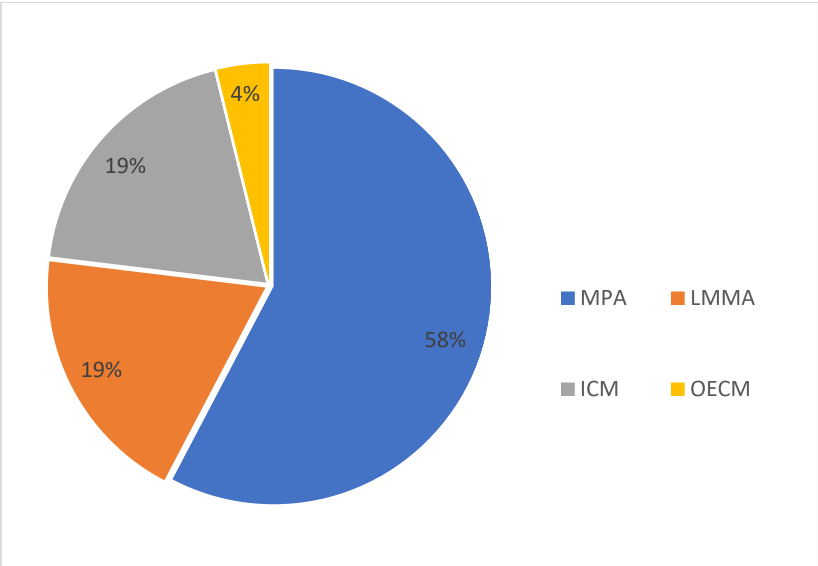

Figure 22. Forms of protection and management for seagrass meadows

Twelve of 17 responses stated that there are local ordinances/regulations for supporting the protection of seagrass meadows and the majority (58%) said that the ordinance/legislations are enforced (Table 16). This highlights that while there are local regulations in place, their enforcement remains a challenge.

Table 16. Local laws/regulations and their enforcement for seagrass meadows

Presence of local laws/regulations	No. of Response	Enforcement of local laws/regulations	No. of Response
Yes	12	Yes	7
		No	5
No	5		

Meanwhile, 11 out of 18 responses said that there is regular monitoring for the seagrass meadows in their areas. Some examples are from the Philippines, such as the the Oriental Mindoro Resource Monitoring Team (ORMT), a collaborative effort comprising staff from the Provincial Agriculture Office's Coastal Resources Management Division, Coastal Resources Management Coordinators from municipalities and cities, representatives from Bantay Dagat groups, and volunteers from non-governmental and private organizations; the Bureau of Fisheries and Aquatic Resources and Romblon State University; academia and the Department of Environment and Natural Resources (DENR) in Cavite. In Bintan, Indonesia, regular monitoring occurred via Coremap CTI and LIPI.

Seagrass restoration is not as common as mangrove restoration. This was confirmed from the responses received where only 6 from 14 responses said that there were efforts to restore seagrass. Some examples are from Cavite, the Philippines for seagrass transplantation and in Dongying, China by Ocean University of China (OUC), Institute of Oceanology, Chinese Academy of Sciences, FIO, and MNR.

Ten out of 15 responses mentioned that there were/are projects assisted by donors or supported by governments. In the Philippines, Catanduanes support from the local government and collaboration with NGOs is enhancing conservation efforts. Moreover, Romblon's conservation efforts are supported by the Bureau of Fisheries and Aquatic Resources and Romblon State University. In Viet Nam, Danang's City government collaborates with the Nha Trang Institute of Oceanography to conduct scientific research on coral reefs and related ecosystems along their coastline. In Dongying, China the Shandong Department of Ecology and Environment has established a Seagrass Bed Ecosystem Conservation Observation Station, supported by efforts in seagrass restoration led by institutions like OUC and FIO. In Cambodia, Kep benefits from support by MCC for its conservation endeavors, while Koh Kong receives substantial government support for conservation initiatives and Preah Sihanouk engages in conservation through the CCCA program, alongside FFI, FACT, and WEA initiatives. In Manado, Indonesia, UNSRAT, ICCTF, YAPEKA, WCS, and ALMANUSTRA collaborate on conservation projects. Lastly, in Timor-Leste, Manatuto benefits from a PEMSEA-supported project and university-backed research efforts.

Ten out of 13 sites indicated that they have experts work on seagrass meadows. In the Philippines, Cavite recognizes Glenn Bryan Gracia. In Danang, Viet Nam, experts from Nha Trang

Institute of Oceanography, Da Nang Polytechnic University, and Da Nang University of Education contribute. In China, Dongying's expertise in seagrass bed restoration is led by Zhou Yi from the Institute of Oceanology, Chinese Academy of Sciences. In Cambodia, Koh Kong benefits from expertise at the Provincial Department of Agriculture and Fishery, while Preah Sihanouk are supported by FFI and WEA. In Indonesia, local universities such as University of Sam Ratulangi in Manado and Raja Ali Haji Maritime University are recognized as seagrass experts.

4.1.3. Salt marshes

Status

Only seven sites in China stated that they have salt marshes (Table 17). The size of the salt marshes ranges from 6,100 hectares in Jinzhou to 166,974.4 hectares in Lianyungang. These salt marsh ecosystems thrive due to the country's extensive coastline influenced by tidal flows from seas like the Yellow Sea and the Bohai Sea, supporting diverse salt-tolerant flora and fauna.

As most of the information about salt marshes were extracted SOCs, there are not so many samples to rate the state of the salt marshes. Qingdao rated its salt marsh as fair, while Dongying rated its salt marsh as very good (Table 17).

Table 17. Countries and sites with salt marshes

No.	Country	Site	Area (ha)	Rating of BCE State (1 to 5)
1	China	Dongying	35,715	4
2		Jinzhou	6,100	N/A
3		Laoting	N/A	N/A
4		Lianyungang	166,974.4	N/A
5		Qingdao	84,600	2
6		Qingdao Blue Valley	N/A	N/A
7		Xiamen	37,300	N/A

Issues and Threats

Salt marshes in China are facing various problems (Figure 23). The main issues include coastal development and pollution. The marshes are being destroyed because of activities like reclaiming land, building on wetlands, and depositing silt. Aquaculture is expanding, causing sand erosion and illegal housing, and garbage is also a problem. Water pollution is another serious issue, harming plants and animals.

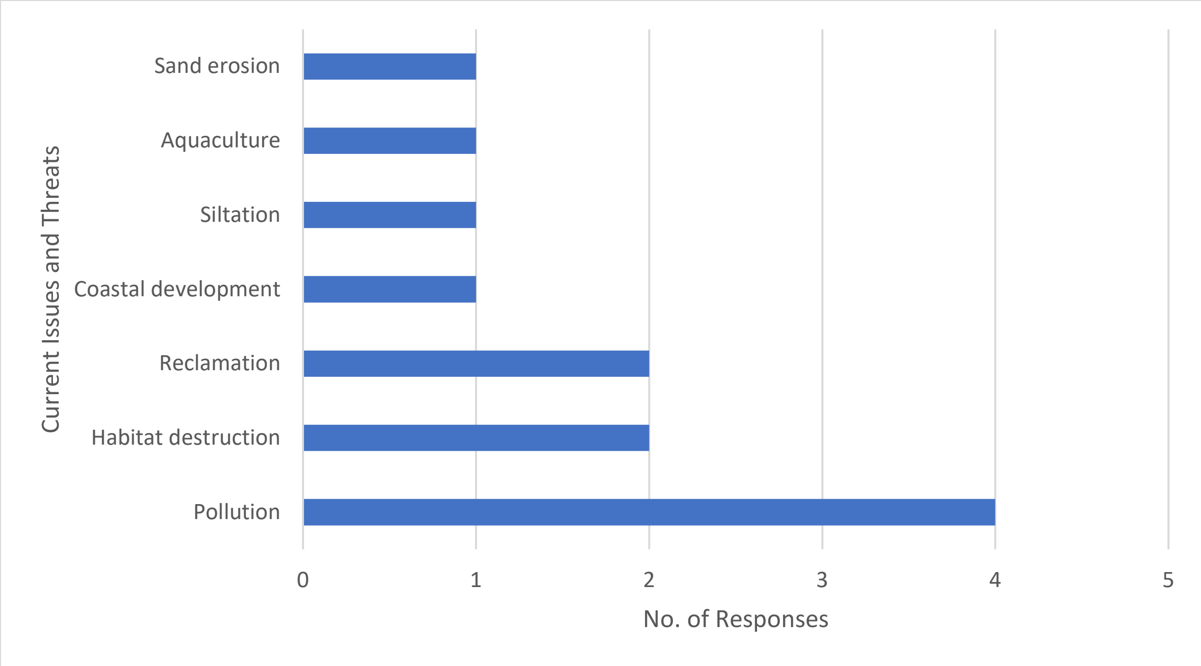

Figure 23. Current threats faced by salt marshes in China

Use, Activities and Income Generation

Salt marshes are used mainly for aquaculture, particularly in cultivating shellfish like four-horned clams, razor clams, cockles, and mud snails, and tourism. The areas generate income primarily from aquaculture and tourism. Fishing happens, though not as often, aiming for fish in the marshes and nearby waters. Some salt marshes function as ports, facilitating maritime activities and commerce. Furthermore, many marshes are designated conservation sites, crucial for preserving biodiversity and providing habitats for various species. Salt production also takes place in certain areas, where salt is harvested through natural evaporation processes (Figure 24).

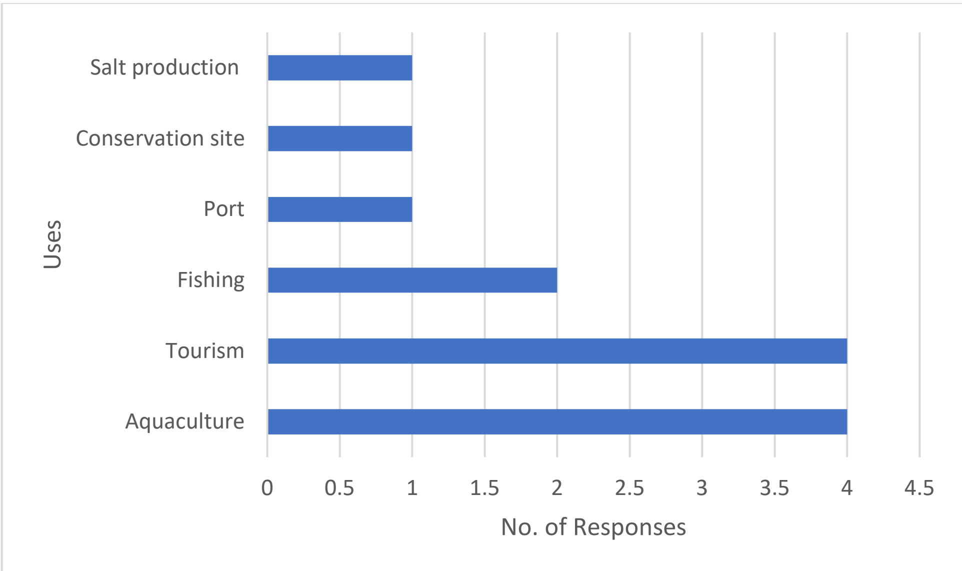

Figure 24. Current uses occur within salt marshes in China

Resource Users

Management Programs and Support

Some parts of the salt marshes are under the protection and management, such as Yellow River Delta Nature Reserve (YRDNR) in Dongying, JinZhou DaNijiaShan National MPA in Jinzhou, Lushan Wetland Park in Laoting, Lianyungang Haizhou Bay Ecological and Natural Relics Marine Special Protection Area in Lianyungang, and Jiazhou Bay National Marine Park in Qingdao. They also have regular monitoring such as Jinzhou Marine Environmental Monitoring and Forecasting Center based on the Jinzhou Marine Fishery Environmental Monitoring Station in Jinzhou, First Institute of Oceanography of the State Oceanic Administration in Qingdao, and Yellow River Delta Nature Reserve Ecological Monitoring Center that was just established in 2022.

Regarding restoration efforts, three sites reported conducting restoration activities. Firstly, in Jizhou, vegetation restoration included planting 150 ha of reeds, 147.3 ha of *Suaeda salsa*, and 167 ha of *S. vulgaris*. In Xiamen, by 2021, construction began on 38 wetland protection and ecological restoration projects, with an estimated investment of 7.25 billion yuan, and 39 reserve projects were initiated concurrently. Lastly, Dongying implemented the "Restoration Development of Blue Economy Case Study on Enhancing Sustainable Development of the Yellow River Estuary Ecosystem through Integrated River Basin Management," supported by PEMSEA. In addition, Dongying also has Saline-alkali Land restoration project by FIO and indicated some experts for ecological restoration and master plan from FIO in the MNR.

4.1.4. Seaweed beds

There was not much information gathered from both the survey and SOC reports. Only two sites indicated they considered seaweed beds as BCEs – Guimaras, Philippines and Bintan, Indonesia. Only Bintan provided relatively comprehensive information.

In Bintan, Indonesia, seaweed beds are found in scattered locations across islands like Penyengat, Terkulai, Senggarang, and Klong, as well as along the coastal and eastern waters of Bintan. These areas cover about 2,781.2 hectares, spread across various villages and subdistricts. The condition of these ecosystems is rated as 3, mainly due to climate change impacts. They are used for fishing and educational/research purposes, earning income primarily from the fisheries sector. Users include fisherfolk, coastal communities, researchers, academics, and government entities. No single owner controls these areas, which are managed by local communities, NGOs, and government agencies. There are conflicts over using marine space for shipping and fishing. These ecosystems lack formal protection or management, and though there are local laws supporting their conservation, enforcement is uncertain. Monitoring and restoration efforts have been sporadic, with occasional support from institutions like Raja Ali Haji Maritime University.

4.1.5. Tidal flats

Status

Seven sites across five countries reported having tidal flats in their areas (Table 18). Tidal flat coverage varies, ranging from 450 hectares in Ansan, Republic of Korea, to 31,700 hectares in Qingdao, China. Only three sites provided information on the state of their tidal flats: Quang Nam in Viet Nam reported them as fair, Bintan in Indonesia as good, and Ansan in the Republic of Korea as very good. Additionally, Masan Bay noted improvement in their tidal flats.

Table 18. Countries and sites with tidal flats

No.	Country	Site	Area (ha)	Rating of BCE State (1 to 5)
1	China	Qingdao	31,700	N/A
2		Xiamen	11,700	N/A
3	Indonesia	Bintan	N/A	3
4	Philippines	Guimaras	N/A	N/A
5	Republic of Korea	Ansan	450	4
6		Masan Bay	N/A	N/A
7	Viet Nam	Quang Nam	N/A	2

Issues and Threats

Current issues affecting tidal flats include the build-up of minor coastal developments such as fisheries ports and marina expansions in Ansan City, which can disrupt natural habitats and alter tidal patterns. Bintan indicates reclamation and climate change poses a significant threat by influencing sea level rise and altering sea surface temperatures. In Masan Bay and Changwon City, pollution from various sources, compounded by ongoing reclamation projects, further degrades water quality and threatens biodiversity in these sensitive environments.

Use, Activities and Income Generation

Tidal flats are important for fishing, providing livelihoods to coastal communities through commercial and gleaning activities. People visit tidal flats for recreational fishing and to explore the unique coastal landscapes. In Qingdao, China, reclaimed tidal lands are used for farming, which supports local economies and tourism by producing agricultural goods.

In Bintan, Indonesia, fishing is vital, with income from selling seafood caught in tidal flats. Guimaras earns from selling shellfish, supporting local livelihoods. Masan Bay and Changwon City, Republic of Korea, earn from tourists paying to visit the tidal flats.

Resource Users

Most tidal flats are considered public lands. Yet, many actors are involved in their management. Those are coastal communities, academics, NGOs, and local and national governments. In places like Hoi An City, Quang Nam, Viet Nam, the People's Committee, along with local communes and wards, coordinate efforts to sustainably manage tidal flats.

Conflicts in tidal flats, like those in Bintan, involve disputes over fisheries resources and space for jetties along the coast. In Quang Nam, issues arise from electric shock fishing and fisheries exploitation, impacting marine biodiversity. Addressing these conflicts requires balancing economic activities with environmental conservation through collaborative management and regulations to sustain tidal flat ecosystems.

Management Programs and Support

Tidal flats in different areas are managed and protected using various methods. For instance, Bintan has the Bintan Marine Protected Area (MPA) to preserve marine resources and habitats. Guimaras uses ICM to ensure sustainable use. Nonetheless, even though there was a local ordinance in Guimaras, unfortunately, it was not enforced. In Masan Bay and Changwon City, approaches include Locally Managed Marine Areas LMMA, OECM, and being recognized as Ramsar sites.

Two sites from the Republic of Korea stated that they have restoration efforts. Ansan City created a 4.19 km^2 wetland to clean pollutants entering a lake. This aimed to improve water quality naturally. Meanwhile, in Masan Bay, community groups like the Masan People's Coalition for Bay Restoration work together to restore the bay's ecology and river systems.

Finally, only one site identified potential experts involved in tidal flats. Bintan specifically mentioned Raja Ali Haji Maritime University as having expertise in this area.

A summary from each BCE is presented in Appendix 3.

4.2. GAPS AND CHALLENGES

The survey revealed four major groups of gaps and challenges for managing the BC ecosystems. They are: governance and enforcement challenges, capacity and resource constraints, environmental and climate change impacts, and data and knowledge gaps.

Fragmented governance and inconsistent enforcement, fragmented governance and conflicts among stakeholders complicate conservation efforts, while limited law enforcement allows illegal activities to harm these habitats. The lack of effective planning and management further hinders the implementation of necessary protections.

Capacity and resource constraints exacerbate these challenges. Insufficient capacity within governmental and non-governmental organizations hampers their ability to monitor and enforce regulations, as well as to undertake restoration and conservation efforts. Meanwhile, financial and manpower limitations restrict the scale and scope of conservation projects, preventing comprehensive protection of blue carbon habitats.

Environmental challenges worsen governance and resource limitations. Climate change, with rising sea levels, ocean acidification, and stronger storms, disrupts carbon storage and biodiversity support in these ecosystems. Invasive species harm habitats by displacing native plants and animals, altering natural balances. Coastal development and unsustainable practices shrink blue carbon habitats, reducing their ability to offer crucial ecological benefits.

Lastly, the **lack of data and information** makes it challenging to enact informed policies and mobilize resources effectively. This also results in reduced public awareness which is crucial for supporting conservation and management initiatives. Addressing these issues requires coordinated efforts to strengthen governance, improve resource management, mitigate environmental threats, and enhance public awareness and engagement.

4.3. INTEREST AND EXISTING PROGRAMS ON BLUE CARBON

From the 20 surveyed sites, all sites have implemented BC projects in the forms of conservation, research and monitoring, restoration, and carbon market (Figure 25). Blue carbon restoration efforts are focused on establishing mangrove nurseries in Guimaras and Jakarta essential for replenishing coastal ecosystems. There are also mangrove planting and reforestation initiatives across Bataan, Batangas, Guimaras, Jakarta, Tangerang, Manatuto, and Preah Sihanouk.

Blue carbon conservation efforts focus on protecting mangroves, seagrass meadows, and tidal flats. In Batangas, Philippines and Manatuto, Timor-Leste dedicated seagrass protected areas were established. Moreover, there are mangrove conservation projects in Guimaras and Batangas in the Philippines and Tangerang in Indonesia and efforts in Changyi, China to conserve tidal flats.

All of the surveyed sites conducted research and/or monitoring for at least one blue carbon ecosystem. Specifically, in 2023, Dongying, China initiated the monitoring of carbon storage in the salt marsh ecosystem of Yellow River Estuary. Dongying has been selected as one of the national typical coastal ecosystem carbon sink monitoring pilot cities. Lastly, regarding the carbon market, in July 2021, the Xiamen Property Rights Trading Center established the first Marine Carbon Sink Trading Service Platform in China and conducted the first-ever marine carbon sink transaction—2,000 tons of marine carbon sink in Quanzhou Luoyang River mangrove ecological restoration.

Various entities are involved in blue carbon projects, encompassing a wide range of stakeholders. These include government bodies, NGOs, academic institutions, local communities, and civil society organizations. Collaboration across these sectors aims to promote sustainable practices, conserve coastal ecosystems, and enhance community resilience. Academic involvement contributes to research and knowledge dissemination, while governmental support ensures regulatory alignment and policy implementation. NGOs and civil society organizations play crucial roles in advocacy and community engagement, facilitating local participation and empowerment. Private sector engagement, through CSR initiatives and partnerships with universities, fosters innovation and investment in sustainable development practices. This collective effort underscores a shared commitment to protecting blue carbon ecosystems and mitigating climate change impacts globally.

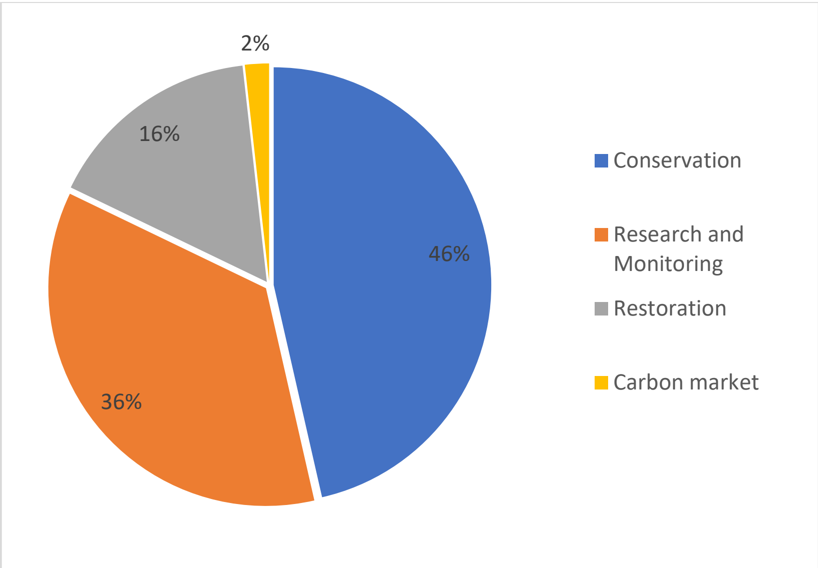

Figure 25. Existing Blue Carbon projects

All the surveyed sites mentioned interest in developing or implementing BC programs in their areas with several potential blue carbon projects have been identified (Figure 26). The majority of the sites proposed BCE restoration and conservation followed by BCE assessments that also include carbon accounting and ecosystem valuation. BCE management focuses more on co-management of the BCEs by multi stakeholders, management of BCEs in general, and enforcement. Only three sites proposed carbon credits and trading-related activities. Specifically, Koh Kong emphasized their need for Blue Carbon credits to enhance the protection and restoration of their mangrove forests. Lastly, Batangas and Guimaras mentioned the need for advocacy, community awareness and engagement, and capacity building. Although often not emphasized sufficiently, assistance and capacity building are crucial for ensuring the success of the BC program. Table 19 displays the distribution of proposals across different sites.

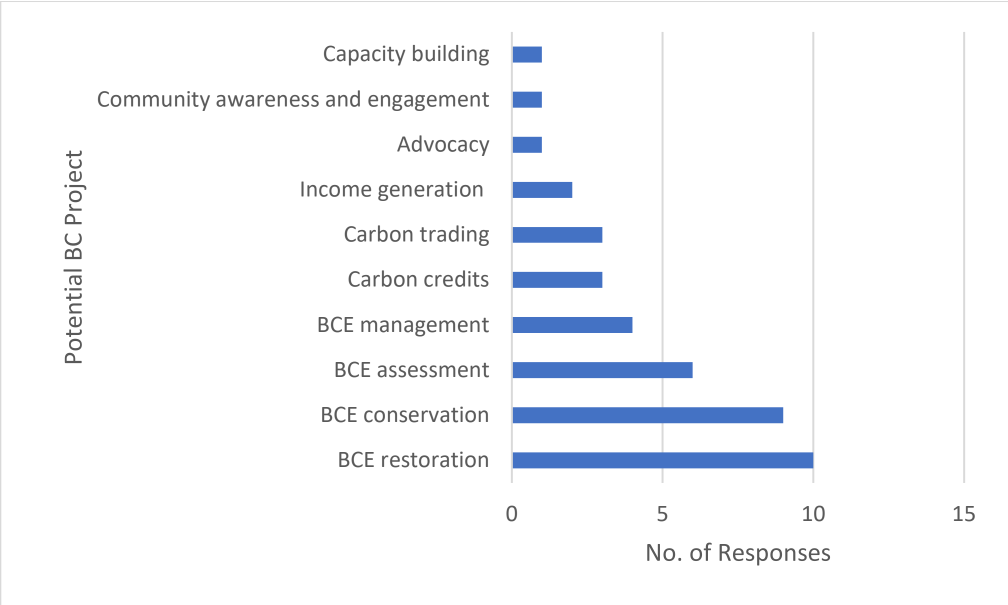

Figure 26. Potential Blue Carbon projects

Table 19. Potential Blue Carbon projects and interested sites

Potential Blue Carbon Project	Interested Site(s)
BCE restoration	Cavite, Changyi, Dongying, Guimaras, Kampot, Koh Kong, Manatuto, Quang Nam, Quanzhou, Tangerang
BCE conservation	Batangas, Bintan, Catanduanes, Dongying, Guimaras, Koh Kong, Manatuto, Quang Nam, Quanzhou
BCE assessment	Bali, Bataan, Batangas, Jakarta Manado, Preah Sihanouk
BCE management	Danang, Dili, Manado, Preah Sihanouk
Carbon credit	Koh Kong, Manatuto, Quang Nam
Carbon trading	Koh Kong, Manatuto, Quang Nam
Income generation	Manado, Preah Sihanouk
Advocacy	Guimaras
Community awareness and engagement	Batangas
Capacity building	Guimaras

The survey listed several potential proponents to support BC projects. In Indonesia, Bali has the Bali Sustainable Development Foundation, a local NGO, leads initiatives aimed at conserving and restoring coastal ecosystems. In Bintan, the Center of Environmental Studies and Center of Coastal and Marine Studies at Raja Ali Haji Maritime University contribute expertise to blue carbon research and conservation efforts.

Across the Philippines, in Bataan, the Provincial Government coordinates efforts to enhance blue carbon awareness and implementation. Batangas involves a diverse group including community organizations, local government units (MAO/MENRO/PGENRO/ tourism office), national government agencies, NGOs, private sector entities, and academic institutions, working collaboratively to address blue carbon challenges and opportunities. Moreover, Batangas Province formulated Comprehensive Mangrove Development Plan for the Province of Batangas 2015-2030. In Catanduanes, Catanduanes State University collaborates with LGU, NGOs, and coastal communities to advance blue carbon initiatives. In Cavite, academic institutions partner with governmental bodies to integrate scientific research and management practices for blue carbon ecosystems.

In China, Changyi's Marine Development Center oversees initiatives to protect and restore coastal habitats crucial for blue carbon storage. In Dongying, the Municipal Bureau of Fisheries and Marine Development spearheads projects to monitor and sustain mangrove habitats essential for blue carbon sequestration. Meanwhile, in Viet Nam, Danang's Department of Natural Resources and Environment leads local efforts to manage and conserve blue carbon ecosystems.

More detailed responses per site are presented in Appendix 4.

5. CONCLUSION

Status of Blue Carbon Ecosystems in the EAS region

- The EAS region hosts a substantial number of BCEs, including mangroves, seagrass meadows, salt marshes, seaweed beds, and tidal flats. These ecosystems play critical roles in carbon sequestration, climate regulation, and coastal resilience by sequestering and storing substantial amounts of CO_2 and mitigating greenhouse gas emissions. Despite their importance, BCEs continue to face threats from human activities such as aquaculture and coastal development, resulting in significant habitat loss and depletion of carbon stocks.
- Compared to mangroves, seagrass meadows, and salt marshes, there is less available information on the status and carbon stocks of seaweed beds and tidal flats. Mangroves, specifically, have been more extensively studied due to their proximity to terrestrial ecosystems, which are more advanced in terms of carbon accounting and stock assessments. However, there appears to be an increasing number of new studies on other BCEs. For instance, there is growing research into the carbon sequestration capabilities of seaweed beds, seaweeds produced from aquaculture, and tidal flats.

Blue Carbon Site Findings

- From the information received from the survey and gathered from the SOC reports, the survey results show similar trends compared to the regional and national desk study results where BCEs are deemed important ecologically, economically, and socially, but nonetheless threatened by various anthropogenic activities. Efforts are emerging to manage and protect BCEs through various forms of protection (e.g., MPAs, LMMAs, OECM, ICM), along with BCE-related laws, ordinances, and management plans. However, there appear to be challenges in ensuring the effectiveness of protection, management, and law enforcement.
    - Based on the survey findings from 29 sites in seven countries (Table 13), the EAS region's mangrove forests confront significant threats such as logging, pollution (from oil spills and chemicals), climate change, coastal development, and illegal activities like fishing and settlement encroachment. Mangroves support local economies through activities like fisheries and tourism, predominantly benefiting coastal communities. Ownership is mostly public, managed with support from governmental agencies and international organizations. Conflict arises from competing land uses and illegal activities, mitigated by initiatives like MPAs. Regular monitoring and enforcement of local regulations show promise in protecting mangroves, alongside active restoration efforts supported by governments, NGOs, and academic institutions to bolster resilience and biodiversity conservation.
    - The survey findings highlight the presence and varied extents of seagrass meadows across 24 sites (Table 15) in seven EAS countries. Seagrass meadows mainly face threats from pollution, coastal development, climate change, and other anthropogenic activities. Seagrass meadows contribute significantly to local economies through fisheries, tourism, and aquaculture, while also serving as crucial habitats for biodiversity and scientific research. All surveyed responses indicated that seagrass meadows are considered public lands with management approaches including MPA, LMMA, and ICM, supported by local regulations.
    - The survey underscores the presence and importance of salt marsh ecosystems across seven sites in China (Table 17). The salt marshes face threats from coastal development, pollution, and aquaculture expansion. They contribute economically through aquaculture, tourism, and salt production, while also serving as essential conservation sites. Management efforts include designated protected areas, ongoing monitoring initiatives, and restoration activities, such as extensive vegetation planting and ecological projects.
    - The survey highlights a lack of data on seaweed beds, with only two sites—Guimaras, Philippines, and Bintan, Indonesia—recognizing their importance. Bintan provides more comprehensive information, revealing that seaweed beds face challenges from climate change and conflicts between shipping and fishing. Moreover, they lack adequate protection and enforcement. More information about seaweed beds needs to be gathered to better understand their status in the EAS region.
    - Across five countries, seven sites (Table 18) reported the presence of tidal flats. Tidal flats are under pressure from coastal developments like fisheries ports and marina expansions, as well as rising sea levels due to climate change and pollution from reclamation projects. Despite these challenges, tidal flats play a vital role in supporting

fishing activities, providing livelihoods to coastal communities, facilitating research on coastal biodiversity, and attracting tourists for recreational purposes.

- Overall, the survey identified four primary categories of gaps and challenges in managing BC ecosystems: issues with governance and enforcement, limitations in capacity and resources, impacts from environmental and climate change factors, and deficiencies in data and knowledge.
- Regarding interest in developing and implementing BC projects, all respondents expressed interest in developing and implementing BC projects. Various BC projects have been implemented, focusing on conservation, research, monitoring, restoration, and participation in the carbon market. BCE restoration, conservation, and assessments received the highest interest and are followed by more sophisticated initiatives, such as carbon crediting and trading.

6. RECOMMENDATIONS

The study conducted provides an indication of the status and level of management, programs, support systems, and awareness of BC from the supply side within the EAS region. Another round of study is needed and can be leveraged by engaging partners with similar interests. The next survey can target countries and sites that have not responded, especially countries that can be considered more advanced in BC initiatives, such as Japan and Republic of Korea. This is to provide a better picture of the current BC supply side landscape in the EAS region.

Furthermore, more data were collected from mangrove forests and seagrass meadows, as these ecosystems are predominant in the region. However, the EAS region also holds significant BC potential from salt marshes, seaweed beds, and tidal flats, which were underrepresented in the current study. Therefore, another survey targeting these BCEs will provide a more comprehensive understanding of BC potential in the region.

This study from the supply side will offer a more comprehensive perspective when complemented by the concurrent study of market demand. This approach is particularly valuable for identifying gaps that require attention in future initiatives.

For future BC initiatives, PEMSEA may prioritize supporting BCE restoration, conservation, and assessment in potential project sites. Expertise in carbon crediting and trading may also be necessary to maximize the economic benefits from these BCEs which can be achieved by partnering with established entities at international, regional, or national levels.

In the meantime, PEMSEA calls on institutions, local governments, NGOs, coastal communities working on blue carbon to fill up our supply checklist so we can have a better grasp of the BC supply landscape in our region. To download a copy of the checklist, pls click on

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APPENDICES

APPENDIX 1. SITE SELECTION CHECKLIST

POTENTIAL BLUE CARBON SITE SELECTION CHECKLIST

Coastal and marine ecosystems such as mangrove forests, seagrass meadows and tidal marshes capture and store huge amount of carbon. This is called 'Blue Carbon' to distinguish it from carbon stored by terrestrial ecosystems, including forests and other land-based vegetation. There has been an increasing interest focusing on the conservation of 'blue carbon ecosystems' in recent years given their importance in climate change mitigation, their biodiversity value, the key role they play in coastal livelihoods as well as the significant threats they face primarily from anthropogenic pressures due to increasing population, urbanization and industrialization across the world.

The East Asian Region is known to have the largest expanse of coral reefs, mangroves and seagrasses and is cited as a global hotspot for carbon sequestration and storage (Stankovic et al. 2023[1]). Southeast Asia in particular has approximately 35 per cent of the world's total mangrove area and harbors nearly 75 per cent of the world's mangrove species and >45 per cent of seagrass species (Burke et al. 2002[2]). Fortes (2010[3]) cited that the region has at least 20 per cent of the world's seagrass beds.

The PEMSEA Blue Carbon Program aims to help improve the condition of the coastal blue carbon ecosystems in the East Asian region and optimize their contribution to the reduction of greenhouse gases and carbon sequestration which in turn are expected to enhance coastal resilience and habitat protection, conservation and restoration. In order to achieve the above objectives, the PEMSEA Resource Facility (PRF) is embarking on a survey to assess the extent of current and potential blue carbon interventions in the region in general, and at the local level in particular, i.e., identifying potential sites where blue carbon projects may be developed and implemented.

To assist us in this endeavor, PRF appreciates your time and effort in providing the requested information below. Please feel free to attach any documents or photos you think might be relevant.

The survey requests for info on the types of blue carbon ecosystems, current uses, actual and potential program and management efforts.

Should you have any questions regarding the survey, please contact Casandra Tania at ctania@pemsea.org.

We would appreciate it if you can send back the complete survey form on or before 15 May 2024. Thank you.

Respondent's Information

Country:	
Name:	
Designation:	
Organization:	
Date:	

[1] Stankovic, M., A.K. Mishra, Y.P. Rahayu, J. Lefcheck, J. Murdiyarso, D.A. Friess, M. Corkalo, T. Vukovic, M.A. Vanderklift, S.H. Farooq, J.D. Gaitan-Espitia, A. Prathep. 2023. Blue Carbon Assessments of Seagrass and Mangrove Ecosystems in South and Southeast Asia: Current Progress and Knowledge Gaps. Sci. Total. Environ., 904, Article 166618.

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1 | POTENTIAL BLUE CARBON SITE SELECTION CHECKLIST

No	Question	Response (please provide response for all relevant ecosystems)				
1	**Blue Carbon Resources**	**Mangroves**	**Seagrass Meadows**	**Salt Marshes**	**Seaweed Beds**	**Mudflats/Tidal Flats**
1.1	Do you have these ecosystems in your area?					
	(Y/N)					
1.2	If yes, where are these ecosystems located **(name of site)?** Please provide coordinates/spatial map if available					
1.3	How many hectares are these ecosystems?					
1.4	How do you rate the state of the ecosystems (1= poor, 2=fair, 3=good, 4=very good, and 5=excellent)? Please provide photo(s) if available					
1.5	What are the current issues and threats to the ecosystems?					
2	**Uses and Managers**	**Mangroves**	**Seagrass Meadows**	**Salt Marshes**	**Seaweed Beds**	**Mudflats/Tidal Flats**
2.1	What are the current uses of these ecosystems in your area?					
2.2	Does the area generate income from the uses of the ecosystems? (Y/N) If yes, from what?					
2.3	Who are the current users of the area?					
2.4	Does anyone own the area?					
2.5	What agencies/organizations/groups are responsible for managing the area?					
2.6	Are there any resource use conflicts in the area (Y/N)? If yes, please explain					

2 | POTENTIAL BLUE CARBON SITE SELECTION CHECKLIST

3	Programs and Management Efforts	Mangroves	Seagrass Meadows	Salt Marshes	Seaweed Beds	Mudflats/Tidal Flats
3.1	Are the ecosystems under protected/managed status? (Please select all relevant responses) a. Yes, Marine Protected Area. Name: b. Yes, Locally Managed Marine Area. Name: c. Yes, Other Effective Area-based Conservation Measures. Name: d. Yes, Integrated Coastal Management. Name: e. Yes, internationally designated/recognized site (e.g. Convention on Wetlands) No					
3.2	Are there any local ordinances/legislations for supporting the protection of the ecosystems (Y/N)?					
3.3	Are the ordinances/legislations being enforced effectively (Y/N)?					
3.4	Were/are there regular monitoring programs to assess the status of the ecosystems (Y/N)? Please provide supporting documents if available					
3.5	Were/are there restoration efforts to improve the ecosystem state (Y/N)? Please provide supporting documents if available					
3.6	Were/are there projects (donor-assisted or government-supported) or research related to the ecosystems (Y/N)? If yes, what and who are they?					
3.7	Are there ecosystem experts who work in the area (Y/N)? If yes, please provide names and/or institutions					

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No	Question	Response
3	**Programs and Management Efforts**	
3.8	Are there management plans to manage and protect the ecosystems (Please select all relevant responses)?	a. Yes, mangrove/seagrass/seaweed/salt marsh/tidal flat management plan. b. Yes, MPA management plan. c. Yes, ICM plan. d. Yes, climate change action plan. e. Yes, EAFM plan. f. Yes, other. Please provide the title of the plan: g. None
3.9	What are the gaps and challenges in the effective management of the ecosystems?	
4	**Interest and Existing Programs on Blue Carbon**	
4.1	Are there existing blue carbon projects/programs in the area (Y/N)?	
4.2	If yes, please provide the activities conducted	
4.3	If yes, who are involved in the program?	
4.4	Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	
4.5	If yes, what will be a potential blue carbon program?	
4.6	If yes, who will be the potential project proponents?	
Additional remarks:		

APPENDIX 2. LIST OF RESPONDENTS

No	Country	Site	Name	Designation	Organization
1	Cambodia	Kampot	Ven Serei Sophorn	Kampot Local Government Officer	Provincial Planning and Investment Division
2		Koh Kong	Kong Huot	Deputy of Intersectoral Division	Koh Kong Provincial Administration
3		Preah Sihanouk	Nay Sally	Chief of International Relations and ICM Program Assistant	Preah Sihanouk Provincial Administration
4	China	Changyi	Zhang Yanhua	Engineer	Changyi Marine Development Center
5		Dongying	Liu Pei	Engineer	Dongying Huanhai Institute of Marine Conservation and Development
6		Quanzhou	Wu Shouji	Deputy Director	Natural Resources and Planning Bureau, Quanzhou City, Fujian Province
7	Indonesia	Bali	Dr. Ketut Gede Dharma Putra	Environmental Specialist	Center for Sustainable Development Udayana University
8		Bintan	Dr. Febrianti Lestari	Lecturer	Maritime Raja Ali Haji University
9		Jakarta	Suharini Eliawati	Head of Food Security Marine and Agriculture Agency	Jakarta Capital City Government
10		Manado	Stephanus Mandagi, PhD	Lecturer	Sam Ratulangi University
11		Tangerang	SM. Agustin Hari Mahardika	Division Head	Environment & Hygiene Agency of Tangerang Regency
12	Philippines	Bataan	Karen June A. Balbuena	Senior Environmental Management Specialist	Provincial Government of Bataan
13		Batangas	Luis A. Awitan	Department Head	Provincial Government Enviroment and Natural Resources Office
14		Catanduanes	Kristian Aldea	Assistant Vice President for Research, Extension, and Production Affairs	Catanduanes State University
15		Cavite	Glenn Bryan Creencia	Designated Faculty Researcher	Cavite State University

No	Country	Site	Name	Designation	Organization
16		Guimaras	Leonard S. Pasiderio	Provincial Environment and Natural Resources Officer	Provincial Government of Guimaras-Guimaras Environment and Natural Resource Office
17	Timor-Leste	Dili	Timotio Alves	Fisheries Officer/Technical staff	Ministry of Agriculture, Livestock, Fisheries and Forestry
18		Manatuto	Duarte da Costa	Chief Department of Environment, Manatuto Municipality or Secretary of ICM- PEMSEA of Manatuto Site	Service Municipality for Water, Sanitation and Environment
19		Danang	Truong Cong Hai, Pham Thi Chin	Danang City	Danang Department of Natural Resource and Environment
20		Quang Nam	Quang Nam Province	Tam Ky City	Quang Nam Department of Natural Resources and Environment

APPENDIX 3. SUMMARY FROM EACH BLUE CARBON ECOSYSTEM

Criteria	Mangrove forests	Seagrass Meadows	Salt Marshes	Seaweed Beds	Tidal Flats
No. of sites (from survey)	17	16	1	2	3
No. of sites (from SOC reports)	12	8	6	0	4
Total sites	29	24	7	2	7
Total countries	7	7	1	2	5
Area (ha)	62 – 62,000	2.4 – 25,250	6,100 – 166,974.4	2,781.2	450 – 31,700
Rating of BCE state (1 to 5)	2 – 5 (avg 3.1)	1 – 5 (avg 2.6)	2 (Qingdao) & 4 (Dongying)	3 (Bintan)	Quang Nam (2), Bintan (3), Ansan (4)
Primary current issues/threats	Logging/deforestation Pollution Climate change Coastal development Illegal activities Conversion to aquaculture	Coastal development Aquaculture Dredging Boating Illegal fishing	Pollution Habitat destruction Reclamation	Climate change	Coastal development Reclamation Climate change Pollution
Primary current uses	Tourism Fishing Aquaculture	Fishing Tourism Aquaculture	Aquaculture Tourism Fishing	Fishing Educational/research purposes	Fishing Tourism
Primary income generating	Fishing Tourism User fee Aquaculture	Fishing Tourism Aquaculture	Aquaculture Tourism Fishing	Fishing	Fishing Tourism
Major users	Coastal community (40%) Fisherfolk (27%) Tour operator (21%)	Fisherfolk (38%) Coastal community (24%) Government (14%)	Government – YRDNR	Fisherfolk Coastal community Researcher Academic Government	Coastal community Academic NGOs Local & national governments

Criteria	Mangrove forests	Seagrass Meadows	Salt Marshes	Seaweed Beds	Tidal Flats
Ownership	Public lands (25%) Communities (15%) Private lands (10%)	Public lands (100%)	Nation-owned – YRDNR	No single ownership - managed by local communities, NGOs, government agencies	Public lands (majority)
Conflicts	Yes (44%) - business vs public uses, encroachment, illegal logging	Yes (41%) - tourism vs fishing vs boating, illegal activities, encroachment	N – YRNDR	Yes - shipping vs fishing	Yes – fishing vs port
Forms of protection & management	MPA (65%) ICM (17%) LMMA (12%) OECM (6%)	MPA (58%) LMMA (19%) ICM (19%) OECM (4%)	MPA (71%)	N/A	MPA ICM LMMA OECM Ramsar site
Local laws/regulations	Yes (72%)	Yes (71%)	Y – YRDNR	Yes	N/A
Enforcement	Yes (69%)	Yes (58%)	Y – YRDNR	Lack enforcement	N/A
Regular monitoring	Yes (67%)	Yes (61%)	Yes (43%)	Yes but sporadic	N/A
Restoration	Yes (86%)	Yes (43%)	Yes (43%)	Yes but sporadic	Yes - Ansan & Masan Bay
Previous/current projects	Yes (90%)	Yes (67%)	Yes	N/A	N/A
Experts	National & local experts - government agencies, universities, research institutes, eNGOs	National & local experts - government agencies, universities, research institutes, eNGOs	National expert – government agencies, research institutes	Local experts – Raja Ali Haji Maritime University	Local experts – Raja Ali Haji Maritime University

APPENDIX 4. SURVEYED SITES INTEREST AND EXISTING BLUE CARBON PROGRAM

Country	Site	4.1. Are there existing blue carbon projects/programs in the area (Y/N)?	4.1. Explain	4.2. If yes, please provide the activities conducted	4.3. If yes, who are involved in the program?	4.4. Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	4.5. If yes, what will be a potential blue carbon program?	4.6. If yes, who will be the potential project proponents?
Philippines	Cavite	Y	Only carbon modelling and assessment for mangrove and mud flats	Research Fieldwork	Academe	Y	Science-based mangrove tree planting; economic valuation of the fisheries, mangrove, seagrass, carbon, mud flat; ex situ propagation of seagrass and seagrass transplantation	Academe together with the government
Indonesia	Bali	N				Y	Carbon accounting	Bali Sustainable Development Foundation (local NGO)
Indonesia	Manado	N	Only ecological surveys have been done in some districts		Almanustra Foundation who received funding from Rainforest Trust, YAPEKA received fund from ICCTF	Y	Carbon (all) assessment in all areas or districts to get complete data, blue carbon ecosystem management, community economic	It depends on the needs and conditions in each area

Country	Site	4.1. Are there existing blue carbon projects/programs in the area (Y/N)?	4.1. Explain	4.2. If yes, please provide the activities conducted	4.3. If yes, who are involved in the program?	4.4. Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	4.5. If yes, what will be a potential blue carbon program?	4.6. If yes, who will be the potential project proponents?
							development (ecotourism, silvo fishery, etc)	
Indonesia	Tangerang	Y		Since 2016 we are plated more than 1,4 milion stem of mangrove with 10.000 people join the mangrove planting, training more than 300 mangrove group nursery, 20 CSR support and colaboration with 10 University (IPB, UI, UNILA, Untirta, STP Pasarminggu, University Brawijaya, Pamulang University,	Several Enrironment Activist such as KAHMI, Pesisir Mengajar, Marrine Buddies , Earth Hour Tangerang , Habitat for Humanity and private company from YKK AP, Indah Kiat, PLN, PLTU 3 Lontar, Panca Budi, Prudential, PNM, Paragon, Strechline, BJB, Perumdam TKR CSR support and colaboration with 10 University (IPB, UI, UNILA, Untirta, STP Pasarminggu, University Brawijaya, Pamulang University, Muhammadiyah University, Sinarmas	Y	Mangrove Rehabilititation , mangrove Restoration also we has feed back from nature with progresively source of Thacypleus sp (horseshoe crab) to create coalaboration with university and private company	Tangerang Agency with PEMSEA, NGO and University

Country	Site	4.1. Are there existing blue carbon projects/programs in the area (Y/N)?	4.1. Explain	4.2. If yes, please provide the activities conducted	4.3. If yes, who are involved in the program?	4.4. Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	4.5. If yes, what will be a potential blue carbon program?	4.6. If yes, who will be the potential project proponents?
				Muhammadiyah University, Sinarmas World Academy and UMN)	World Academy and UMN)			
Cambodia	Koh Kong	N	we will have the blue carbon projects/programs soon because now we have the contract with the Korean Company who has the specialist and budget of supporting to plant more	Mangrove replanting	MPA authority, coastal community, Management and Development of Koh Kong Coastal Committee	Y	Conserving blue carbon ecosystems, restoring blue carbon ecosystems, carbon credit, carbon trading	Management and Development of Koh Kong Coastal Committee, MPA authority, coastal community

Country	Site	4.1. Are there existing blue carbon projects/programs in the area (Y/N)?	4.1. Explain	4.2. If yes, please provide the activities conducted	4.3. If yes, who are involved in the program?	4.4. Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	4.5. If yes, what will be a potential blue carbon program?	4.6. If yes, who will be the potential project proponents?
			magrove and find blue carbon credit for the local Autourity					
Philippines	Batangas	Y		Mangrove planting and reforestation, conduct of research studies/assessment by the LGU/academe/NGOs/private sectors, seagrass protected area/conservation	POs/community, local government unit, provincial government, NGAs, NGOs, private sector, academe	Y	Increase of mangrove protected area/conservation establishment, carbon footprint counting, community awareness and engagement regarding blue carbon ecosystems, increase of seagrass protected area/conservation establishment, survey and mapping of seagrass areas which are not yet declared as MPA	POs/community, local government unit (MAO/MENRO/PGENRO/tourism office), NGAs, NGOs, private sector, academe

Country	Site	4.1. Are there existing blue carbon projects/programs in the area (Y/N)?	4.1. Explain	4.2. If yes, please provide the activities conducted	4.3. If yes, who are involved in the program?	4.4. Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	4.5. If yes, what will be a potential blue carbon program?	4.6. If yes, who will be the potential project proponents?
Philippines	Guimaras	Y		Establishment of mangrove nurseries and mangrove reforestation	Civil Society Organization, academe, National Government Agencies, People's Organization, Local Government Units, and the community	Y	Capacity building and advocacy, conservation and restoration projects	Local Government Units
China	Changyi	N		N	N	Y	Restoring and conserving blue carbon ecosystems	Changyi Marine Development Center
China	Quanzhou	Y		In July 2021, Xiamen Property Rights Trading Center established the first Marine Carbon Sink Trading Service Platform in China, and conducted the first ever marine carbon sink transaction -	Xiamen Property Rights Trading Center	Y	Restoring and conserving blue carbon ecosystems	Natural Resources and Planning Bureau, Quanzhou City

Country	Site	4.1. Are there existing blue carbon projects/programs in the area (Y/N)?	4.1. Explain	4.2. If yes, please provide the activities conducted	4.3. If yes, who are involved in the program?	4.4. Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	4.5. If yes, what will be a potential blue carbon program?	4.6. If yes, who will be the potential project proponents?
				2,000 tons of marine carbon sink in Quanzhou Luoyang River mangrove ecological restoration.				
China	Dongying	Y		In 2023, Dongying initiated the monitoring of carbon storage in salt marsh ecosystem of Yellow River Estuary. Dongying has been selected as one of the national typical coastal ecosystem carbon sink monitoring pilot cities	Government and technical supporting institutes	Y	Restoring and conserving blue carbon ecosystems	Dongying Municipal Bureau of Fisheries and Marine Development

Country	Site	4.1. Are there existing blue carbon projects/programs in the area (Y/N)?	4.1. Explain	4.2. If yes, please provide the activities conducted	4.3. If yes, who are involved in the program?	4.4. Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	4.5. If yes, what will be a potential blue carbon program?	4.6. If yes, who will be the potential project proponents?
Timor-Leste	Manatuto	Y		Mangrove replanting, mangrove conservation (fence), seagrass conservation	Coastal community	Y	Conserving blue carbon ecosystem, restoring blue carbon ecosystem, carbon credit, carbon trading	Coastal communities, local government, universities, NGO
Viet Nam	Danang	N				Y	Program to restore marine ecosystems and build a mechanism for co-management of marine ecosystems	Department of Natural Resources and Environment of Danang city
Philippines	Catanduanes	Y		Some mangrove initiatives	Cantaduanes State University, LGU, NGO, Coastal Community	Y	Catanduanes Tidal Flats-Seagrass Blue Carbon Project	Catanduanes State University, LGU, NGO, coastal community\
Viet Nam	Quang Nam	N				Y	- Plant trees in the mountains, rivers and lakes in the city. - Use sustainable energy in buildings. - Blue carbon ecosystem conservation, blue carbon ecosystem	- People's Committee of Tam Ky city. - Management Board of Cu Lao Cham Marine Protected Area.

Country	Site	4.1. Are there existing blue carbon projects/programs in the area (Y/N)?	4.1. Explain	4.2. If yes, please provide the activities conducted	4.3. If yes, who are involved in the program?	4.4. Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	4.5. If yes, what will be a potential blue carbon program?	4.6. If yes, who will be the potential project proponents?
							restoration, carbon credits, carbon trading	
Cambodia	Preah Sihanouk	Y		Mangrove replanting, coral nursering and patroling	Technical working group, local authorities, and fishery and coastal community	Y	Enforcement, tourism activities to improve local livelihood, and carbon accounting	UNEP, FFI and WEA
Philippines	Bataan	Y		Mangrove planting should consider the mangrove species and the location or zonation. Ultimately, mangroves should be planted in the right place to avoid high mortality rates	Wetlands International Philippines, Provincial Government of Bataan & Municipalities with mangrove area	Y	Carbon accounting	Provincial Government of Bataan
Indonesia	Jakarta	Y		Mangrove replanting,	Marine Aquaculture and Conservation	Y	Carbon accounting	Mangrove Jakarta, Lestari Mangrove dan

Country	Site	4.1. Are there existing blue carbon projects/programs in the area (Y/N)?	4.1. Explain	4.2. If yes, please provide the activities conducted	4.3. If yes, who are involved in the program?	4.4. Is there interest in developing/implementing a blue carbon project in the area (Y/N)?	4.5. If yes, what will be a potential blue carbon program?	4.6. If yes, who will be the potential project proponents?
				mangrove nursery	Center (PBKL), coastal community, NGO			Alam (LEVA), IPB University
Timor-Leste	Dili	N		N/A	N/A	Y	Government, Private Sectors and agencies Local and International	
Indonesia	Bintan	N				Y	Mangrove and seagrass ecosystems in the waters of Bintan Regency and Tanjungpinang City	Center of Environmental Studies; and Center of Coastal and Marine Studies at Raja Ali Haji Maritime University.
Cambodia	Kampot	N		N	N	Y	Mangrove restoration	Local Government

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