Chapter 12
Malaysia's Blue Carbon Overview

Waseem Razzaq Khan, Roland Kueh Jui Heng, Jane Koh, Malcom Demies, Abdul Razaque Memon, and Faridah Hanum Ibrahim

Abstract Climate change is one of the greatest challenges in the world and attracted many countries to mitigate greenhouse gas emissions through several mechanisms. Blue carbon has captured great interest recently. Malaysia has untapped blue carbon especially mangrove forests. The online review suggested that there are still a limited number of scientific studies on the overall aspect of blue carbon, though some reports on carbon storage in mangrove forests. Malaysia is highly committed to this matter through various international signatories and national level initiates such as through the establishment of the Malaysian Climate Action Council, Twelve

W. R. Khan (✉)
Department of Forestry Science, Faculty of Agricultural and Forestry Sciences, Universiti Putra Malaysia, Bintulu, Sarawak, Malaysia

Institut Ekosains Borneo, Universiti Putra Malaysia, Bintulu, Sarawak, Malaysia

Faculty of Forestry and Environment, Universiti Putra Malaysia, Serdang, Selangor Darul Ehsan, Malaysia
e-mail: khanwaseem@upm.edu.my

R. K. J. Heng (✉)
Department of Forestry Science, Faculty of Agricultural and Forestry Sciences, Universiti Putra Malaysia, Bintulu, Sarawak, Malaysia
e-mail: roland@upm.edu.my

J. Koh
Faculty of Forestry and Environment, Universiti Putra Malaysia, Serdang, Selangor Darul Ehsan, Malaysia

Southridge Malaysia Sdn Bhd, Kuala Lumpur, Malaysia

M. Demies
Forest Department Sarawak Headquarters, Kuching, Sarawak, Malaysia

A. R. Memon
Huawei Tech United Arab Emirates, FZ LLC, Dubai, United Arab Emirates

F. H. Ibrahim
Institute of Tropical Forestry and Forest Products (INTROP), Universiti Putra Malaysia, Serdang, Selangor Darul Ehsan, Malaysia

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Malaysian Plan, and National Policy on Biodiversity. Despite these, Malaysia still requires extensive data and research to realize the blue carbon potential. Strong coordination and cooperation between Federal/State, amendment to current law, and incorporation of GIS and Lidar technology in research. With these improvements, it is hoped that Malaysia can capitalize on the blue carbon potential and enhance its preservation and protection.

Keywords Blue carbon · Mangrove forest · Seagrass · Salt marsh · Malaysia

12.1 Introduction

Today, climate change is one of the greatest challenges in the world. Climate change occurring across the globe has sparked serious interest in mitigating greenhouse gas emissions through several mechanisms such as international commitment (United Nations Framework Convention on Climate Change or UNFCCC) and participatory programs such as carbon reduction programs through restoration/reforestation, Reduced Emissions from Deforestation and Forest Degradation (REDD+) and Clean Development Mechanism (CDM). Many countries have pledged to commit to reducing their countries' emissions. Malaysia is set to cut carbon intensity against GDP by 45% by 2030 compared to 2005 levels. After these commitments, countries will need to find ways to reduce their dependency on fossil fuels. As suggested by many, one of the solutions is carbon markets. This provides a platform for businesses and individuals to buy and sell carbon credits.

Recently, scientists have termed a full spectrum of colours for carbon namely brown, black, blue, red, teal, and green (Zinke 2020). Brown carbon is emission from the burning of fossil fuels and releasing CO_2 while black carbon arises from incomplete combustion of fossil fuels, biofuel, and biomass. Both carbons are major contributors to global warming. In contrast, green carbon is carbon removed by photosynthesis and stored in terrestrial plants and soil of the natural ecosystem, while blue carbon is the carbon captured by the oceans (Nellemann et al. 2009; IPCC 2021). Red carbon is the newest colour which refers to all biological particles on snow and ice that reduce albedo to survive, while teal carbon relates to carbon stored in inland freshwater wetlands (Zinke 2020).

Natural fixes using the natural ecosystem to capture and store carbon are among the suggested solutions by many scientists. Trumper et al. (2009) reported that if the forest, peatlands, and agriculture ecosystems are safeguarded and their' carbon restored, it may help to reduce over 50 gigatonnes of carbon emissions that would otherwise enter the atmosphere. This also includes grasslands and coastal ecosystems like mangroves (Khan and Aljahdali 2022). This is because it is estimated about 20% of greenhouse gas emissions are sourced from the clearing and burning of forests.

While many are concerned with the declining green carbon ecosystem as well as there is a need also to promote interest in the blue carbon ecosystem. This is because blue carbon has been reported to have captured more than 55% of green carbon.

These are stored in the form of (i) sediments from mangroves, (ii) salt marshes, and (iii) seagrasses (Nellemann et al. 2009). Despite this, some scientists classified blue carbon into (i) deep blue carbon which is in the high seas, where carbon is stored in continental shelf waters, deep sea waters, and sea floor, and (ii) coastal blue carbon focuses on the coastal zone (mangroves, seagrass, and tidal marshes) (UNEP 2017; Twilley and Rovai 2019; Ocean Frontier Institute 2023; Rastogi and Siegel 2023).

The decline and degradation of coastal and marine ecosystems can release the captured carbon back into the atmosphere, which contributes to climate change and reverses the climate adaptation mitigation benefits they provide. According to Rastogi and Siegel (2023), global emission reduction alone is insufficient to achieve net zero but needs to include carbon dioxide removal (CDR) effort. CDR has been focused on terrestrial-based such as reforestation, soil capture, and technology-based direct-air capture. The opportunity of ocean-based CDR or marine CDR (mCDR) should not be dismissed as the ocean is the largest carbon storage sink on earth.

In the Malaysian context, mangroves are considered the front runner for blue carbon research due to their difficulty in reaching salt marshes and seagrasses meadows. A report by Omar et al. (2020) suggested that the largest mangrove areas are found in Sabah (60%), followed by Sarawak (22%) and 18% in Peninsular Malaysia with a total area estimated at 629,038 ha in 2017. The estimated average of Malaysia's mangrove carbon stock (above- and below ground) is about 181 MgC/ha. Between 1990 to 2017, the loss of mangrove area accounted for 3.3% which contributes to about 14 million Mg CO_2 emissions. Although the report also suggested caution that the figures obtained are generally crude, it provides an idea for further studies to about detailed studies related to carbon cycle/storage in the mangrove forest.

12.2 Research Studies in Malaysia

A review by Taillardat et al. (2018) found that global blue carbon ecosystems have the highest carbon sinks per plot compared to other types of ecosystems. It is suggested that the highest carbon sink is in salt marshes, followed by mangroves and seagrasses. Despite this, it is also highlighted the lack of data limits the assessment of the role of blue carbon. Therefore, articulating the role of this blue carbon in climate change mitigation, it is essential to address the data limitation.

In Malaysia, such a scenario is similar where some of the accessible literature via Google Scholar search was summarized in Table 12.1. Only literature related to the above, below ground, soil biomass/carbon of mangrove forests while other components of the carbon pool in this blue carbon context are relatively limited. The salt marsh is a coastal ecosystem in the upper coastal intertidal zone between land and open saltwater and is dominated by salt-tolerant plants. Seagrass is a flowering plant rooted in sediment on the sea bottom with shoots appearing above the substrate which are an important community in the shallow marine environment together with seaweeds and phytoplankton (Japar Sidik et al. 2012). Japar Sidik et al. (2012) made

Table 12.1 Information on the carbon storage at different blue carbon forests in Malaysia

	Total	Biomass (Mg/ha)	Carbon (MgC/ha)	Reference
1	Malaysia		181	Omar et al. (2020)
2	Peninsular Malaysia		151.40–895.8	Omar et al. (2016), Hong et al. (2017), Adame et al. (2018), and Rozainah et al. (2018a, b)
	Above ground			
1	Peninsular Malaysia	2.6–311.6	35.4–121.8	Tanouchi et al. (2000), Kasawani et al. (2007), Norhayati et al. (2009), Faridah-Hanum et al. (2012), Tengku Zarawie et al. (2015), Hong et al. (2017), Otero et al. (2018), Rozainah et al. (2018a, b), and Muhammad-Nor et al. (2019)
2	*Rhizophora apiculata*	460.0		Putz and Chan (1986)
3	*Bruguiera parviflora*	16.5		Hossain et al. (2007)
4	Mature *Rhizophora*		64.1	Hamdan et al. (2013)
	Logged-over *Rhizophora* (≤20 years)		49.5	Hamdan et al. (2013)
	Avicennia-Sonneratia mixed forest		18.2	Hamdan et al. (2013)
	30-year-old R. apiculata	372.0		Goessens et al. (2014)
	30-year-old R. apiculata	334.0		Hazandy et al. (2015)
	15-year-old R. apiculata	235.0		Khan et al. (2019)
	25-year-old R. apiculata	241.0		Khan et al. (2019)
	30-year-old R. apiculata	266.0		Khan et al. (2019)
5	Sabah	196.9	136.6	Wong et al. (2020) and Mhd Hatta et al. (2022)
	Sarawak			
6	*Rhizophora apiculata*	116.8		Chandra et al. (2011).
	Below ground			
1	Peninsular Malaysia	20.8–62.6	3.3–26.1	Hong et al. (2017), Rozainah et al. (2018a) and Muhammad-Nor et al. (2019)
2	Sabah		45.5	Mhd Hatta et al. (2022)
	Soil			
	Peninsular Malaysia			
1	0–100 cm depth		384.6–413.3	Rozainah et al. (2018a, b)

(continued)

Table 12.1 (continued)

	Total	Biomass (Mg/ha)	Carbon (MgC/ha)	Reference
2	0–20 cm depth		90.1–119.7	Hong et al. (2017)
	Sabah			
3	0–100 cm depth		273.8	Mhd Hatta et al. (2022)
	Seagrass			
1	Malaysia		108.6	Stankovic et al. (2021)

a review paper on seagrass and indicated that the subject matter is the least studied in Malaysia. They cited a few papers such as those by Ethirmannasingam et al. (1996), and Japar Sidik et al. (1996).

12.3 Malaysia's Commitment

Malaysia is highly committed to the issues related to climate change and carbon where engagement with the international community includes the signing of the UNFCCC in 1993 and Kyoto Protocol in 1999 and the Paris Agreement in 2016. Malaysia declared its Nationally Determined Contribution (NDC) under the Paris Agreement to reduce its economy-wide GDP-linked greenhouse gas (GHG) emission intensity by 45% in 2030 compared to the 2005 level. The first NDC (2015) included a condition that 10% of the emission intensity reduction is only committed upon international assistance. The updated NDC (2021) committed to a 45% emission intensity reduction unconditionally. They elucidate the highest level of government's commitment to the matter and tall order for the nation. The National Steering Committee on Climate Change (NSCC) was established in 1994 and the Malaysian Climate Change Action Council (MyCAC) was established in 2021 to formulate and implement policies to address and adapt to climate change.

Under the Twelfth Malaysia Plan (2021–2025), advancing sustainability was highlighted which is to guarantee continuous economic growth that balances the quality of life while at the same time protecting the environment, and conserving natural resources. Among others the key performance indicators used are (i) a 45% reduction in greenhouse gas (GHG) emissions intensity to GDP by 2030, (ii) 25% in government green procurement, (iii) at least 20% terrestrial and inland water areas conserved, (iv) at least 10% in coastal and marine area conserved.

These plans are in line with the National Policy on Biological Diversity 2016–2025 which policy envisions that by 2025 all production **forests, agriculture production, and fisheries will be managed and harvested sustainably. For example, by 2025, 100% of timber and products will be certified under the Malaysian Timber Certification Scheme (MTCS) scheme, while for agricultural areas under Malaysian Sustainable Palm Oil (MSPO), Roundtable on**

Sustainable Palm Oil (RSPO) and fisheries under Good Agricultural Practices (GAP), Marine Stewardship Council (MSC), etc.

Under this policy, it also hoped that by 2025 (i) at least 20% of terrestrial areas and inland waters, and 10% of coastal and marine areas, will be conserved through a representative system of protected areas and other effective area-based conservation measures, (ii) vulnerable ecosystems and habitats, particularly limestone hills, wetlands, coral reefs, and seagrass beds, are adequately protected and restored.

12.4 Challenges and Opportunities

In adapting the blue carbon concept and as mitigating measures towards climate change, Malaysia still requires extensive data and research to realize especially the actual coastal blue carbon potential. This will help in preparing Malaysia to be ahead of time to be one of the key players in the blue carbon system. This has been highlighted in a paper presented by Teh (2014). The mangrove ecosystem is also under threat posed by development projects and encroachment.

A national data repository is also an important tool for data storage and sharing which can evaluate the value and role of mangrove ecosystems as carbon sinks and CDR while national level toolkits or guidelines facilitate and standardize the research and reporting protocol. This provides coordinated efforts in the research and reporting of data suitable for the market. Eventually, such a data pool can assist in policy improvement and efforts toward quantifying the role of the blue carbon ecosystem in mitigating climate change.

Malaysian federal organizations and state governments are in the process establish establishing carbon laws. Prime Minister Datuk Seri Anwar Ibrahim has announced a ten million ringgit for a voluntary carbon market to show government seriousness to support and achieve net zero and with it, Bursa Malaysia has announced its Voluntary carbon market (VCM) to trade carbon credits. Further, Sarawak state amended its Forest Ordinance in 2022 and added important sections to support carbon trading (Ministry of Finance 2023).

With all these efforts, there are fewer attempts have been seen to establish laws and regulations for blue carbon. The Malaysian government has created a section to support blue carbon research but until now, no methodologies have been recommended by the government organizations to do further research on carbon quantification in blue carbon. So, by looking at this scenario, a research-based unit that will solely work on blue carbon needs time to support this ecosystem.

12.5 Conclusion

Malaysia has great potential for blue carbon research. Government attention is greatly needed to propel and coordinate efforts as there are many universities, NGOs, federal/state agencies, and federal/state government involved. Without these systematic and coordinated efforts, Malaysia will not be able to capitalize on the mangrove blue carbon forest in the country. Furthermore, GIS and Lidar tools can be useful to increase the data depository of blue carbon in this country. Specifically, coordination at the Federal and State levels in establishing a framework for blue carbon initiatives and methodologies is crucial in providing the foundation for future involvement in carbon trading and any other CDR programme. Amendment in the forestry and fisheries legislation at federal and state levels to legitimate carbon as produce so that it can be monetized. With these improvements, it is hoped that the blue carbon can be further preserved and protected under the national legal system.

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Conflict of Interest The authors declare no conflict of interest.

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