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Article

The Estimation of Carbon Stock in Seagrass Biomass of Kedindingan Island, East Kalimantan

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Abstract: Kedindingan Island is a part of marine conservation area in East Kalimantan. This island has a seagrass ecosystem, which could potentially provide ecosystem service in climate change mitigation as a carbon sink. However, there is limited information on the carbon content of the seagrass ecosystem there. This study aimed to estimate the carbon stock in the seagrass biomass on Kedindingan Island. Field sampling activities for collecting seagrass biomass were done in September 2021. A PVC core with a 20 cm diameter, 3 mm thick, and 80 cm length was used to collect seagrass biomass. The loss on ignition (LOI) method was applied to determine the concentration of organic carbon in the biomass. The results of this study found 7 species of seagrass in the study area, which were dominated by *Thalassia hemprichii*. The organic carbon concentration in above-ground biomass and below-ground biomass ranged from 30.8-31.7% and 29.4-31.4%, respectively. The average biomass was 4.99 Mg/ha and its average carbon stock was estimated at 1.53 MgC/ha. Based on the total carbon stock analysis, the above-ground biomass stored more carbon (79.28%) than the below-ground biomass.

Keywords: carbon stock; seagrass; Kedindingan island; seagrass biomass.

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1. Introduction

The seagrass ecosystem is one of the blue carbon ecosystems, which have the capacity to absorb and store carbon (Nellemann et al., 2009). This is due to the natural photosynthesis carried out by seagrasses and the ability of seagrass foliage structures to trap and accumulate sediment particles associated with organic carbon material originating from seagrass ecosystems and from outside seagrass ecosystems (McLeod et al., 2011; Howard et al., 2017). The carbon stored in the sediment will remain stored for an extended period, whereas the carbon stored in the biomass will only be stored when the seagrass is alive (Howard et al., 2014). The stored carbon can be emitted back to the atmosphere if seagrasses are damaged and not managed properly (Fourqurean et al., 2012; Howard et al., 2017). Consequently, seagrasses, in conjunction with other blue carbon ecosystems, namely mangroves and salt marshes, constitute coastal ecosystems that play a role in climate change mitigation (Howard et al., 2017).

The accessibility of carbon stock data is crucial for integrating ecosystems into national climate change policies, as it provides a foundation for greenhouse gas inventory data (Howard et al., 2017). Moreover, data on carbon stocks in seagrass sediments and biomass are required to ascertain seagrass emission factors that are pertinent for the establishment of seagrass baseline emission data in climate change policy (Wahyudi & Febriani, 2021). The most recent compilation of carbon stock estimates in Indonesian seagrass ecosystems is estimated to reach 69.49 MgC/ha, with details of carbon stocks in the upper biomass ranging from 0.01 to 1.85 MgC/ha. The lower biomass ranged from 0.05 to 1.84 MgC/ha, while the sediment ranged from 0.32 to 65.80 MgC/ha (Stankovic et al., 2023). Moreover, recent studies indicate that carbon stock measurements in seagrass ecosystems in Indonesia remain scarce, particularly on the island of Kalimantan, where data collection locations are limited to Berau, East Kalimantan (Stankovic et al., 2023; Stankovic et al., 2021; Wahyudi et al., 2020).

Kedindingan Island is a marine island situated in the coastal waters of Bontang. It is included in the East Kalimantan Provincial Marine Conservation Area in accordance with East Kalimantan Provincial Regulation No. 2 of 2021. The recent research conducted by Widyawati et al. (2022) on Kedindingan Island revealed the presence of various seagrass species, including *Thalassia hemprichii*, *Halophila minor*, *Halophila ovalis*, *Enhalus acoroides*, *Syringodium isoetifolium*, and *Cymodocea rotundata*. However, no research has been conducted on the capacity of the seagrasses on the island to sequester carbon. Consequently, this study was initiated as an initial investigation into the measurement of carbon stocks on Kedindingan Island. The objective of this study was to estimate the carbon stocks present in the seagrass biomass on Kedindingan Island, East Kalimantan.

2. Materials and Methods

Sampling was conducted in September 2021 on Kedindigan Island, located in the East Kalimantan Province. The location selected for the biomass sampling was on the west side of the island, which is where the seagrass ecosystems are present (Fig. 1). The location was selected based on information provided by local residents regarding the location of seagrass ecosystems on the island, which was deemed to be safe and easily accessible, and protected from waves, thus facilitating activities in the field. Furthermore, according to the information provided in the Appendix of the East Kalimantan Governor Regulation No. 32 of 2021 concerning the Management and Zoning Plan for the Bontang Marine Protected Area of East Kalimantan

Province for 2021-2041, the coastal waters of Bontang that are protected from waves have extensive seagrass beds.

The sampling process was conducted using the Seagrass-Watch transect method, as modified by Rahmawati et al. (2019). This method entailed the establishment of three 100-meter transects, extending perpendicularly from the nearest seagrass point to the land and towards the sea, with a distance of 50 meters between each transect. Each transect was then divided into four plots for the purpose of sampling seagrass biomass. A total of four plots were established along each transect for the purpose of sampling seagrass biomass. Transect 1 was situated at the following geographical coordinates: 0°04'55.37" LU and 117°32'33.24". The easternmost transect (Transect 2) is located at the following coordinates: 0°04'56.68" LU and 117°32'32.24". Transect 1 is located at coordinates 0°04'55.37" LU and 117°32'33.24" East, while Transect 2 is situated at coordinates 0°04'56.68" LU and 117°32'32.24" East (Figure 1). The laboratory analysis of biomass and organic carbon concentration was conducted at the Botanical Laboratory of the Oceanographic Research Center (BRIN) in Jakarta.

Biomass samples were obtained using a PVC core with the following dimensions: 3 mm thick, 20 cm in diameter, and 80 cm in length. The biomass samples were subsequently divided into two categories: aboveground biomass (AGB), comprising leaf fronds and seagrass leaves, and belowground biomass (BGB), consisting of rhizomes and roots. Moreover, the seagrass leaves were subjected to a cleaning process to remove any attached epiphytes. Subsequently, the biomass samples were subjected to oven drying at 60°C for a period of 72 hours or until the dry weight reached a stable equilibrium (Howard et al., 2014). Moreover, the organic carbon concentration of each seagrass species was determined through the loss on ignition (LOI) method, which entailed burning the biomass samples at 450°C for 4-8 hours in a furnace (Howard et al., 2014; Rahmawati et al., 2019). In the event that this measurement cannot be performed, the conversion value of the seagrass carbon-to-biomass ratio is 33.6%, as determined by Duarte (1990) (Rahmawati et al., 2019).

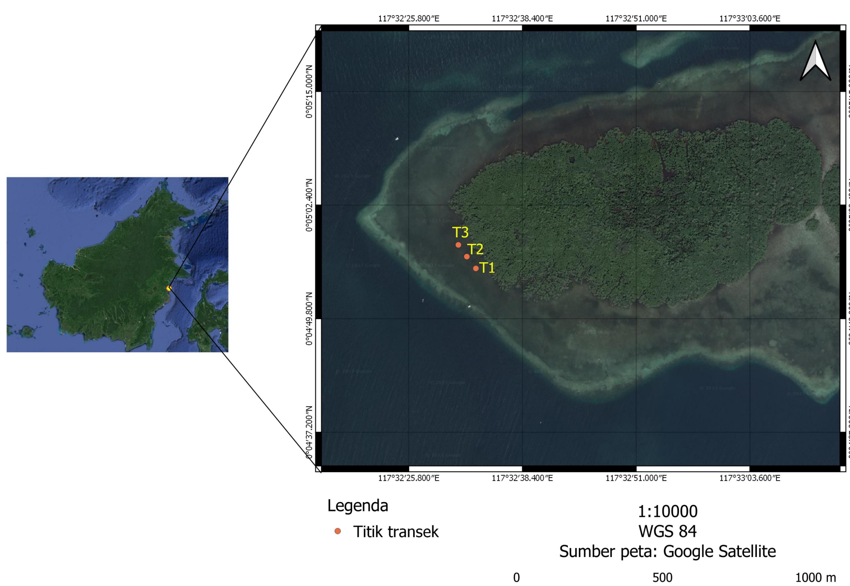

Figure 1. The sampling locations on Kedindingan Island are as follows: T1 is Transect 1, T2 is Transect 2, and T3 is Transect 3.

Seagrass density (stand/m^2) in this study was calculated based on the number of seagrass species taken through cores. The weight of AGB and BGB (g/m^2) was calculated from the dry weight of biomass. Organic carbon concentration (%C_{org}) in seagrass biomass (AGB and BGB) was calculated using equations 1 and 2 (Rahmawati et al., 2019). The %C_{org} results of each biomass were then multiplied by the weight of AGB and BGB to obtain carbon stocks in AGB and BGB (Howard et al., 2014; Rahmawati et al., 2019). The unit of carbon stock used is MgC/ha.

$$\%C_{org} = 0{,}40 \times \%LOI \text{ jika hasil LOI} < 20\% \quad (1)$$

$$\%C_{org} = 0{,}43 \times \%LOI - 0{,}33 \text{ jika hasil LOI} > 20\% \quad (2)$$

3. Results

3.1. Geographical Condition of Kedindingan Island

In 2021, Kedindingan Island was designated as a marine protected area in East Kalimantan Province through the Regional Regulation of East Kalimantan Province No. 2 of 2021, which concerns the Zoning Plan for Coastal Areas and Small Islands of East Kalimantan Province for the period 2021-2041. In accordance with the map of the Bontang marine conservation area in the Appendix of the East Kalimantan Governor Regulation No. 32 of 2021, the location point for seagrass data collection in this study is situated within the core zone of the conservation area. From a geographical perspective, Kedindingan Island is circumscribed by the following boundaries: to the north, it is adjacent to Malahing Village; to the south, it is contiguous with Beras Basah Island; to the east, it is situated adjacent to the Makassar Strait; and to the west, it is bordered by maritime routes and the mainland of Kalimantan Island.

In addition to seagrass ecosystems, the island is home to mangrove and coral reef ecosystems (Samin et al., 2023). As detailed in the Appendix to East Kalimantan Governor Regulation No. 32 of 2021, the seagrass ecosystems on the island are in a healthy state, with a diverse range of species, including *Cymodocea serrulata*. Furthermore, *Enhalus acoroides*, *Halodule uninervis*, *Halophila decipiens*, *Halophila minor*, *Halophila ovalis*, *Syringodium isoetifolium*, and *Thalassia hemprichii* have been identified. Moreover, previous research by Samin et al. (2023) indicated that the water quality of Kedindingan Island in terms of temperature, pH, and dissolved oxygen parameters exhibited values that were consistent with the quality standards for sea water necessary for the survival of marine biota.

3.2. Seagrass Density

The seagrass species composition at the study site is a mixed vegetation assemblage comprising seven species: *Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, *Cymodocea serrulata*, *Halophila ovalis*, *Halodule uninervis*, and *Syringodium isoetifolium*. The *Thalassia hemprichii* species exhibited the highest average density compared to other species, with an average value of 977 stands/m^2. Conversely, the lowest average density was observed in the E. acoroides species, with an average value of 74 stands/m^2. The highest density of seagrass was observed in Transect 1, with an average of 2261 stands/m^2. This was due to the presence of large seagrass species, namely Thalassia hemprichii and Enhalus acoroides, which were more abundant than in Transect 2 and Transect 3. As indicated in Tab. 1, the mean total seagrass density on Kedindingan Island at the time of data collection was 1810 stands/m^2.

Table 1. Seagrass density on Kedindingan Island

Seagrass species	density (stands/m²)		
	Transect 1	Transect 2	Transect 3
Enhalus acoroides	135	N/A	88
Thalassia hemprichii	1011	947	971
Cymodocea rotundata	56	127	119
Cymodocea serrulata	207	159	64
Halophila ovalis	366	80	350
Halodule uninervis	255	N/A	72
Syringodium isoetifolium	231	88	104

Notes: N/A indicates that data is not available

3.2. Seagrass Biomass

The highest seagrass biomass was observed in Transect 1, with a total seagrass biomass value of 6.03 Mg/ha. In contrast, the lowest biomass was recorded in Transect 2, with a total seagrass biomass value of 3.45 Mg/ha (Figure 2). The estimated mean seagrass biomass for Kedindingan Island was 4.99 Mg/ha. The results of the biomass weight analysis indicated that the lower portion of the seagrass plants exhibited a greater biomass than the upper portion (Fig. 2).

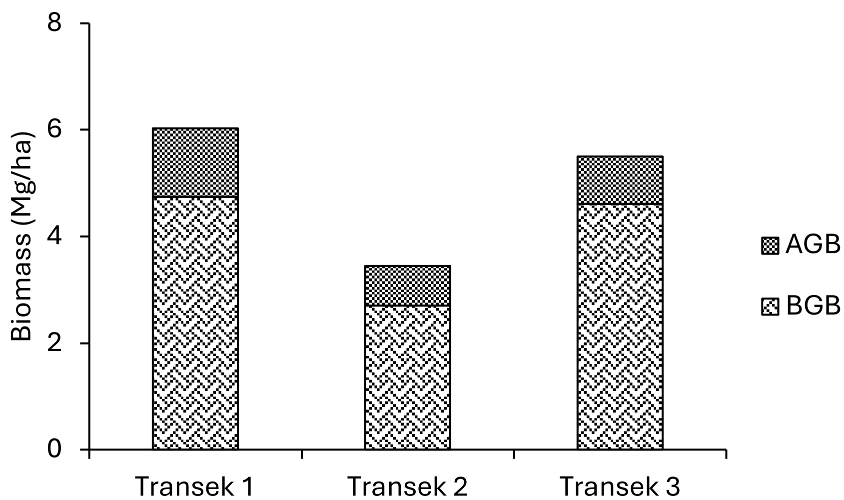

Figure 2. Aboveground (AGB) and belowground (BGB) biomass weight of seagrasses in Kedindingan Island.

3.3. Organic Carbon Content

The measurement of organic carbon concentration presented in this study is limited to the Enhalus acoroides and Thalassia hemprichii species (see Tab. 2). The organic carbon concentration exhibited comparable values between the upper and lower biomass. The organic carbon concentration of Enhalus acoroides was found to be higher than that of Thalassia hemprichii (AGB: 31.7% and BGB: 31.4% and AGB: 30.9% and BGB: 29.4%, respectively). A number of additional species were excluded from the analysis due to insufficient biomass sample dry weight, which did not meet the minimum requirements for measuring organic carbon concentration using the LOI method. Accordingly, the organic carbon concentration of AGB and BGB in these species is based on the seagrass carbon-biomass ratio, which is then employed in the calculation of the carbon stock for each species (Rahmawati et al., 2019).

Table 2. Measurement results of organic carbon concentration (%) for each seagrass species at the study site.

Spesies lamun	Transect 1		Transect 2		Transect 3	
	AGB	BGB	AGB	BGB	AGB	BGB
Enhalus acoroides	31,7	31,4	N/A	N/A	31,7	31,4
Thalassia hemprichii	30,8	29,8	N/A	29,4	31	29,7
Cymodocea rotundata	N/A	N/A	N/A	N/A	N/A	N/A
Cymodocea serrulata	N/A	N/A	N/A	N/A	N/A	N/A
Halophila ovalis	N/A	N/A	N/A	N/A	N/A	N/A
Halodule uninervis	N/A	N/A	N/A	N/A	N/A	N/A
Syringodium isoetifolium	N/A	N/A	N/A	N/A	N/A	N/A

3.4. Carbon Stock

The mean total organic carbon stock in seagrass biomass at the study site was 1.53 MgC/ha. The highest organic carbon stock was observed in transect 1, with an average value of 1.85 MgC/ha. In contrast, the lowest stock was recorded in transect 2, with an average carbon stock of 1.07 MgC/ha (Figure 3). The findings indicated that the lower biomass stored a greater quantity of organic carbon (comprising 79.28% of the total organic carbon stock in seagrass biomass) than the upper biomass (representing 20.72% of the total organic carbon stock in seagrass biomass).

4. Discussion

The seagrass area under investigation was situated in the western portion of Kedindingan Island, in close proximity to the mangrove ecosystem. The *Thalassia hemprichii* species is the most prevalent seagrass species observed at the study site, comprising 54% of the total species composition. Similarly, Widyawati et al. (2022) observed a dominance of the *Thalassia hemprichii* species in the seagrass area on the south side of Kedindingan Island. This suggests that *Thalassia hemprichii* is the species most capable of adapting to the specific seagrass habitat substrate found on Kedindingan Island. This is believed to be due to the fact that *Thalassia hemprichii* is capable of growing on a variety of substrates within seagrass habitats. This species can be found on sandy substrates, which are a mixture of fine and coarse sands, as well as on substrates that are dominated by rubble and coral reefs (Sondak & Kaligis, 2022). The species is distributed globally in Indo-Pacific coastal waters (Discover Life, 2023). Furthermore, seagrass species are frequently observed in proximity to mangrove and coral reef ecosystems (van Tussenbroek et al., 2006).

The elevated biomass weight observed in Transect 1 (Fig. 2) can be attributed to the higher density of the *Enhalus acroides* and *Thalasia hemprichii* species in comparison to Transects 2 and 3 (Table 1). These two species are both large and medium-sized seagrasses, which have been observed to have high biomass weight and large carbon content in their biomass parts (Stankovic et al., 2017; Shafiya et al., 2021; Rustam et al., 2017; Mazarrasa et al., 2018). Furthermore, the findings of this study indicated that the lower biomass of seagrass stands was greater than the upper biomass. These findings are consistent with those of Nugraha et al. (2020) in seagrass ecosystems of North Papua waters, Reyes et al. (2022) in the seagrass ecosystem of Oyon Bay, Philippines, and Stankovic et al. (2018) in the seagrass ecosystem of the Andaman coast of Thailand. It is postulated that this phenomenon may be attributed to the greater storage of photosynthetic products in the biomass beneath the substrate, which represents a form of seagrass adaptation to thrive in shallow waters susceptible to disturbances from water waves (Nurdin et al., 2022).

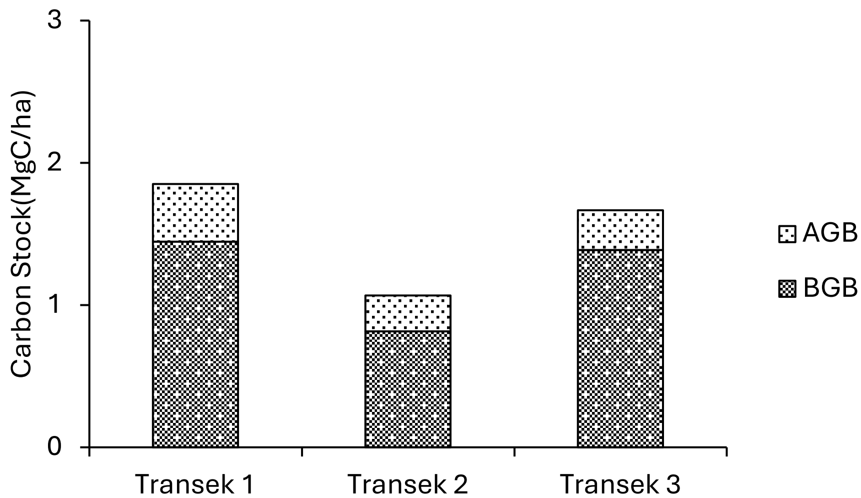

Figure 3. Organic carbon stocks in the aboveground (AGB) and belowground (BGB) biomass of seagrasses on Kedindingan Island.

Prior research by Stankovic et al. (2017) and Wahyudi et al. (2020) indicates that seagrass biomass is a key factor influencing organic carbon stocks in seagrass ecosystems. This is because the CO2 absorbed by seagrasses through the photosynthesis process is stored in the form of seagrass plant biomass (Stankovic et al., 2023). A comparison of the organic carbon stocks in seagrass biomass stands between transects (Fig. 3) obtained in this study also exhibits a similar pattern to the comparison of seagrass biomass weight between transects (Fig. 2). This is due to the fact that the number of individuals of large-sized seagrass species with high biomass weight, such as *Thalasia hemprichii* and *Enhalus acoroides*, was found to be greater in Transect 1 than in Transect 2 and in Transect 3. In this study, it was also determined that the two species exhibited the highest percentage of organic carbon stock relative to the total organic carbon stock in seagrass biomass, namely 76.63% from *Thalasia hemprichii* and 13.72% from *Enhalus acoroides*. Prior research indicates that both species possess a considerable morphological size, which is subsequently accompanied by a substantial carbon storage capacity in their biomass (Stankovic et al., 2017; Rustam et al., 2017; Nugraha et al., 2019). Moreover, a notable correlation exists between the weight of seagrass biomass and the carbon content of seagrass stands. An increase in biomass weight is associated with an elevated organic carbon concentration in seagrass stands (Stankovic et al., 2017). Consequently, the composition of seagrass species can impact the variability of carbon stocks in seagrass ecosystems (Stankovic et al., 2023).

The allocation of organic carbon storage in seagrass biomass was highest in the lower biomass, representing 80.24% of the total (Fig. 3). This elevated level of organic carbon in the lower biomass is also corroborated by the findings of seagrass biomass carbon stock assessments conducted at various locations across multiple Southeast Asian regions (Stankovic et al., 2023; Stankovic et al., 2018; Reyes). (Nugraha et al., 2020; Khairunnisa et al., 2018; Budiarto et al., 2021; Rustam et al., 2021). Previous research has demonstrated that the weight and carbon concentration of seagrass biomass influence the value of carbon storage in seagrass (Khairunnisa et al., 2018). However, this study did not identify a significant difference in organic carbon concentrations between the upper and lower biomass (Tab. 2). Therefore, the elevated organic carbon stock in the lower biomass observed in this study was predominantly influenced by the greater weight of the lower biomass relative to the weight of the upper biomass of seagrass stands (Figure 2). This is believed to be due to the fact that the upper biomass of seagrass plants, namely the leaves, is more utilized in the food chain and decomposes more rapidly than the lower biomass, namely roots and rhizomes. This results in the lower biomass storing a greater amount of carbon (Zou et al., 2021; Tupan & Wawo, 2020). Moreover, the lower biomass is typically more solid and possesses a larger morphological size (Rahman et al., 2018). This is believed to be the consequence of seagrass photosynthesis processes that are stored more in the lower biomass, reflecting seagrass adaptation to thrive in shallow waters (Nurdin et al., 2022).

The mean organic carbon stock value of seagrass biomass in this study is less than that of the mean organic carbon stock of seagrass biomass in Indonesia, as reported by Stankovic et al. (2023). However, it remains within the range of biomass carbon stock values observed in several seagrass sites in Indonesia (Tab. 3). The total organic carbon stock value found in this study was observed to be lower than the carbon stock value in seagrass biomass in the coastal waters of Poton Boko-East Lombok and in the eastern coastal waters of Bintan Island (Figure 4), despite the higher seagrass density observed in Table 3. The elevated concentration of organic carbon in seagrass biomass at both locations is posited to contribute to the elevated carbon stock value in seagrass biomass (Tab. 3). Furthermore, the seagrass biomass in the coastal waters of Paton Boko has a higher weight than that in Kedindingan Island, which is 6.76 Mg/ha (Rahman et al., 2018). The comparison demonstrates that the weight of the biomass can influence the carbon content of the seagrass biomass.

The low stock of organic carbon in seagrass biomass at this research site in comparison to seagrass areas in the Thousand Islands (Fig. 4) is thought to be influenced by the seagrass species that dominate seagrass areas in the Thousand Islands, namely *Enhalus acoroides* and *Thalassia hemprichii*, which have large morphological sizes (Rustam et al., 2021). Large seagrasses tend to exhibit a greater allocation of biomass and a higher carbon storage capacity than their smaller counterparts (Stankovic et al., 2017; Hertyastuti et al., 2020; Supriadi et al., 2014).

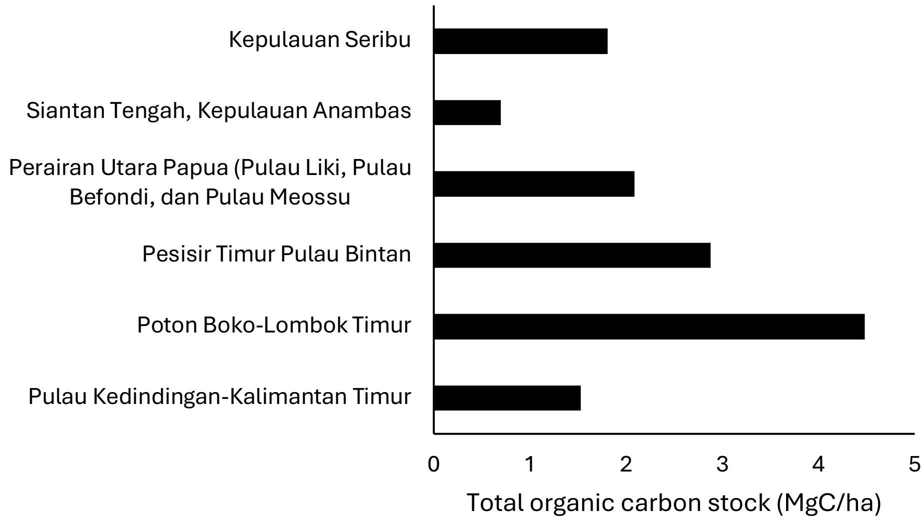

Figure 4. Comparison of total organic carbon stock in seagrass stand biomass between Kedindingan Island (results of this study) and several other locations in Indonesian coastal waters. Values shown are average values (reference sources listed in Table 3).

It is similarly postulated that discrepancies in the methodologies employed for the measurement of organic carbon content may have an impact on the accuracy of carbon stock estimates (Stankovic et al., 2023). This is illustrated by a comparison of the seagrass biomass carbon stocks at Kedindingan Island with the findings of the study by Nugraha et al. (2020) on several islands in the North Papua waters (Figure 4). The application of biomass-organic carbon concentration conversion factor values in the estimation of carbon stocks in AGB and BGB in the North Papua waters (Tab. 3) appears to yield higher carbon stock values than those observed in this study. In some species, direct measurements of C-org concentrations in biomass were employed to estimate carbon stock values. Furthermore, the data in Tab. 3 demonstrate that C-org concentrations exhibit variability across different geographical regions. The environmental conditions surrounding seagrass habitats can influence the carbon content stored within the biomass (Stankovic et al., 2018).

Table 3. Comparison of average organic carbon stocks in seagrass biomass at several locations in Indonesian coastal waters.

Location	Dominant species	Average seagrass density (stands/m²)	C-org concentration (%)		Total organic carbon stock Biomass	Organic carbon measurement method	Reference
			AGB	BGB			
Pesisir Timur Pulau Bintan	*Enhalus acoroides*	239,00	26,95-42,49	30,75-46,51	2,88	*Walkey and Black*	Khairunnisa et al., 2018
Poton Bako, Lombok Timur	*Cymodocea rotundata*	384,67	26,40-49,05	17,93-49,09	4,48	LOI	Rahman et al. (2018)
Perairan Utara Papua (Pulau Liki, Pulau	N/A	N/A	33,6	33,6	2,09	Conversion factor	Nugraha et al. (2020)

Location	Dominant species	Average seagrass density (stands/m²)	C-org concentration (%)		Total organic carbon stock Biomass	Organic carbon measurement method	Reference
			AGB	BGB			
Befondi Dan Pulau Meossu)							
Siantan Tengah, Kepulauan Anambas	*Enhalus acoroides*	N/A	N/A	N/A	0,70	*Walkey and Black*	Budiarto et al. (2021)
Kepulauan Seribu	*Enhalus acoroides* dan *Thalassia hemprichii*	N/A	N/A	N/A	1,81	*Elemental analyzer*	Rustam et al. (2021)
Pulau Kedindingan, Kalimantan Timur	*Thalasia hemprichii*	1810	30,8-31,7	29,4-31,4	1,53	LOI	Results of this study
Indonesia (rata-rata kompilasi data nasional)	N/A	N/A	N/A	N/A	1,96		Stankovic et al. (2023)

The findings of Reyes et al. (2022) indicate that protected seagrass habitats tend to accumulate greater quantities of carbon than seagrass ecosystems that are subjected to human-induced disturbances due to their proximity to anthropogenic activities. This is evidenced by the higher organic carbon stock observed at the study site in comparison to seagrasses in the coastal waters of Siantan Tengah, Anambas Islands, despite the dominance of large species in the seagrass area (Figure 4). This is believed to be due to the location of the seagrasses in the coastal waters of Siantan Tengah, which is in close proximity to human settlements and activities (Budiarto et al., 2021), whereas the seagrass location on Kedindingan Island is situated at a greater distance from human settlements and is included within the core zone of the conservation area, and thus is not thought to be affected by human activities. The impact of disturbance and pressure on seagrass ecosystems can result in alterations to the total carbon stock stored in seagrass biomass (Stankovic et al., 2018).

The organic carbon content of seagrass biomass exhibits variability contingent on the specific seagrass type, the composition of the seagrass community (uniform or mixed), the prevailing environmental conditions, and the manner in which the seagrass area is managed (Stankovic et al., 2018; Stankovic et al., 2017; Supriadi et al., 2014; Reyes et al., 2022; Juma et al., 2020). Another factor that is believed to influence carbon content in seagrass biomass is the availability of nutrients. According to Govindasamy et al. (2013), the addition of nutrients in seagrass areas can enhance seagrass biomass. However, an excessive increase in nutrients can have a deleterious impact on the seagrass environment (Cabaço et al., 2013). Further research is required to examine the nutrient content of seagrass areas in Kedindingan Island and to ascertain the impact of nutrient concentrations on seagrass biomass and carbon content within the ecosystem. Furthermore, additional research is required to quantify the total carbon stock within the seagrass ecosystem of Kedindingan Island, including measurements of carbon stock in the sediment. The availability of these data can be useful for the purpose of greenhouse gas inventory data in the calculation of potential carbon emissions from the blue carbon sector in climate change mitigation policies (Howard et al., 2017; Wahyudi & Febriani, 2021).

5. Conclusions

The seagrass ecosystem on Kedindingan Island is dominated by *Thalassia hemprichii*, which represents a total of seven species, namely *Enhalus acoroides*, *Thalassia hemprichii*, *Cymodocea rotundata*, *Cymodocea serrulata*, *Halophila ovalis*, *Halodule uninervis*, and *Syringodium isoetifolium*. The range of organic carbon stock in seagrass biomass on Kedindingan Island was found to be 1.07–1.85 MgC/ha. The largest percentage of organic carbon stock was contributed by Transect 1, which was found to contain a greater abundance of large species than the other transects. This study corroborates the findings of previous studies in this field, confirming that the proportion of organic carbon stock in seagrass biomass stands is in the lower biomass category, with a percentage of 79.28% of the total organic carbon stock.

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