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Carbon sequestration potential of seagrass species in the selected sites of Don Marcelino, Davao Occidental, Philippines

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ABSTRACT. The study determined the carbon sequestered by seagrass species from the three (3) coastal sites of Don Marcelino: Talagutong, Kinanga, and Lawa. The study employed one-shot sampling survey at the study sites. The survey was conducted during the lowest tide of the day, and the observation of seagrass species was limited to a depth of 0–3 meters. A total of four species of seagrasses were identified using taxonomic field guides. The species *Halodule pinifolia, Thalassia hemprichii,* and *Cymodocea rotundata* were present in Talagutong, while *Thalassia hemprichii, Cymodocea rotundata, Halophila ovalis,* and *Halodule pinifolia* were recorded in Kinanga and Lawa. *Thalassia hemprichii* was the most dominant seagrass species had the highest percentage cover (7.42%), followed by *Cymodocea rotundata* (4.11%). Moreover, *Thalassia hemprichii* was more dominant in the study area, which also obtained the highest shoot density (4.38 shoot/m^2), followed by *Cymodocea rotundata* (258.67 shoot/m^2). *Cymodocea rotundata* obtained the highest sequestered total carbon from Lawa compared to the other two (2) sites. The carbon sequestered by *Thalassia hemprichii* in Talagutong and Lawa was significantly higher compared to Kinanga. Furthermore, the carbon sequestered by *Halophila ovalis* in Lawa and Kinanga was significantly higher (21.11 and 18.56 g/m^2) than in Talagutong. It is highly recommended for the local government unit to include seagrass areas of Don Marcelino for marine protected areas as part of the implementation of proactive climate change mitigation.

Keywords: *Climate change, marine, protection, carbon stock*

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INTRODUCTION

Climate change refers to long-term shifts in the weather conditions and patterns of extreme weather events. These shifts may be natural, such as through variations in the solar cycle (Dhore et al., 2017). Since the 1800s, human activities have been the main driver of climate change, primarily due to burning fossil fuels like coal, oil, and gas. Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures (Cook et al., 2016).

Climate change is an inter-governmental complex challenge globally with its effect over multifaceted components of the ecological, environmental, socio-political, and socio-economic disciplines (Abbass et al., 2022). Besides, the irregular weather patterns, the retreating of global ice sheets, and the corresponding elevated sea level rise are among the most common effects of climate change (Lipczynska-Kochany, 2018; Macusi et al., 2020).

Carbon sequestration is the ability of an ecosystem to store excess carbon (blue carbon) removed from the atmosphere as carbon dioxide. Coastal ecosystems can absorb and store carbon over long periods; Including mangrove forests and sea-grass beds (Santos et al., 2022). Seagrass beds are complex and productive ecosystems in marine and coastal ecosystems. One of the main roles of seagrass is to store carbon (Kennedy and Bjork, 2009) apart from being a habitat for nearshore marine organisms (Salang and Macusi, 2020).

Seagrass ecosystems sequester carbon at disproportionately high rates, approximately 10% compared to terrestrial ecosystems, and represent a powerful potential contributor to climate change mitigation and adaptation projects. The ability of seagrass to sequester carbon demonstrated its capacity to be an essential natural carbon stock in the ecosystem. However, at a local scale, rich heterogeneity in seagrass ecosystems may lead to variability in carbon sequestration. Differences in carbon sequestration rates, both within and between seagrass meadows, are related to a wide range of interrelated biophysical and environmental variables that are difficult to measure holistically using traditional field surveys. Though the outlined approach is complex, it is suitable for accurately and efficiently producing a full picture of seagrass carbon stock (Simpson et al., 2009).

Hence, the study would be carried out to gather information and present the findings of the carbon sequestration potential of seagrass, particularly in Don Marcelino, Davao Occidental which has abundant seagrass species. The study generally aims to determine the carbon sequestration potential of seagrass species in Don Marcelino, Davao Occidental. Specifically, it sought to identify the seagrass species, percent cover, shoot density, carbon sequestration potential of each species, and the physicochemical parameters of the habitat of the seagrass species.

METHODOLOGY

Sampling design and technique

The study used a transect Quadrat method for estimating the abundance of seagrass species. The field survey was conducted only on a one-shot sampling during the lowest tide and was employed per station. There are three (3) stations to be established. For each station, three (3) transect lines were laid out following the protocol of Short et al., (2001). In all stations, five quadrats were placed along each 50-meter transect. 10-meter intervals, and a 0.5-meter x 0.5-meter quadrat with 25 sub squares was used.

Identification of the seagrass species

Identification of seagrass species was conducted in the field; a taxonomic key was used. The Field Guide to the Common Mangroves, Seagrasses, and Algae of the Philippines by Calumpong and Meñez (1997)

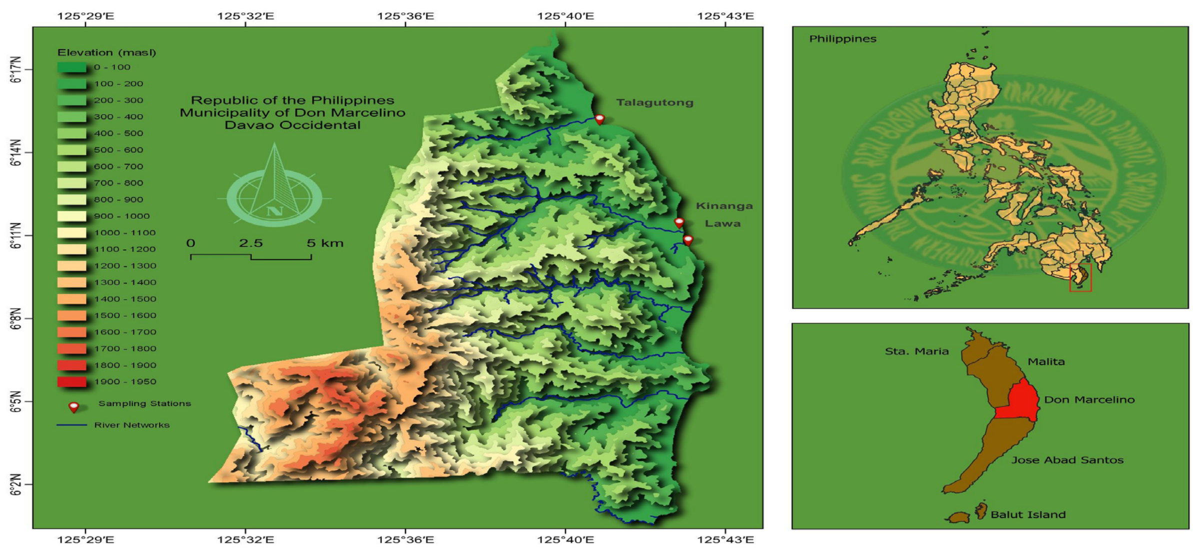

Figure 1. Map of the three (3) study sites of Don Marcelino, Davao Occidental

Determination of the percent cover of seagrass

The categories was adopted from Capin et al.,(2020) were used to record the percent cover of the seagrass species per quadrant following the formula below;

$$C = \frac{\sum M_i F_i}{F}$$

Where:

C = percent cover

M_i = midpoint percentage of class (j)

F = frequency (number of species with the class of dominance (j)

F_i = number of frequencies of the class

Determination of shoot density

Using the transect method, the shoots were counted and recorded. The process was repeated for each species in the quadrant, following the protocol of Kenworthy and Björk (2009).

$$D = \frac{\text{No. of individuals of the same}}{\text{Area (m}^2\text{)}}$$

Determination of physicochemical parameters

Water samples were collected using an aseptic transparent bottle from each sampling station. Analysis was done at the study sites. The physicochemical parameters, namely conductivity, pH, and temperature, were analyzed using a multiparameter water tester following the Hanna Instruments Instruction Manual (Bárta et al., 2017). Salinity was determined using the refractometric method (U.S. Environmental Protection Agency, 1979).

Determination of biomass

Biomass sampling was carried out on seagrass shoots, which were separated into two parts consisting of above-ground biomass (AGB) and below-ground biomass (BGB). Seagrass was dried using an oven at 60 degrees Celsius for 72 hours until it reached a constant weight (Rahmawati et al., 2019). The equation used to analyze biomass content is shown below:

$$AGB = (AGB_x)(DS_x)$$

$$BGB = (BGB_x)(DS_x)$$

Where: AGB is total above-ground biomass and BGB is total below-ground in unit g.m^{-2}, AGB_x is above-ground biomass species x in unit g/shoots, BGB_x is below-ground biomass of species x, and DS_x is shoot density per species.

Carbon Sequestration

The sequestered carbon of seagrass was determined using the protocol of

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Harahap et al., (2021). Seagrass carbon analysis was carried out using the loss on ignition (LOI) approach. The calculation of organic carbon stock in seagrass is determined by multiplying the percentage of the organic carbon content of each species by the dry biomass. LOI is loss on ignition, OCC is organic carbon content, and OCS is organic carbon stock.

$$\%LOI = \frac{\text{Weight before burning} - \text{Weight after burning}}{\text{Weight before burning}} \times 100\%$$

AG_x – OCS (g/C or g.m^{-2}) = (OCC_x) (AGB_x)

BG_x – OCS (g/C or g .m^{-2}) = (OCC_x) (AGB_x

Statistical tool

Frequency and percentage were used in quantifying the various species of seagrasses. The mean was used to determine the percentage cover of seagrasses, shoot density of seagrasses, and carbon sequestration potential of the seagrasses. To compare the sequestered carbon of each species at each site, a one-way ANOVA was used.

RESULTS AND DISCUSSION

Seagrass species

The total of four seagrass species were found in the sampling stations namely *Halodule pinifolia, Halophila ovalis, Thalassia hemprichii* and *Cymodocea rotundata* (see Table 1). The *Thalassia hemprichii* and *Cymodocea rotundata* are the most common species.

Table 1. Percentage cover (%) of the seagrass in the study area.

Species	Site: Talagutong	Site: Kinanga	Site: Lawa
Halodule pinifolia	0	4.83	1.67
Thalassia hemprichii	2.58	9.6	10.07
Halophila ovalis	0	1.24	1.04
Cymodocea rotundata	2.97	4.84	4.52

In Talagutong (Table 1) *Cymodocea rotundata* had a higher percent cover of 2.97% compared to *Thalassia hemprichii* with a 2.58% cover. This means that *Cymodocea rotundata* is abundant in this area compared to *Thalassia hemprichii.* In Kinanga (Table 1), *Thalassia hemprichii* had a higher percent age cover this time, with a total of 9.6% cover in every quadrat compared to the rest of the species, which is *Cymodocea rotundata* which has 4.04% cover. *Halodule pinifolia* has a 4.83% cover and *Halophila ovalis* has a 1.24% cover; this is also by quadrat. Meanwhile, in Lawa (Table 1), *Thalassia hemprichii* has a high percent cover of 10.07%, followed by *Cymodocea rotundata* with 4.52%, and *Halodule pinifolia* with 1.67% cover and *Halophila ovalis* have 1.04% cover.

Table 2 shows that there were highly significant differences in the means of the

Table 2. ANOVA of differences in terms of percent cover of the various seagrass species found in the study sites.

Factor	df	MS	*F*	MS	*F*
Between Groups	2	236.121	18.012**	26.9	12.026**
Within Groups	24	13.109	2.237		
Total	26				

**Note=highly significant

percentage cover in the sampling sites, since the *F* value of 18.012 has a highly significant level of statistics, this indicate that the percent cover among in the sites were different from each other.

Among the three species *C. rotundata* and *T. hemprichii* were the most abundant in terms of shoot density. C. rotunda has an average shoot density of 259 shoot/m^2, while *T. hemprichii* has 438 shoot/m^2. *Halodule pinifolia* has an average shoot density of 149 shoot/m^{2,} while *Halophila ovalis* has the lowest average shoot density, with a value of 22 shoot/m^2 (see Table 3). The shoot density of seagrass species is an important factor in determining the health and productivity of seagrass beds. The values given in the prompt indicate the shoot density of different seagrass species at three different monitoring stations.

At Talagutong (Table 3) *Thalassia hemprichii* had a higher shoot density of 652 shoots/m^2 compared to *Cymodocea rotundata* which had a shoot density of 106 shoots/m^2. This suggests that *Thalassia hemprichii* is more dominant in that area and has better adaptability than *Cymodocea rotundata.*

At Kinanga (Table 3) *Thalassia hemprichii* had a lower shoot density of 250 shoots/m^2 but was still dominant over other seagrass species, such as *Halodule sp.* which had a shoot density of 66 shoots/m^2, *Halophila ovalis* which had a shoot density of 11 shoots/m^2, and *Cymodocea rotundata* which had a higher shoot density of 365 shoots/m^2.

At Lawa (Table 3) *Thalassia hemprichii* still had a high shoot density of 413 shoots/m^2, followed by *Cymodocea rotundata* with 305 shoots/m^2, *Halodule pinifolia* with 116 shoots/m^2, and *Halophila pinifolia* with 32 shoots/m^2.

However, based on statistical analysis (Table 2), the shoot density of the seagrass among the sampling sites was significantly different. The wide area of the intertidal zone with a sandy substrate at the study sites is favorable for seagrass growth and distribution. Likewise, the seasonal variations in the physicochemical parameters of the area affect the occurrence and distribution of seagrass species (Aboud and Kannah, 2017).

Table 3. Shoot density of the seagrass in the study area

Species	Shoot Density (shoot/m^2)		
	Talagutong	Kinanga	Lawa
Halodule pinifolia	-	66	166
Thalassia hemprichii	652	250	413
Halophila ovalis	-	11	32
Cymodocea rotundata	106	365	305

The shoot densities at all sampling sites ranged from 32 shoots/m^2 to 652 shoots/m^2. *Thalassia hemprichii* dominated at all sites, which could be attributed to the sandy substrates, and is usually found in shallow waters in the lower inter and subtidal areas up to 15 m depth (International Union for Conservation of Nature, 2019).

The total carbon sequestered by *C. rotundata* is 2.20, and the *T. hemprichii* is 2.35, which means that *T. hemprichii* is significantly higher than *C. rotundata* in Talagutong site (Table 4). On the other hand, in Lawa site (Table 4), the total carbon is sequestered by *C. rotundata* is 2.37, and the *T. hemprichii* is 2.55, while *Halophila ovalis* has 21.11 and 18.44 in *Halodule pinifolia. Halophila ovalis* is significantly higher than the rest of the stated species. In Kinanga site (Table 4), the total carbon sequestered by *C. rotundata* is 2.10, *T. hemprichii* 2.13, *Halophila ovalis* has 15.89, and *Halodule pinifolia* is 18.56. The highest total carbon sequestered in Kinanga site is the *Halodule pinifolia* species.

The statistical analysis shows that carbon sequestered by *C. Rotundata* (Table 5) was highly significant among sampling sites *(F* (2,24) = 8.96, *p* = 0.001). This was also true for carbon sequestered by *T. hemprichii* (Table 5) was also statistically highly significant among sampling sites (*F* (2,24) = 10.79, *p* < 0.001).

Every species has a different ability to absorb and store carbon, the carbon stock contained in its tissues are largerly stored at the rhizomes and roots. Seagrass that thrives in tropical water has a high ability to absorb and store carbon because of the larger size of the stem, rhizome, and roots than other species, so it can produce large biomass and high carbon uptake (Duarte et al., 2010). Large species are also able to survive longer because of the slow turnover of roots and rhizomes compared to small species such as *Halophila ovalis* which affects their ability to accumulate total carbon storage (Setyobudiandi and Boer, 2018; Kaewsrikhaw et al., 2016; Rahmawati et al., 2011). Seasonal factors also affect the ability of seagrass to store carbon. High waves in the rainy season cause litter to increase and reduce its ability to store seagrass, while in the dry season, the sun's intensity is higher, so that seagrass is more exposed to the sun during low tide, which enhances the seagrass ability to absorb and store carbon (Supriadi et al., 2014). The amount of carbon stored in seagrass is influenced by various factors, so there are differences in carbon stocks in different species of seagrass at each station (Table 5). Seagrass is proven to be able to absorb and store carbon dioxide in its biomass.

This shows that seagrass has an important role in climate change mitigation, so this needs to be preserved to protect the seagrass ecosystem for climate change mitigation. However, when the seagrass beds are damaged, it eliminates their ecological function and releases the carbon stored back into the atmosphere (Russel et al., 2013; Wawo et al., 2014; Lovelock et al., 2017).

Physicochemical parameters of the study area

The physicochemical parameters collected in the study are important factors that affect the growth and survival of seagrass. In terms of salinity, the range of 30 to 31 ppm is within the usual range for most seagrass species. However, extreme changes in salinity can stress seagrass, leading to reduced growth and even mortality. Temperature is another important factor that affects seagrass.

Table 4. Carbon sequestration among seagrass species

	Site (g.m^{-2})		
Species	**Talagutong**	**Lawa**	**Kinanga**
Cymodocea rotundata	2.20	2.37	2.10
Thalassia hemprichi	2.35	2.55	2.13
Halophila ovalis	5.00	21.11	15.89
Halodule pinifolia	5.00	18.44	18.56

Table 5. ANOVA for the carbon sequestrations of *Thallasia hemprichi* and *Cymodocea rotundata.*

	Thallasia hemprichi			*Cymodocea rotundata*		
Factor	**df**	**MS**	***F***	**df**	**MS**	***F***
Between Groups	2	.389	10.785**	2	.164	8.956**
Within Groups	24	.036	-	24	.018	-
Total	26	-	-	26	-	-

**Note=highly significant

The range listed (28.8 to 29.7 °C) is generally within the optimum range for seagrass growth. However, prolonged exposure to extreme temperatures outside of this range can also stress seagrass, ultimately leading to its decline (Table 6). The pH of the water is also a crucial factor that affects seagrass. The pH range of 9.0 to 9.1 is generally considered to be within the normal range for seagrass (Table 6). However, sudden changes in pH can disrupt the balance of chemical reactions within the water and affect the growth and survival of seagrass. Alkalinity is another important parameter that affects seagrass, as it indicates the overall buffering capacity of the water. In this case, the alkalinity is in a moderate range of 3–4 mg/L, which is considered acceptable for seagrass growth (Table 6). Conductivity measures the electrical conductivity of the water, which can affect plant nutrient uptake. In this case, the conductivity is in the range of 12.20 to 12.22 s/m, which is within the acceptable range for most seagrass species. The result of the physicochemical analysis of the seagrass habitat was observed to be within the DENR water quality guidelines and general effluent standards of 2016 (DAO, 2016). Moreover, the availability of light and TSS were known to be critical factors affecting seagrass distribution (Holland et al., 2013). In relation to the availability of light, the depth of the seagrass ecosystem would probably affect the amount of stored carbon (Harahap et al., 2021).

Table 6. Physicochemical parameters of seagrass habitat

Location	Salinity (ppm)	Temperature (°C)	pH	Alkalinity (mg/L)	Conductivity (s/m)
Talagutong	30	28.9	09.0	4	12.22
Kinanga	31	28.8	09.1	3	12.20
Lawa	31	29.7	09.1	4	12.22

CONCLUSION

The following conclusions were derived on the four species of seagrass found in the study area. There were four species found in the study area namely *Thalassia hemprichii, Cymodocea rotundata, Halophila ovalis* and *Halodule pinifolia.* Brgy. Lawa had the highest overall percentage cover of seagrass, followed by Kinanga, while Talagutong obtained the lowest percentage cover. *Thalassia hemprichii* obtained the highest shoot density among the seagrass species.*Thalassia hemprichii* obtained the highest mean of sequestered carbon through roots and leaves followed by *Halophila ovalis*. The utilization of seagrass as essential for carbon sequestration should lead to its conservation and protection in our marine environment. It is highly suggested that seagrass species be included as one of the highly protected species. The protection of seagrass species must be a high priority for the mitigation of climate change.

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