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Reviewer Report

Article for Review: Role of Seagrass bed in Kemujan Island, Karimunjawa Islands, Indonesia as a Carbon Sink Area

Research Network: Climate

Instructions

- Provide a response and score for each of the five sections.
- Kindly use concrete examples when offering criticism and feedback.
- Please do not offer advice or criticism regarding styles or formatting.
- This file contains the manuscript for review. When returning reports, the manuscript must remain attached to verify the report appropriately matches the correct manuscript.
- Each category is scored on a range of 0 to 5 points.

0	1	2	3	4	5
Very Poor	Poor	Below Average	Above Average	Good	Very Good

Scoring Summary

After providing a written response for each the five evaluation criteria, please total your scores below.

EVALUATION CRITERIA	SCORE
1. Empirical Grounding	5 of 5
2. Conceptual Modeling	5 of 5
3. Explanatory Logic	5 of 5
4. Implications and Applications	5 of 5
5. Quality of Communication	5 of 5
TOTAL SCORE	25 of 25

1. Thematic Focus and Empirical Grounding

When considering the Thematic Focus and Empirical Grounding, please use the following prompts to guide your overall response and evaluation.

- Is this a topic that needs addressing?
- Is the area investigated by the article: significant? timely? important? in need of addressing because it has been neglected? intrinsically interesting? filling a gap in current knowledge?
- Are data collection processes, textual analyses, or exegeses of practice sufficient and adequate to answer the research questions?
- Does the article adequately document, acknowledge, and reference the existing findings, research, practices, and literature in its field?
- Does the article relate in a coherent and cogent way with issues of real-world significance?

RESPONSE:

- Journal demonstrated practical research methods that aid in the originality of the study.
- There seems to be good information gathering and collection as presented in the study to produce the desirable results.
- The author relates the study to previous articles near the study area, which gave the reader a comparative understanding of what was studied and what was not.

SCORE:

- (FIVE)

2. Conceptual Model

When considering the Conceptual Model, please use the following prompts to guide your overall response and evaluation.

- Are the main concepts or categories appropriate to the investigation?
- Should other concepts or categories have been considered?
- Are key concepts adequately defined? Are they used consistently?
- Does the article make necessary or appropriate connections with existing theory?
- Does the article develop, apply, and test a coherent and cogent theoretical position or conceptual model?

RESPONSE:

- The objectives stated in the introduction was the author's primary focus.

SCORE:

- (FIVE)

3. Explanatory Logic

When considering the Explanatory Logic, please use the following prompts to guide your overall response and evaluation.

- How effectively does the article reason from its empirical reference points?
- Are the conclusions drawn from the data, texts, sources, or represented objects clear and insightful? Do they effectively advance the themes that the article sets out to address?
- Does the article demonstrate a critical awareness of alternative or competing perspectives, approaches, and paradigms?
- Is the author conscious of his or her own premises and perhaps the limitations of his or her perspectives and knowledge-making processes?

RESPONSE:

- Logic and explanation are appropriate for a climate change journal article.

SCORE:

- (FIVE)

4. Implications and Applications

When considering the Implications and Applications, please use the following prompts to guide your overall response and evaluation.

- Does the article demonstrate the direct or indirect applicability, relevance, or effectiveness of the practice or object it analyzes?
- Are its implications practicable?
- Are its recommendations realistic?
- Does the article make an original contribution to knowledge?
- To what extent does it break new intellectual ground?
- Does it suggest innovative applications?
- What are its prospects for broader applicability or appreciation?
- How might its vision for the world be realized more widely?

RESPONSE:

- The method and result proved real and benfiical to the intent of CO_2 storage mechanism.
- Technical result demonstrated genuinity in the author data acquisition for the study.

SCORE:

- (FIVE)

5. Quality of Communication

When considering the Implications and Applications, please use the following prompts to guide your overall response and evaluation.

- Is the focus of the article clearly stated (for instance, the problem, issue, or object under investigation; the research question; or the theoretical problem)?
- Does the article clearly express its case, measured against the standards of the technical language of its field and the reading capacities of audiences academic, tertiary student, and professional?
- What is the standard of the writing, including spelling and grammar?
- If necessary, please make specific suggestions or annotate errors in the text.

RESPONSE:

- Concise.
- Consistent flow and delivery.

SCORE:

- (FIVE)

RECOMMENDATION:
How is the quality of communication as it relates to English language proficiency?

[√] Publishable as is (Language problems are few to none)

[ ] Minor Proofing Required (Content should be proofread by a colleague or critical friend of the author)

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Role of Seagrass bed in Kemujan Island, Karimunjawa Islands, Indonesia as a Carbon Sink Area

Author Name,[1] University Affiliation, Country
Author Name, University Affiliation, Country

Abstract: Java Sea acts as the carbon source, which contributes to the release of carbon dioxide into the atmosphere. The existence of blue carbon ecosystems in Karimunjawa Islands may absorb and store the carbon. As one of the blue carbon ecosystems, the carbon stock in Kemujan Island, Karimunjawa Islands, has been estimated using a remote sensing approach. In the present study, we investigate the carbon stock at the seagrass bed at Kemujan Island by conducting field observation and laboratory analysis. The result shows that there are only two seagrass species found in the study area, i.e. Enhalus acoroides and Thalassia Hemprichii, which are categorized as nearly dense and very dense, respectively. Regarding the carbon biomass, the carbon stock below substrate is more than above substrate. However, carbon stock in the seagrass biomass is less than in the sediment. The average carbon stock in the seagrass bed at Kemujan Island, Karimunjawa Islands, Indonesia, is 4901.91 g C/m2, which is much more than the amount estimated by means of remote sensing. Furthermore, this amount is also much larger than the other areas in Karimunjawa Islands. The large amount of carbon stock stored in the seagrass bed at Kemujan Island denotes the role of seagrass bed at Kemujan Island as a carbon sink area.

Keywords: Seagrass bed, Carbon stock, Kemujan Island, Karimunjawa Islands

Introduction

The increase of recent global mean surface temperature reached 0.87°C in 2006-2015 relative to the pre-industrial period (1850-1900), which causes climate change (Hoegh-Guldberg et al. 2018). This surface warming is majorly contributed by the increase of carbon dioxide (CO_2) in the atmosphere due to the rapid increase of fossil fuel use, cement manufacture, and land-use change over the last decade (Friedlingstein et al., 2010). Jackson et al. (2018) reported that based on the observations from NOAA-ESRL, the CO_2 concentration in the atmosphere in 2000, 2010, and 2018 was 369.55 ppm; 389.90 ppm; and 409.68 ppm, respectively. Thus, the emissions of anthropogenic CO_2 become the main contributor for the climate change.

On the other hand, oceans play an important role in carbon storage. About one-quarter of the anthropogenic carbon emission is thought to be sequestered in the ocean, annually (Le Quéré et al., 2009). The annual global ocean uptake of anthropogenic CO_2 is estimated at 1.4 to 2.5 Pg C yr-1 (e.g., Takahashi et al., 2002; Takahashi et al., 2009; McKinley et al., 2011), whereas the cumulative uptake since the pre-industrial period is about 120–140 Pg C (Sabine et al., 2004; Khatiwala et al., 2009). However, oceans can act as the source or sink of CO_2 influenced by a number of biological and physical processes such as wind speed, sea surface temperature, salinity, photosynthesis, and respiration rate (Chester, 2000; Botkins and Keller, 2000).

By collecting and conducting the measurements of sea surface pCO_2 from 1984 to 2013 within Indonesian Seas mainly during the summer monsoon, Kartadikaria et al. (2015) showed that Indonesian Seas predominantly act as the carbon source. Focusing on an area in the Java Sea, Wirasatriya et al. (2020) estimated the CO_2 flux by using satellite data. They found that Java Sea

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becomes the CO_2 source reaching a maximum during the summer. Only small areas along the southern Borneo Island during May 2015 and August 2016 become the sink areas of CO_2. Due to the limitation of the spatial resolution of satellite data used by Wirasatriya et al. (2020), Karimunjawa waters were left blank in their analysis. Later on Latifah et al. (2020) conducted field survey and managed to calculated the carbon flux in the Karimunjawa waters during summer monsoon. They found that Karimunjawa waters also act as carbon source. Thus, generally Java Sea acts as a carbon source, which contributes to CO_2 release to the atmosphere.

As an ocean ecosystem entity, coastal ecosystems play an important role in the carbon sequester, which is known as the blue carbon ecosystems. In the tropics, mangrove and seagrass ecosystems are the major blue carbon ecosystem (Siikamäki et al. 2013). Seagrass beds have an important role as a natural carbon sink that can sequester and store large amounts of carbon in a millennium timescale (Duarte et al. 2005; Kennedy et al. 2010; Fourqurean et al. 2012). Furthermore, Fourqurean et al. (2012) stated that seagrass ecosystems can globally store up to 19.8 Pg carbon. This amount is comparable to mangrove ecosystems that can store up to 20 Pg carbon (Donato et al. 2011).

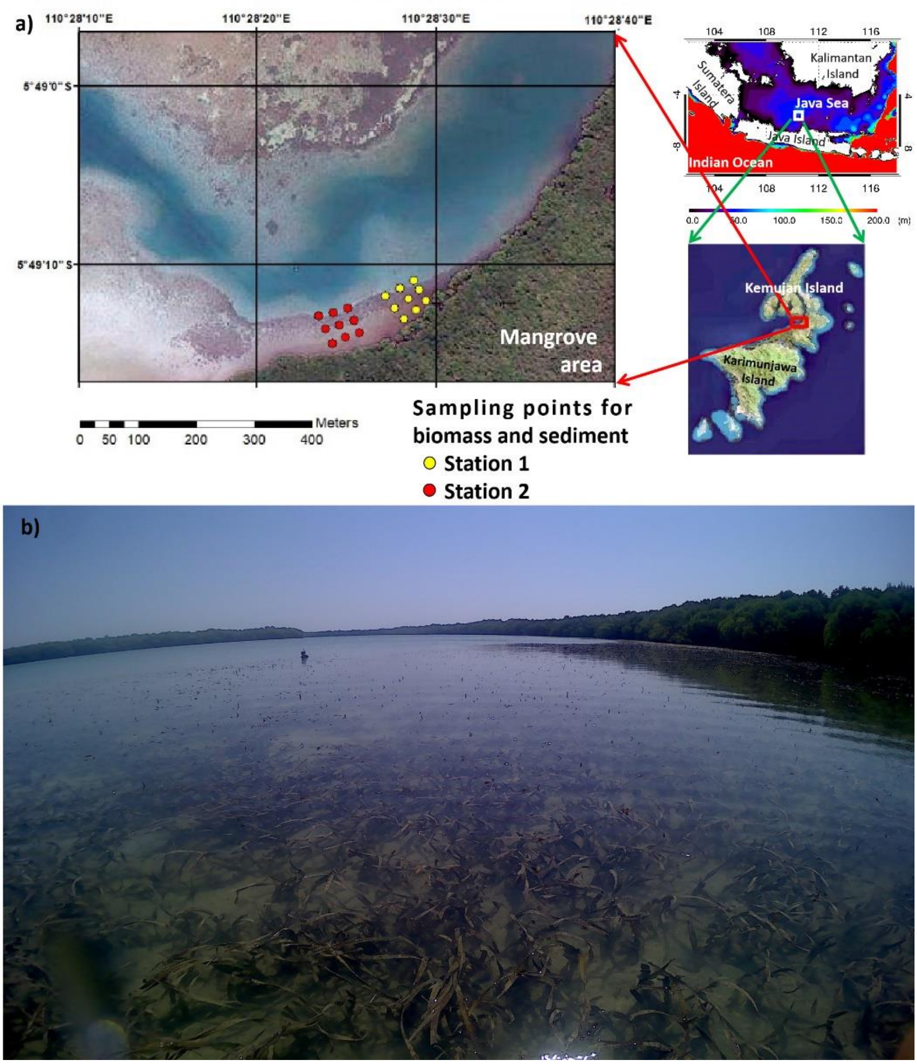

Figure 1: a) Study area in Kemujan Island with the sampling points; b) Seagrass bed condition in the study area

Karimunjawa Islands, located at the center of the Java Sea (Fig. 1a), enclose the complete blue carbon ecosystems, that may balance the role of the Java Sea as the carbon source. In the present study, we investigate the carbon stock of the seagrass ecosystems in Kemujan Island, one of two main islands in Karimunjawa Islands. Fig. 1b shows the high seagrass bed density in the study area. The estimation of the carbon stock in the mangrove ecosystem in Kemujan Island has been conducted by Hartoko et al. (2014) by using a remote sensing approach. They found that about 91.2 tons of carbon are stored in the above ground mangrove biomass. With respect to seagrass ecosystems, Hafizt and Danoedoro (2015) have mapped the distribution of carbon stock in the seagrass bed at the northern to the southern part of Kemujan Island by using a remote sensing approach. They found that the approximate carbon storage is about 6.66 tons of carbon. In the present study, we investigate the carbon stock in the seagrass ecosystems inside the bay at the southern part of Kemujan Island (Fig. 1a), which is missing in the analysis by the Hafizt and Danoedoro (2015) by using field survey and laboratory analysis.

Materials and Methods

Sampling site, design and method

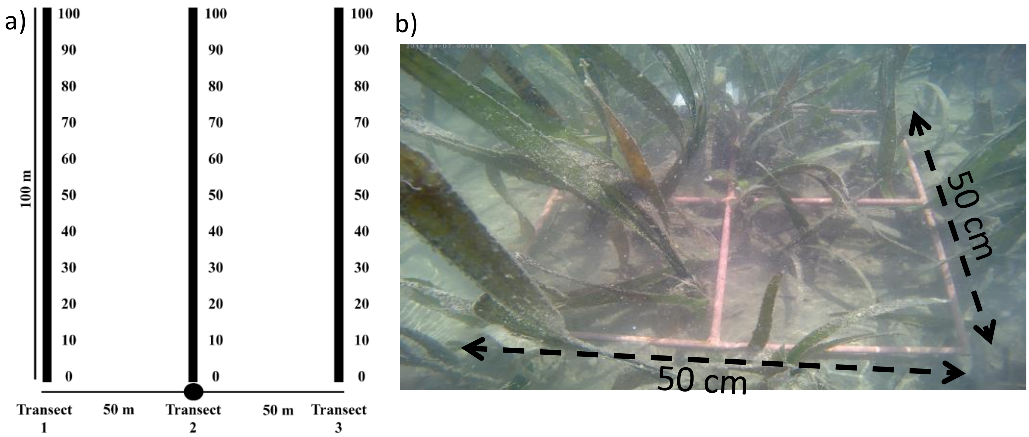

Figure 2: a) Transect design in each station for density and species of seagrass; b) quadrant transect of 50 cm × 50 cm.

The sampling location was selected inside the bay at the southern part of Kemujan Island, where the seagrass bed area is located in front of the mangrove area (Fig. 1a). We divided the area into two stations, which represent the different characteristics of seagrass and sediment. Station 1 is located at 110°28 '23,2 " E - 110° 28 ' 25,7 " E; 5 °49 '12,9 "S - 5 °49 '13,8 " S while station 2 is at 110°28 '28,7 " E - 110° 28 ' 28,2" E; 5 °49 '10,9 " S - 5 °49 '13,1 " S. Each station consists of three line transects. The seagrass species and density sample in each line were taken each at 10 m (Fig. 2a) with 50 cm × 50 cm quadrant transect (Fig. 2b). The seagrass biomass and sediment were taken each at 50 m in each line transect, which makes each line transect consist of three sampling points for biomass and sediment. Thus, total sampling points for biomass and sediment were 18 sampling points for 2 stations (Fig. 1a). Biomass and sediment samples were taken using seagrass core from the surface bed to about 25 cm depth following Rustam et al. (2019). The density of seagrass was calculated following Tuwo (2011).

$$Kji = \frac{Ni}{A} \tag{1}$$

where Kji is the ith seagrass species density (ind/m^2), Ni is the total number of individual species from the ith species (ind), and A is areal size of sampling transect (m^2).

Laboratory analysis

Laboratory analysis was conducted to obtain the carbon stock in seagrass biomass and sediment. To calculate the carbon stock in seagrass biomass, we used the loss on ignition method following Rustam et al. (2019). By using this method we got the percentage of organic matter and percentage of carbon organic (C). Seagrass biomass and carbon weight biomass were calculated using Duarte (1990) formula.

$$B = W \times K \quad (2)$$

$$BC = B \times \%C \quad (3)$$

where B is seagrass biomass (g/m^2), W is dry weight of seagrass (g/ind), K is seagrass density (ind/m^2), C is percentage of carbon organic (%) and BC is carbon biomass of seagrass (g C/m^2).

Carbon in the sediment was analyzed following Kauffman and Donato (2012) by calculating dry bulk density and carbon biomass. We also analyzed the grain size of the sediment by using granulometry method. The classification of the grain size of sediment follows Shepard (1954).

Results

Carbon stock in seagrass biomass

We found only two seagrass species in the study area i.e., *Enhalus acoroides* and *Thalassia hemprichii.* The density of each species is presented in Fig. 3. In station 1 the density of *Thalassia hempricii* (*Enhalus acoroides*) is 341 ind/m^2 (92 ind/m^2), while in station 2 is 372 ind/m^2 (53 ind/m^2). Thus, the density of *Thalassia hemprichii* is higher than *Enhalus acoroides* in both stations. Based on the classification of Braun-Blanquet (1965) the density of *Thalassia hemprichii* (*Enhalus acoroides*) is categorized as very dense (nearly dense).

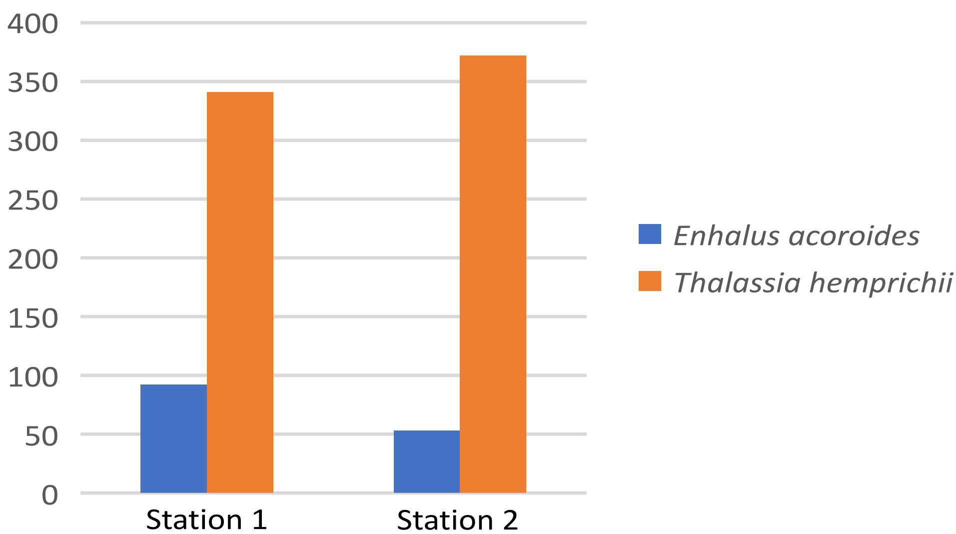

Figure 3: The density of seagrass (ind/m^2) in stations 1 and 2. The position of stations is depicted in Fig. 1a.

We divided the analysis of the biomass of seagrass into biomass above and below substrate. In addition, we also analyzed the seagrass biomass by organ. The results are listed in tables 1, 2, and 3.

Table 1 : Biomass of *Enhalus acoroides* (g/m^2)

Station	*Transect*	*Biomass by organ*			*Biomass by position*		
		Root	*Rhizome*	*Leaf*	*Below substrate*	*Above substrate*	*Total*
1	1	6.26	16.45	9.41	22.71	9.41	32.12
	2	6.14	20.73	6.36	26.87	6.36	33.23
	3	11.55	24.16	9.31	35.71	9.31	45.02
		Total			85.29	25.08	110.37
2	1	2.11	3.73	2.18	5.84	2.18	8.03
	2	2.11	3,73	2.18	5.84	2.18	8.03
	3	1.49	5.09	2.19	6.58	2.19	8.77
		Total			18.27	6.56	24.83

Table 2 : Biomass of *Thalassia hemprichii* (g/m^2)

Station	*Transect*	*Biomass by organ*			*Biomass by position*		
		Root	*Rhizome*	*Leaf*	*Below substrate*	*Above substrate*	*Total*
1	1	10.12	1.64	2.15	11.76	2.15	13.91
	2	0.29	2.34	2.09	2.63	2.09	4.71
	3	0.97	2.95	2.02	3.92	2.02	5.94
		Total			18.30	6.26	24.56
2	1	0.75	0.98	0.53	1.73	0.53	2.26
	2	0.19	0.43	1.25	0.62	1.25	1.87
	3	0.44	0.11	0.47	0.55	0.47	1.02
		Total			2,90	2.25	5.15

Table 3. Total seagrass biomass (g/m^2)

Station	*Total Biomass*		
	Below substrate	*Above substrate*	*Total*
1	103.59	31.34	134.93
2	21.17	8.80	29.97

Root and rhizome are the components of the below substrate biomass. Tables 1 and 2 show that the biomass of below substrate is higher than above substrate for both species and both stations. This result is consistent with Hemminga and Duarte (2000). Furthermore, Erftemeijeret *et al*. (1993) stated that since rhizome stores more organic matter as produced by photosynthesis, rhizome biomass is higher than above substrate biomass. Table 3 summarizes the seagrass biomass at the study area. Seagrass biomass in station 1 is higher than in station 2. Seagrass biomass data was then converted into carbon biomass data as shown in table 4, 5 and 6.

As also derived from seagrass biomass, carbon biomass is higher below substrate than above substrate. Supriadi (2012) stated that the higher carbon stock below substrate is due to the less physical disturbance than above substrate. Furthermore, Kennedy and Bjork (2009) reported that the carbon stock below substrate remained stored, despite the shoot being dead. In contrast, the carbon biomass above substrate is stored if only the shoot is a live.

Table 4 : Carbon stock of *Enhalus acoroides* (g C/m^2)

Station	*Transect*	*Biomass by organ*			*Biomass by position*		
		Root	*Rhizome*	*Leaf*	*Below substrate*	*Above substrate*	*Total*
1	1	190.98	562.03	297.57	753.01	297.57	1050.59
	2	400.10	847.70	304.05	1247.80	304.05	1551.85
	3	223.83	485.41	119.80	709.24	119.80	829.04
		Total			2710,05	721,43	3431,48
2	1	71.49	124.74	71.62	196.23	71.62	267.85
	2	87.88	140.65	77.12	228.54	77.12	305.66
	3	158.55	102.88	88.02	261.43	88.02	349.45
		Total			686.20	236.76	922.95

Table 5 : Carbon stock of *Thalassia hemprichii* (g C/m^2)

Station	*Transect*	*Biomass by organ*			*Biomass by position*		
		Root	*Rhizome*	*Leaf*	*Below substrate*	*Above substrate*	*Total*
1	1	17.41	57.25	69.07	74.65	69.07	143.72
	2	10.38	43.72	63.84	54.11	63.84	117.95
	3	6.10	41.50	55.47	47.60	55.47	103.06
		Total			176.36	188.37	364.73
2	1	23.12	29.97	15.70	53.09	15.70	68.80
	2	23.12	29.97	15.70	53.09	15.70	68.80
	3	25.26	25.24	6.69	50.50	6.69	57.19
		Total			156.68	38.10	194.78

Table 6 : Total carbon biomass (g C /m^2)

Station	*Total carbon biomass*		
	Below substrate	*Above substrate*	*Total*
1	2886.41	909.80	3796.21
2	842.88	274.86	1117.74

The analysis by species shows that *Enhalus acoroides* has higher carbon biomass than *Thalassia hemprichii* since the biomass of *Enhalus acoroides* is higher than *Thalassia hemprichii*. As stated by Graha (2015), the variation of carbon biomass is influenced by biomass differences among species and organ. The increase of carbon stock is parallel with the increase of biomass.

Carbon stock in the sediment

Based on sediment classification, both stations are dominated by sand. However, at station 1 the sand color is darker than station 2 since sands in station 1 contain more silt than sands in station 2. The substrate type in station 1, which is silty sand is more favorable for seagrass growth. This causes the seagrass biomass in station 1 to be higher than station 2. Carbon stock in sediment is listed in Table 7.

Tabel 7 : Carbon stock in sediments (g C/m^2)

Station	*Transect*	*Measurement*	
		Dry Bulk Density (g/ml)	*Carbon in sediment (g C/m^2)*
1	1	6.14	722.87
	2	6.26	910.27
	3	7.42	955.69
Total		19.81	2588.83
2	1	7.85	851.60
	2	7.11	728.90
	3	7.13	720.54
Total		22.09	2301.03

Similar to the carbon biomass, carbon stock in sediment in station 1 is also higher than in station 2. This is caused by the denser seagrass in station 1 than station 2. Madjid (2007) stated that the main organic source of the sediment is derived from the plant organic tissue such as leaf, branch, fruit, root and rhizome. The weathering process of the falling leaves and also the dead organisms associated with seagrass increases the organic content of the sediment. Furthermore, total organic carbon is also higher at the finer grain size than the coarser grain size of the sediment (Dewanti et al. (2016).

Total carbon storage in the seagrass bed

The total carbon storage in the seagrass bed in Kemujan Island is calculated by summing the carbon biomass with carbon in the sediment, as shown in Table 8. Furthermore, to obtain the spatial distribution of total carbon stock, we interpolated nine sampling points in each station as presented in Fig. 4. Station 1 has twice the amount of total carbon stock than station 2. The total carbon stock at stations 1 and 2 are 6385.04 g C/m^2 and 3418.77 g C/m^2, respectively. Thus, the average carbon stock in both areas is 4901.91 g C/m^2, which is much higher than the amount obtained by Hafitz and Danoedoro (2015), who estimated it by remote sensing approach.

The total carbon stock in the study area is also much higher than other areas in Karimunjawa Islands as reported by the previous studies. For example, the total carbon stocks at the seagrass bed in Menjangan Kecil Island and Sintok Island are only 301,80 g C/m^2 and 29,72 g C/m^2, respectively (Hartati et al. 2017), Ganefani et al. (2019) found that the total carbon stock around the harbor area of Karimunjawa Island and Pancuran Beach are only 97,06 g C/m^2 and 127,82 g C/m^2, respectively. The much higher total carbon stock in the study area may correspond to the location of the study area, which is in a semi-enclosed bay. This area is protected from the high wave and strong current, enabling the organic matter to settle and be sequestered by the seagrass ecosystem. In addition, this area is also close to the mangrove area, which may become the source of organic matter transported to the seagrass area.

Table 8 : Total carbon stock (g C/m^2)

Station	*Carbon stock*			
	Below substrate	*Above substrate*	*Sediment*	*Total*
1	2886.41	909.8	2588.83	6385.04
2	842.88	274.86	2301.03	3418.77

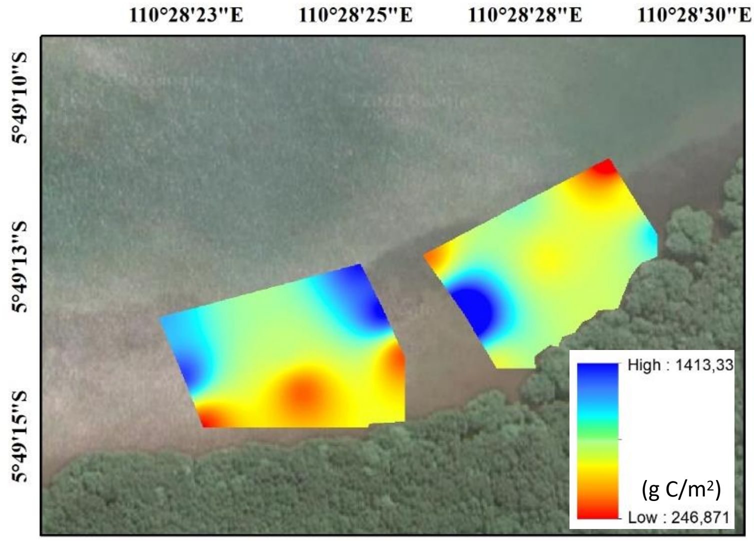

Figure 4 : Spatial distribution of carbon stock in Kemujan Island

Conclusions

The carbon stock at the seagrass beds at Kemujan Island, Karimunjawa Islands, Indonesia, has been investigated using field observation and laboratory analysis. The conclusions are summarized as follows:

1. There are only two seagrass species found in the study area i.e., *Enhalus acoroides* and *Thalassia Hemprichii*. The density of *Enhalus acoroides* (*Thalassia Hemprichii*) is categorized as nearly dense (very dense).
2. Regarding the carbon biomass, the carbon stock below substrate is more than above substrate. However, carbon stock in the seagrass biomass is less than in the sediment.
3. The average carbon stock at seagrass bed at Kemujan Island, Karimunjawa Islands, Indonesia, is 4901.91 g C/m^2. This amount is much more than the amount found in the

other area in Karimunjawa Islands. The ability of the seagrass bed at Kemujan Island to store high carbon stock denotes the importance of the seagrass bed at Kemujan Island as carbon sink area.

Acknowledgement

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COMMON GROUND

Reviewer Report

Article for Review: Role of Seagrass bed in Kemujan Island, Karimunjawa Islands, Indonesia as a Carbon Sink Area

Research Network: Climate

Instructions

- Provide a response and score for each of the five sections.
- Kindly use concrete examples when offering criticism and feedback.
- Please do not offer advice or criticism regarding styles or formatting.
- This file contains the manuscript for review. When returning reports, the manuscript must remain attached to verify the report appropriately matches the correct manuscript.
- Each category is scored on a range of 0 to 5 points.

0	1	2	3	4	5
Very Poor	Poor	Below Average	Above Average	Good	Very Good

Scoring Summary
After providing a written response for each the five evaluation criteria, please total your scores below.

EVALUATION CRITERIA	SCORE
1. Empirical Grounding	_4_ of 5
2. Conceptual Modeling	_4 of 5
3. Explanatory Logic	_4_ of 5
4.Implications and Applications	_3_ of 5
5. Quality of Communication	_4_ of 5
TOTAL SCORE	_19_ of 25

1. Thematic Focus and Empirical Grounding

When considering the Thematic Focus and Empirical Grounding, please use the following prompts to guide your overall response and evaluation.

- Is this a topic that needs addressing? **YES**
- **It is suggested to extend these studies to other Islands regions.**
- Is the area investigated by the article: significant? timely? important? in need of addressing because it has been neglected? intrinsically interesting? filling a gap in current knowledge? **Yes**
- Are data collection processes, textual analyses, or exegeses of practice sufficient and adequate to answer the research questions? **Yes Adequate**
- Does the article adequately document, acknowledge, and reference the existing findings, research, practices, and literature in its field? **Yes**
- Does the article relate in a coherent and cogent way with issues of real-world significance? **Yes to some Extent**

RESPONSE:

In the present study, investigations on the carbon stock at the seagrass bed at Kemujan Island by conducting field observation and laboratory analysis have been done quite systematically. The result shows novelty that there two seagrass species found in the study area, i.e. Enhalus acoroides and Thalassia Hemprichii, which are categorized as nearly dense and very dense, respectively.

SCORE:

- (SCORE OF ZERO TO FIVE) **4**

2. Conceptual Model

When considering the Conceptual Model, please use the following prompts to guide your overall response and evaluation.

- Are the main concepts or categories appropriate to the investigation? **YES**
- Should other concepts or categories have been considered? **To some extent**
- Are key concepts adequately defined? Are they used consistently? **Yes**
- Does the article make necessary or appropriate connections with existing theory? **To some extent**
- Does the article develop, apply, and test a coherent and cogent theoretical position or conceptual model? **Yes**

RESPONSE:

The main concepts e.g. the surface warming is majorly contributed by the increase of carbon dioxide (CO_2) in the atmosphere due to the rapid increase of fossil fuel use, and , the emissions of anthropogenic CO_2 become the main contributor for the climate change are appropriate to the investigation

SCORE:

- (SCORE OF ZERO TO FIVE) : **4**
-

3. Explanatory Logic

When considering the Explanatory Logic, please use the following prompts to guide your overall response and evaluation.

- How effectively does the article reason from its empirical reference points? **Quite Effectively**
- Are the conclusions drawn from the data, texts, sources, or represented objects clear and insightful? Do they effectively advance the themes that the article sets out to address? **YES**
- Does the article demonstrate a critical awareness of alternative or competing perspectives, approaches, and paradigms? **YES**
- Is the author conscious of his or her own premises and perhaps the limitations of his or her perspectives and knowledge-making processes? **YES**

RESPONSE:

The findings regarding the carbon biomass, the carbon stock below substrate is more than above substrate, and carbon stock in the seagrass biomass is less than in the sediment are very useful for future research in developing the Carbon-sinks.

SCORE:

- (SCORE OF ZERO TO FIVE): 4

4. Implications and Applications

When considering the Implications and Applications, please use the following prompts to guide your overall response and evaluation.

- Does the article demonstrate the direct or indirect applicability, relevance, or effectiveness of the practice or object it analyzes? **Yes**
- Are its implications practicable? **To some extent**
- Are its recommendations realistic? **To some extent**
- Does the article make an original contribution to knowledge? **To some extent**
- To what extent does it break new intellectual ground**? Not much**
- Does it suggest innovative applications? **Not exactly but to some extent**
- What are its prospects for broader applicability or appreciation? **Results are appreciable but, needs more observations over other Islands .**
- How might its vision for the world be realized more widely?

RESPONSE:

As regards, prospects for broader applicability or appreciation is concerned, I think its Results are appreciable but, needs more observations over other Islands and it's correlation with Seagrass bed in Kemujan Island, Karimunjawa Islands, Indonesia and other Islands as a Carbon Sink Area

SCORE:

- (SCORE OF ZERO TO FIVE) **3**

5. Quality of Communication

When considering the Implications and Applications, please use the following prompts to guide your overall response and evaluation.

- Is the focus of the article clearly stated (for instance, the problem, issue, or object under investigation; the research question; or the theoretical problem)? **GOOD**
- Does the article clearly express its case, measured against the standards of the technical language of its field and the reading capacities of audiences academic, tertiary student, and professional? **YES**
- What is the standard of the writing, including spelling and grammar? **OK**
- If necessary, please make specific suggestions or annotate errors in the text. **NO Errors. Well written**

RESPONSE:

The research Methodology adopted is quite appropriate e.g. Carbon in the sediment was analyzed following Kauffman and Donato (2012) by calculating dry bulk density and carbon biomass. We also analyzed the grain size of the sediment by using granulometry method.

SCORE:

- (SCORE OF ZERO TO FIVE): **4**

RECOMMENDATION:

How is the quality of communication as it relates to English language proficiency?

X] Publishable as is (Language problems are few to none)

[ ] Minor Proofing Required (Content should be proofread by a colleague or critical friend of the author)

[ ] Professional Editing Required (English language errors are significant and detract from the overall quality of the article)

Our publishing model is intended to ensure that authors speaking English as a second language are given the equal opportunity to receive feedback from a peer-review process to critique and improve the conceptual material of their article. Some articles can be well researched and formulated but may require assistance with certain nuances of the English language.

Role of Seagrass bed in Kemujan Island, Karimunjawa Islands, Indonesia as a Carbon Sink Area

Author Name,[1] University Affiliation, Country

Author Name, University Affiliation, Country

Abstract: Java Sea acts as the carbon source, which contributes to the release of carbon dioxide into the atmosphere. The existence of blue carbon ecosystems in Karimunjawa Islands may absorb and store the carbon. As one of the blue carbon ecosystems, the carbon stock in Kemujan Island, Karimunjawa Islands, has been estimated using a remote sensing approach. **In the present study, we investigate the carbon stock at the seagrass bed at Kemujan Island by conducting field observation and laboratory analysis**. *The result shows that there are only two seagrass species found in the study area, i.e. Enhalus acoroides and Thalassia Hemprichii, which are categorized as nearly dense and very dense, respectively.* **Regarding the carbon biomass, the carbon stock below substrate is more than above substrate. However, carbon stock in the seagrass biomass is less than in the sediment.** ***The average carbon stock in the seagrass bed at Kemujan Island, Karimunjawa Islands, Indonesia, is 4901.91 g C/m2, which is much more than the amount estimated by means of remote sensing.*** *Furthermore, this amount is also much larger than the other areas in Karimunjawa Islands.* ***The large amount of carbon stock stored in the seagrass bed at Kemujan Island denotes the role of seagrass bed at Kemujan Island as a carbon sink area.***

Keywords: Seagrass bed, Carbon stock, Kemujan Island, Karimunjawa Islands

Introduction

The increase of recent global mean surface temperature reached 0.87°C in 2006-2015 relative to the pre-industrial period (1850-1900), which causes climate change (Hoegh-Guldberg et al. 2018). **This surface warming is majorly contributed by the increase of carbon dioxide (CO_2)**

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in the atmosphere due to the rapid increase of fossil fuel use, cement manufacture, and land-use change over the last decade (Friedlingstein et al., 2010). Jackson et al. (2018) reported that based on the observations from NOAA-ESRL, the CO_2 concentration in the atmosphere in 2000, 2010, and 2018 was 369.55 ppm; 389.90 ppm; and 409.68 ppm, respectively. **Thus, the emissions of anthropogenic CO_2 become the main contributor for the climate change.**

On the other hand, oceans play an important role in carbon storage. About one-quarter of the anthropogenic carbon emission is thought to be sequestered in the ocean, annually (Le Quéré et al., 2009). The annual global ocean uptake of anthropogenic CO_2 is estimated at 1.4 to 2.5 Pg C yr-1 (e.g., Takahashi et al., 2002; Takahashi et al., 2009; McKinley et al., 2011), whereas the cumulative uptake since the pre-industrial period is about 120–140 Pg C (Sabine et al., 2004; Khatiwala et al., 2009). **However, oceans can act as the source or sink of CO_2 influenced by a number of biological and physical processes such as wind speed, sea surface temperature, salinity, photosynthesis, and respiration rate (C**hester, 2000; Botkins and Keller, 2000).

By collecting and conducting the measurements of sea surface pCO_2 from 1984 to 2013 within Indonesian Seas mainly during the summer monsoon, Kartadikaria et al. (2015) showed that Indonesian Seas predominantly act as the carbon source. Focusing on an area in the Java Sea, Wirasatriya et al. (2020) estimated the CO_2 flux by using satellite data. They found that Java Sea becomes the CO_2 source reaching a maximum during the summer. Only small areas along the southern Borneo Island during May 2015 and August 2016 become the sink areas of CO_2. Due to the limitation of the spatial resolution of satellite data used by Wirasatriya et al. (2020), Karimunjawa waters were left blank in their analysis. Later on Latifah et al. (2020) conducted field survey and managed to calculated the carbon flux in the Karimunjawa waters during summer monsoon. They found that Karimunjawa waters also act as carbon source. Thus, generally Java Sea acts as a carbon source, which contributes to CO_2 release to the atmosphere.

As an ocean ecosystem entity, coastal ecosystems play an important role in the carbon sequester, which is known as the blue carbon ecosystems. In the tropics, mangrove and seagrass ecosystems are the major blue carbon ecosystem (Siikamäki et al. 2013). Seagrass beds have an important role as a natural carbon sink that can sequester and store large amounts of carbon in a millennium timescale (Duarte et al. 2005; Kennedy et al. 2010; Fourqurean et al. 2012). Furthermore, Fourqurean et al. (2012) stated that seagrass ecosystems can globally store up to 19.8 Pg carbon. This amount is comparable to mangrove ecosystems that can store up to 20 Pg carbon (Donato et al. 2011).

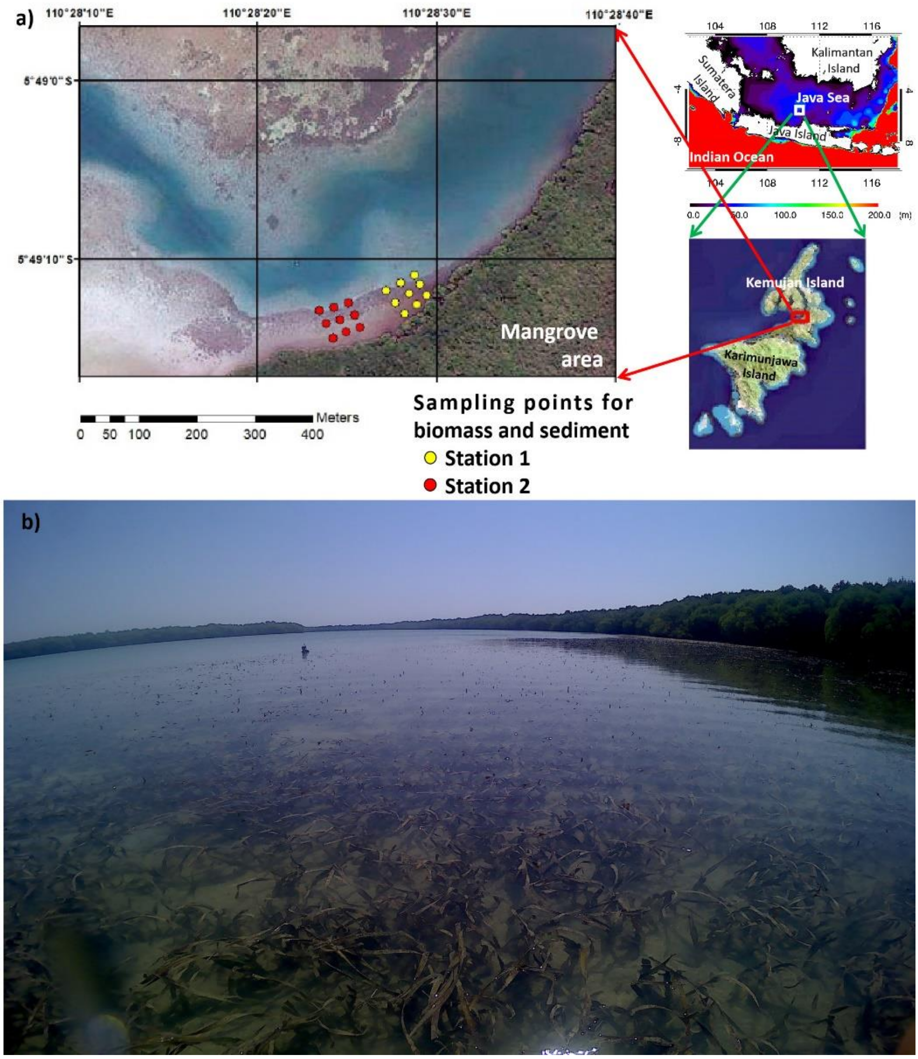

Figure 1: a) Study area in Kemujan Island with the sampling points; b) Seagrass bed condition in the study area

Karimunjawa Islands, located at the center of the Java Sea (Fig. 1a), enclose the complete blue carbon ecosystems, that may balance the role of the Java Sea as the carbon source. In the present study, we investigate the carbon stock of the seagrass ecosystems in Kemujan Island, one of two main islands in Karimunjawa Islands. Fig. 1b shows the high seagrass bed density in the study area. The estimation of the carbon stock in the mangrove ecosystem in Kemujan Island has been conducted by Hartoko et al. (2014) by using a remote sensing approach. They found that about 91.2 tons of carbon are stored in the above ground mangrove biomass. With respect to seagrass ecosystems, Hafizt and Danoedoro (2015) have mapped the distribution of carbon stock in the seagrass bed at the northern to the southern part of Kemujan Island by using a remote sensing approach. They found that the approximate carbon storage is about 6.66 tons of carbon. In the present study, we investigate the carbon stock in the seagrass ecosystems inside the bay at the southern part of Kemujan Island (Fig. 1a), which is missing in the analysis by the Hafizt and Danoedoro (2015) by using field survey and laboratory analysis.

Materials and Methods

Sampling site, design and method

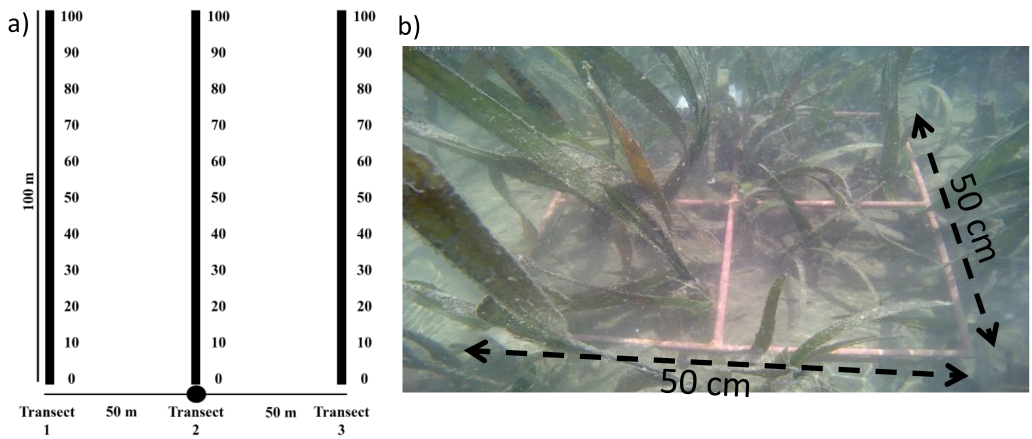

Figure 2: a) Transect design in each station for density and species of seagrass; b) quadrant transect of 50 cm × 50 cm.

The sampling location was selected inside the bay at the southern part of Kemujan Island, where the seagrass bed area is located in front of the mangrove area (Fig. 1a). We divided the area into two stations, which represent the different characteristics of seagrass and sediment. Station 1 is located at 110°28 '23,2 " E - 110° 28 ' 25,7 " E; 5 °49 '12,9 "S - 5 °49 '13,8 " S while station 2 is at 110°28 '28,7 " E - 110° 28 ' 28,2" E; 5 °49 '10,9 " S - 5 °49 '13,1 " S. Each station consists of three line transects. The seagrass species and density sample in each line were taken each at 10 m (Fig. 2a) with 50 cm × 50 cm quadrant transect (Fig. 2b). The seagrass biomass and sediment were taken each at 50 m in each line transect, which makes each line transect consist of three sampling points for biomass and sediment. Thus, total sampling points for biomass and sediment were 18 sampling points for 2 stations (Fig. 1a). Biomass and sediment samples were taken using seagrass core from the surface bed to about 25 cm depth following Rustam et al. (2019). The density of seagrass was calculated following Tuwo (2011).

$$\boldsymbol{Kji} = \frac{\boldsymbol{Ni}}{\boldsymbol{A}} \quad (1)$$

where Kji is the i^{th} seagrass species density (ind/m^2), Ni is the total number of individual species from the i^{th} species (ind), and A is areal size of sampling transect (m^2).

Laboratory analysis

Laboratory analysis was conducted to obtain the carbon stock in seagrass biomass and sediment. To calculate the carbon stock in seagrass biomass, we used the loss on ignition method following Rustam et al. (2019). By using this method we got the percentage of organic matter and percentage of carbon organic (C). Seagrass biomass and carbon weight biomass were calculated using Duarte (1990) formula.

$$B = W \times K \quad (2)$$

$$BC = B \times \%C \quad (3)$$

where B is seagrass biomass (g/m^2), W is dry weight of seagrass (g/ind), K is seagrass density (ind/m^2), C is percentage of carbon organic (%) and BC is carbon biomass of seagrass ($g\ C/m^2$).

Carbon in the sediment was analyzed following Kauffman and Donato (2012) by calculating dry bulk density and carbon biomass. We also analyzed the grain size of the sediment by using granulometry method. The classification of the grain size of sediment follows Shepard (1954).

Results

Carbon stock in seagrass biomass

We found only two seagrass species in the study area i.e., Enhalus acoroides and Thalassia hemprichii. The density of each species is presented in Fig. 3. In station 1 the density of *Thalassia hempricii* (*Enhalus acoroides*) is 341 ind/m^2 (92 ind/m^2), while in station 2 is 372 ind/m^2 (53 ind/m^2). Thus, the density of *Thalassia hemprichii* is higher than *Enhalus acoroides* in both stations. Based on the classification of Braun-Blanquet (1965) the density of *Thalassia hemprichii* (*Enhalus acoroides*) is categorized as very dense (nearly dense).

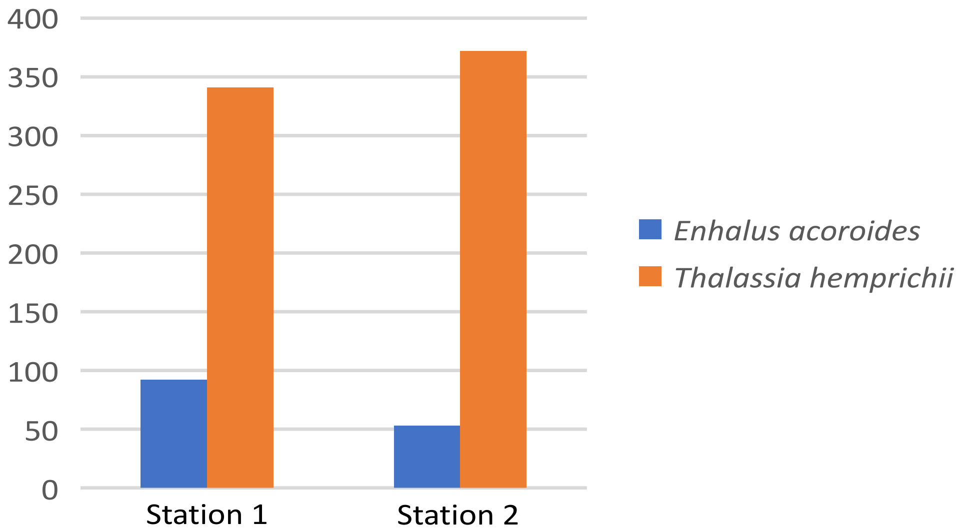

Figure 3: The density of seagrass (ind/m^2) in stations 1 and 2. The position of stations is depicted in Fig. 1a.

We divided the analysis of the biomass of seagrass into biomass above and below substrate. In addition, we also analyzed the seagrass biomass by organ. The results are listed in tables 1, 2, and 3.

Table 1 : Biomass of *Enhalus acoroides* (g/m^2)

Station	*Transect*	*Biomass by organ*			*Biomass by position*		
		Root	Rhizome	Leaf	*Below substrate*	*Above substrate*	*Total*
1	1	6.26	16.45	9.41	22.71	9.41	32.12
	2	6.14	20.73	6.36	26.87	6.36	33.23
	3	11.55	24.16	9.31	35.71	9.31	45.02
Total					85.29	25.08	110.37
2	1	2.11	3.73	2.18	5.84	2.18	8.03
	2	2.11	3,73	2.18	5.84	2.18	8.03
	3	1.49	5.09	2.19	6.58	2.19	8.77
Total					18.27	6.56	24.83

Table 2 : Biomass of *Thalassia hemprichii* (g/m^2)

Station	*Transect*	*Biomass by organ*			*Biomass by position*		
		Root	*Rhizome*	*Leaf*	*Below substrate*	*Above substrate*	*Total*
1	1	10.12	1.64	2.15	11.76	2.15	13.91
	2	0.29	2.34	2.09	2.63	2.09	4.71
	3	0.97	2.95	2.02	3.92	2.02	5.94
		Total			18.30	6.26	24.56
2	1	0.75	0.98	0.53	1.73	0.53	2.26
	2	0.19	0.43	1.25	0.62	1.25	1.87
	3	0.44	0.11	0.47	0.55	0.47	1.02
		Total			2,90	2.25	5.15

Table 3. Total seagrass biomass (g/m^2)

Station	*Total Biomass*		
	Below substrate	*Above substrate*	*Total*
1	103.59	31.34	134.93
2	21.17	8.80	29.97

Root and rhizome are the components of the below substrate biomass. Tables 1 and 2 show that the biomass of below substrate is higher than above substrate for both species and both stations. This result is consistent with Hemminga and Duarte (2000). Furthermore, Erftemeijeret *et al*. (1993) stated that since rhizome stores more organic matter as produced by photosynthesis, rhizome biomass is higher than above substrate biomass. Table 3 summarizes the seagrass biomass at the study area. Seagrass biomass in station 1 is higher than in station 2. Seagrass biomass data was then converted into carbon biomass data as shown in table 4, 5 and 6.

As also derived from seagrass biomass, carbon biomass is higher below substrate than above substrate. Supriadi (2012) stated that the higher carbon stock below substrate is due to the less physical disturbance than above substrate. Furthermore, Kennedy and Bjork (2009) reported that the carbon stock below substrate remained stored, despite the shoot being dead. In contrast, the carbon biomass above substrate is stored if only the shoot is a live.

Table 4 : Carbon stock of *Enhalus acoroides* (g C/m^2)

Station	*Transect*	*Biomass by organ*			*Biomass by position*		
		Root	*Rhizome*	*Leaf*	*Below substrate*	*Above substrate*	*Total*
1	1	190.98	562.03	297.57	753.01	297.57	1050.59
	2	400.10	847.70	304.05	1247.80	304.05	1551.85
	3	223.83	485.41	119.80	709.24	119.80	829.04
		Total			2710,05	721,43	3431,48
2	1	71.49	124.74	71.62	196.23	71.62	267.85
	2	87.88	140.65	77.12	228.54	77.12	305.66
	3	158.55	102.88	88.02	261.43	88.02	349.45
		Total			686.20	236.76	922.95

Table 5 : Carbon stock of *Thalassia hemprichii* (g C/m^2)

Station	*Transect*	*Biomass by organ*			*Biomass by position*		
		Root	*Rhizome*	*Leaf*	*Below substrate*	*Above substrate*	*Total*
1	1	17.41	57.25	69.07	74.65	69.07	143.72
	2	10.38	43.72	63.84	54.11	63.84	117.95
	3	6.10	41.50	55.47	47.60	55.47	103.06
		Total			176.36	188.37	364.73
2	1	23.12	29.97	15.70	53.09	15.70	68.80
	2	23.12	29.97	15.70	53.09	15.70	68.80
	3	25.26	25.24	6.69	50.50	6.69	57.19
		Total			156.68	38.10	194.78

Table 6 : Total carbon biomass (g C /m^2)

Station	*Total carbon biomass*		
	Below substrate	*Above substrate*	*Total*
1	2886.41	909.80	3796.21
2	842.88	274.86	1117.74

The analysis by species shows that *Enhalus acoroides* has higher carbon biomass than *Thalassia hemprichii* since the biomass of *Enhalus acoroides* is higher than *Thalassia hemprichii*. As stated by Graha (2015), the variation of carbon biomass is influenced by biomass differences among species and organ. The increase of carbon stock is parallel with the increase of biomass.

Carbon stock in the sediment

Based on sediment classification, both stations are dominated by sand. However, at station 1 the sand color is darker than station 2 since sands in station 1 contain more silt than sands in station 2. The substrate type in station 1, which is silty sand is more favorable for seagrass growth. This causes the seagrass biomass in station 1 to be higher than station 2. Carbon stock in sediment is listed in Table 7.

Tabel 7 : Carbon stock in sediments (g C/m^2)

Station	*Transect*	*Measurement*	
		Dry Bulk Density (g/ml)	*Carbon in sediment (g C/m^2)*
1	1	6.14	722.87
	2	6.26	910.27
	3	7.42	955.69
Total		19.81	2588.83
2	1	7.85	851.60
	2	7.11	728.90
	3	7.13	720.54
Total		22.09	2301.03

Similar to the carbon biomass, carbon stock in sediment in station 1 is also higher than in station 2. This is caused by the denser seagrass in station 1 than station 2. Madjid (2007) stated that the main organic source of the sediment is derived from the plant organic tissue such as leaf, branch, fruit, root and rhizome. The weathering process of the falling leaves and also the dead organisms associated with seagrass increases the organic content of the sediment. Furthermore, total organic carbon is also higher at the finer grain size than the coarser grain size of the sediment (Dewanti et al. (2016).

Total carbon storage in the seagrass bed

The total carbon storage in the seagrass bed in Kemujan Island is calculated by summing the carbon biomass with carbon in the sediment, as shown in Table 8. Furthermore, to obtain the spatial distribution of total carbon stock, we interpolated nine sampling points in each station as presented in Fig. 4. Station 1 has twice the amount of total carbon stock than station 2. The total carbon stock at stations 1 and 2 are 6385.04 g C/m^2 and 3418.77 g C/m^2, respectively. Thus, the average carbon stock in both areas is 4901.91 g C/m^2, which is much higher than the amount obtained by Hafitz and Danoedoro (2015), who estimated it by remote sensing approach.

The total carbon stock in the study area is also much higher than other areas in Karimunjawa Islands as reported by the previous studies. For example, the total carbon stocks at the seagrass bed in Menjangan Kecil Island and Sintok Island are only 301,80 g C/m^2 and 29,72 g C/m^2, respectively (Hartati et al. 2017), Ganefani et al. (2019) found that the total carbon stock around the harbor area of Karimunjawa Island and Pancuran Beach are only 97,06 g C/m^2 and 127,82 g C/m^2, respectively. The much higher total carbon stock in the study area may correspond to the location of the study area, which is in a semi-enclosed bay. This area is protected from the high wave and strong current, enabling the organic matter to settle and be sequestered by the seagrass ecosystem. In addition, this area is also close to the mangrove area, which may become the source of organic matter transported to the seagrass area.

Table 8 : Total carbon stock (g C/m^2)

Station	*Carbon stock*			
	Below substrate	*Above substrate*	*Sediment*	*Total*
1	2886.41	909.8	2588.83	6385.04
2	842.88	274.86	2301.03	3418.77

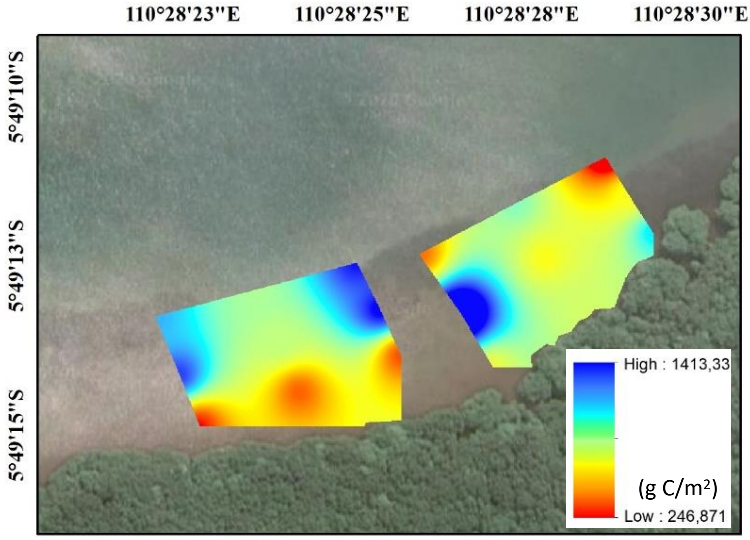

Figure 4 : Spatial distribution of carbon stock in Kemujan Island

Conclusions

The carbon stock at the seagrass beds at Kemujan Island, Karimunjawa Islands, Indonesia, has been investigated using field observation and laboratory analysis. The conclusions are summarized as follows:

1. There are only two seagrass species found in the study area i.e., *Enhalus acoroides* and *Thalassia Hemprichii*. The density of *Enhalus acoroides* (*Thalassia Hemprichii*) is categorized as nearly dense (very dense).
2. Regarding the carbon biomass, the carbon stock below substrate is more than above substrate. However, carbon stock in the seagrass biomass is less than in the sediment.
3. The average carbon stock at seagrass bed at Kemujan Island, Karimunjawa Islands, Indonesia, is 4901.91 g C/m^2. This amount is much more than the amount found in the other area in Karimunjawa Islands. The ability of the seagrass bed at Kemujan Island to store high carbon stock denotes the importance of the seagrass bed at Kemujan Island as carbon sink area.

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