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Relationship Between Tree Diameter and Mangrove Vegetation Carbon Stock in Apar Village, Pariaman City, West Sumatra

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ABSTRACT

This research was conducted in January 2024 in the Mangrove Area of Apar Village, Pariaman City, West Sumatra Province. This research aims to determine mangroves' density and carbon stock conditions and the relationship between the diameter of mangrove trees of the *Rhizophora mucronata, Sonneratia caseolaris,* and *S.alba* types with mangrove carbon stock. The method used in this research is a survey method with direct observation and data collection at the research location. Non-destructive sampling measured the diameter of mangrove trees' breast height in each plot. The average density of mangrove stands at the three research stations was 1,222.22 tons/ha, the average amount of mangrove biomass was 688.49 tons/ha, the average amount of mangrove carbon stock was 323.59 tonnes/ha, and the average mangrove CO_2 uptake is 1,186.51 tons/ha.

Keywords: Biomass, Carbon Stock, Carbon Uptake, Mangrove, Tree Diameter

1. INTRODUCTION

Global warming is a trending topic widely discussed by the world community. The increase in CO_2 in the air has created global warming, which can be directly felt by everyone worldwide. One way to control climate change is to reduce greenhouse gas emissions by maintaining the integrity of natural forests and increasing the population density of trees outside the forest. Forests will become a source of greenhouse gas emissions if not appropriately managed.

Business as Usual (BAU) determines that Indonesia can reduce carbon emissions by 26%. However, this will not be achieved if the Indonesian Government does not immediately develop a strategy and calculate carbon emissions at the national and local levels accurately and correctly. In Indonesia, the availability of carbon stock data in forests and tree-based agricultural lands is still very limited. Plants reduce emissions such as CO_2 by absorbing it in photosynthesis and converting it into organic carbon compounds. One of the ecosystems that absorbs greenhouse gas emissions is mangrove forests.

The mangrove ecosystem is an absorber of CO_2 from the air. Mangrove forests store more carbon than most tropical rainforests. Mangrove forests are forest ecosystems that function as the highest carbon storage in tropical areas and help reduce CO_2 levels in the air (Hartoko in Lestari et al., 2020). Currently, mangroves are experiencing pressures such as deforestation and changes in land use. This will cause considerable damage to mangrove forests, affecting the amount of carbon mangroves absorb.

The ability of mangroves to store carbon is more significant than all land forests in general. One hectare of mangrove forest can store up to five times more carbon than tropical rainforests worldwide (Fitrah, 2019). Besides being influenced by tree density, the biomass value is also influenced by the tree's diameter itself because the more significant the tree's diameter, the greater the biomass value (Mandari et al., 2016).

To estimate or estimate stored carbon stocks and the effect of tree diameter on mangrove biomass is considered necessary because knowing the amount of carbon that can be absorbed by mangroves and the impact of tree diameter on mangrove biomass, considering that there is still a lack of data and references regarding existing carbon stocks in a mangrove ecosystem. This research aims to determine the carbon stock and the relationship between tree diameter and biomass, carbon stock and CO_2 uptake stored in Apar Village, Pariaman City, West Sumatra Province.

2. RESEARCH METHOD

Time and Place

This research was carried out in January 2024 in the mangrove area of Apar Village, Pariaman City, West Sumatra Province (Figure 1).

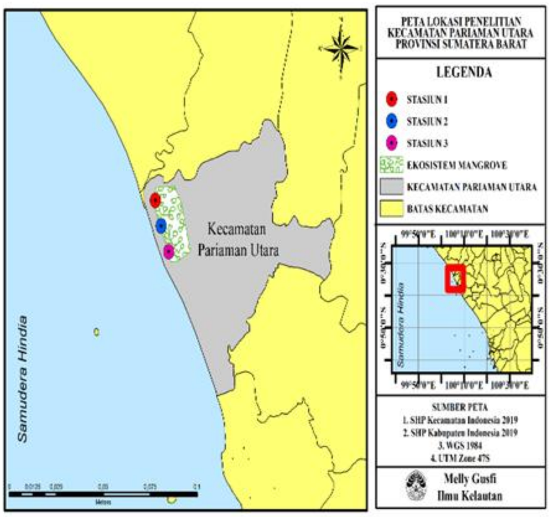

Figure 1. Research location

Method

This research was conducted using a survey, where observations and data collection were carried out directly at the research location. Data obtained from the research location is then processed for analysis. Determining the research station was carried out using a purposive sampling method, namely determining the location deliberately by considering and paying attention to the conditions of the research area. The division of stations in this research is that Station I is close to community settlements, Station II is close to the mouth of the Batang Apar River, and Station III is close to the mangrove tourism bridge in Apar Village.

Sampling used the quadrant transect plot method. At each station, three transect lines were drawn from the sea towards the land for a length of ± 100 m. Each transect line has three plots or quadrant plots of 10 x 10 m^2 for the tree category (Heriyanto & Amin, 2013).

Procedures

Mangrove Stand Density

Density gives an idea of the number of individuals in the plot (Bengen, 2000). The density value can be calculated in the following way:

$$K = \frac{ni}{A}$$

Information:
K = density of a species (ind/m^2)
ni = number of individuals
A = Area of the entire plot (m^2)

Mangrove Biomass

Mangrove biomass data collection was done non-destructively by measuring trees' DBH (Diameter at Breast Height) based on the BSN (2011). The allometric equations referred to by Komiyama et al. (2005) (Table 1).

Table 1. Calculation of the number of mangroves using the allometric equation

Species Name	Above Ground Biomass (AGB)	Below Ground Biomass (BGB)
S.alba	W_{top} = 0,251p $DBH^{2,46}$ (Komiyama et al., 2005)	W_R = 0,199$p^{0,899}$ $DBH^{2,22}$ (Komiyama et al., 2005)
R.mucronata	W_{top} = 0,1466 $DBH^{2,3136}$ (Dharmawan *in* Komiyama et al., 2005)	W_{top} = 0,199 $DBH^{0,899}$ (Dharmawan *in* Komiyama et al., 2005)
S.caseolaris	W_{top} = 0,251 p $DBH^{2,46}$ (Komiyama et al., 2005)	W_{top} = 0,199 $p^{0.90}$ $DBH^{2,22}$ (Komiyama et al., 2005)

Information:

Wtop	:	Top biomass (kg)
WR	:	Bottom biomass (kg)
DBH	:	Tree diameter measured at breast height
p	:	wood density (g/cm^3)

Mangrove Carbon Stock

Mangrove carbon calculations use a formula that refers to the BSN (2011), namely:

$$Cb = B \times \%\ C\ Organic$$

Information:

Cb	:	Mangrove carbon stock (kg)
B	:	Total biomass (kg)
%Organic	:	The percentage value of carbon content is 0,47

CO_2 Uptake

Calculation of CO_2 uptake can use the formula referring to Bismark et al. (2008), namely:

$$S\ CO_2 = \frac{Mr.CO2}{Ar\ C} \times Kc$$

Information:

SCO_2 : Absorption of carbon dioxide gas
Mr CO_2 : The relative molecular weight of the C atom, which is 44
Kc : Carbon content (kg)
Ar. C : Relative atom C, namely 12

Data Analysis

Data analysis used in this research is the ANOVA test and Linear Regression Test. The ANOVA test was used to compare biomass, carbon stock and CO_2 uptake between stations. Linear regression test is used to determine the level of relationship between mangrove tree diameter and other variables (carbon stock). This regression relationship was only carried out for the mangrove species that dominate the study area, namely the types *R.mucronata, S. caseolaris,* and *S.alba* (Tanjung, 2014).

Table 2. Guidelines for providing interpretation of correlation coefficient (r)

Interval	Level of relationship
0,00 – 0,25	Weak
0,26 – 0,50	Currently
0,51 – 0,75	Strong
0,76 – 1,00	Very Strong

3. RESULT AND DISCUSSION

Water Quality

Water quality parameters are essential for every organism to carry out life processes, including mangrove forest areas influenced by land and sea. The results of water quality measurements can be seen in Table 3.

Table 3. Water quality parameter measurement

Parameter	Unit	Station			Avarage Value
		I	II	III	
Temperature	°C	30	32	31	31
pH	-	7	7	7	7
Salinity	‰	15	10	14	13

The results of measuring water quality parameters in the mangrove ecosystem in Apar Village have different temperatures at each station. The temperature ranges between 30-32°C and has an average of 31°C. Based on (MENKLH, 2004), the water temperature at each research location is still classified as suitable for mangrove growth. The salinity at the research location ranges from 10-15‰; the research location is the mangrove area of Apar Village in the estuary area. The degree of acidity (pH) at the research location has the same value, namely 7. Referring to MENKLH (2004), the pH range good for growing mangroves is between 7 - 8.5. With this in mind, the pH conditions for all stations are still suitable for mangrove growth.

Mangrove Stand Density

Based on the research results, four types of mangroves were obtained at the three research stations, namely R. *mucronata, S. alba, S. caseolaris, and R. apiculata*. From the results of research that has been carried out, the stand density of mangrove forests in the Apar Village area can be seen in Table 4.

Table 4. Mangrove density categories in Apar Village

Station	Density (Ind/ha)	Criteria	Condition
I	1.455.56	Good	Congested
II	1.066.67	Good	Congested
III	1.144.44	Good	Congested

Based on Table 4, it can be seen that Station I has the highest density of mangrove stands, namely 1,455.56 ind/ha, while the density found at Station II and Station III, namely 1,066.67 ind/ha and 1,144.44 ind/ha. The density of mangrove stands at Station I is higher than at Stations II and III due to the different characteristics of the three research station areas; where Station I is close to community settlements, so forest use in this area is relatively minimal. Meanwhile, Station II is a mangrove forest near the Batang Apar River Estuary. The estuary currents in this area are strong, so many seedlings fall and are washed away, which also causes the seedlings not to grow well. Station III is close to the tourist bridge, so the mangrove trees in this area were cut down to build a ±50m long tourist bridge; this resulted in the density of Station 3 being lower than that of Station I.

The results of the ANOVA test analysis showed that the density of mangrove stands between stations was not significantly different ($p = 0.675$ or $p \geq 0.05$). Based on the standard criteria for mangrove density quality set by the Ministry of Environment (2004), namely very dense density ≥ 1,500 ind/ha, dense ≥ 1,000 – 1,500 ind/ha, and rarely < 1,000 ind/ha, it was found that the density at each station was in good condition with a dense level of density.

Mangrove Biomass

Based on research conducted in the mangrove forest of Apar Village, the results of mangrove biomass were obtained as in Figure 2

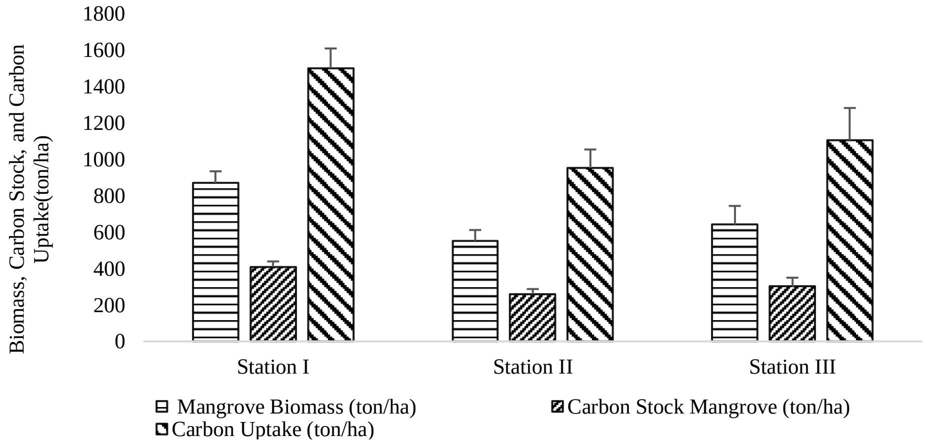

Figure 2. Mangrove biomass (tons/ha)

The biomass calculations at the three research stations show that the highest biomass is at Station I, with a biomass content of 871.26 tonnes/ha. The station with the lowest biomass content is Station II, with a biomass content of 552.42 tonnes/ha. This difference in biomass content occurs because the density of mangroves at Station I is greater than that of mangroves at Station II, and the diameter of the trees at Station I is more significant than that of the trees at Station II. This follows the statement of Mandari et al. (2016) that apart from being influenced by tree density, the tree's diameter also influences the biomass value; the larger the tree's diameter, the greater the biomass value. According to Trissanti et al. (2022), the main element of biomass is carbon, so trees with high biomass will also have a high carbon stock value.

Based on the results of research that has been carried out, it is known that the average mangrove biomass in Apar Village is 688.49 tonnes/ha. The amount of biomass in this area is lower compared to research conducted by Hanif (2018) in the Mangrove Area of Anak Setatah Village, West Rangsang District, with an average biomass of 1,241.11 tons/ha. According to Dharmawan & Siregar (2008), the high and low value of biomass produced in a mangrove ecosystem is caused by soil fertility and tree density in the area. Biomass will increase as the plant ages due to the growth in tree diameter.

Calculating the carbon content at the three research stations shows that the highest total carbon is at Station I, 409.49 tons/ha, while the lowest is at Station II, 259.64 tons/ha. This difference in mangrove carbon stock occurs because the mangrove density stands at Station I, which is greater than at other stations. Based on the research results, mangroves with larger stem diameters have larger biomass and carbon reserves. This statement is also reinforced by Chanan (2012), who states that an increase will follow every increase in biomass content in carbon stock content. This explains that carbon and biomass have a positive relationship, so whatever causes an increase or decrease in biomass will cause an increase or decrease in carbon stock content.

Based on the research results, it is known that the average mangrove carbon stock in Apar Village is 323.59 tons/ha. The amount of carbon stock in this area is lower compared to research conducted by Hanif (2018) in the Mangrove Area of Anak Setatah Village, West Rangsang District, with average biomass of 583.31 tons/ha and higher than the results of research conducted by Cahyaning et al. (2016) in Margasari Village, Labuhan Maringgai District, East Lampung Regency with an average carbon stock of 198.61 tons/ha.

The CO_2 uptake calculations at the three research stations showed that the highest total

CO_2 uptake was at Station I, 1,501.48 tons/ha, while the lowest total CO_2 uptake was at Station II, 952.00 tons/ha. This difference in CO_2 absorption occurs because the density of mangroves at station 1 is greater than that of other stations. According to Oktaviona (2017), CO_2 uptake also has a positive relationship between the total amount of biomass and the biomass carbon content.

Plants absorb CO_2 from the air and then convert it into organic material through photosynthesis, which is used for growth. The condition of the mangrove vegetation also influences carbon uptake. Trees absorb CO_2 from the air through photosynthesis, then convert it into carbon and store it in biomass in the stems, leaves, roots and branches.

Based on data from research that has been carried out, it is known that the average CO_2 uptake of mangroves in Apar Village is 1,186.51 tons/ha. The amount of CO_2 uptake in this area is lower than research conducted by Hanif (2018) in the Mangrove Area of Anak Setatah Village, West Rangsang District, with an average CO_2 absorption of 2,138.85 tonnes/ha.

Relationship between mangrove tree diameter and mangrove carbon stock

Based on the research that has been carried out, the relationship between the diameter of the *R. mucronata* mangrove tree and the carbon stock of mangroves can be seen in Figure 3. A regression test was carried out between tree diameter and mangrove carbon stock to determine how close the relationship is.

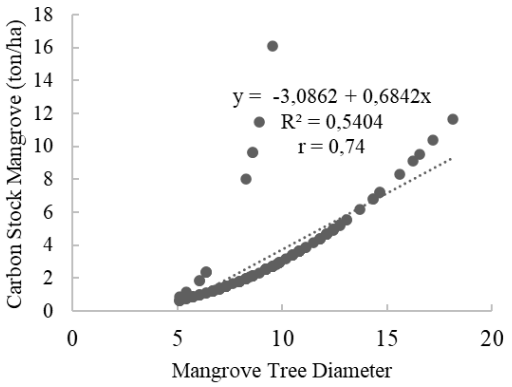

Figure 3. The Relationship between *R. mucronata* tree diameter and mangrove carbon stock.

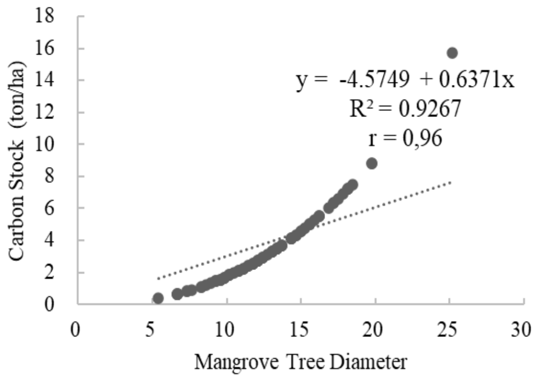

Figure 4. The relationship between *S. caseolaris* tree diameter and mangrove carbon stock.

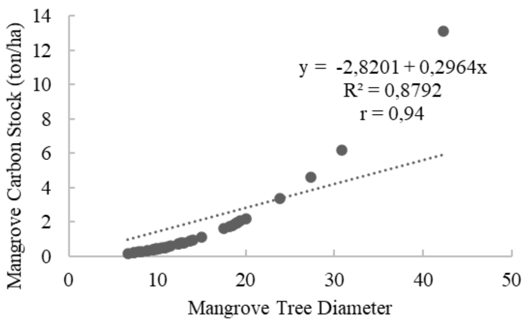

Figure 5. The Relationship between *S. alba* tree diameter and biomass, carbon stock and co_2 uptake

Based on the research that has been carried out, the relationship between the diameter of the *S. caseolaris* mangrove tree and the carbon stock of the mangrove can be seen in Figure 4. To find out how close the relationship is, a regression test was carried out between the tree's diameter and the mangrove's carbon stock. Based on the research that has been carried out, the relationship between the diameter of the *S. alba* mangrove tree and biomass, mangrove carbon stock and CO_2 uptake can be seen in Figure 5.

The correlation coefficient value for the relationship between mangrove tree diameter and carbon stock shows a different correlation value between each type, namely for the *R. mucronata* type with a value of 0.74, which means there is a strong relationship between tree diameter with mangrove carbon stocks has a strong relationship. The value of the *S. caseolaris* type is 0.94, which means there is a very strong relationship between tree diameter and mangrove carbon stock. Likewise, the *S. alba* type with a value of 0.95 indicates a strong relationship between tree diameter and mangrove carbon stock.

Tree diameter has a very close relationship with carbon absorption. These results align with previous research stating that stem diameter is proportional to the biomass value (Panji et al., 2017). The larger the DBH size, the greater the mangrove carbon stock content and vice versa. The smaller the DBH size, the smaller the carbon content. Thus, density greatly influences carbon stocks, and DBH size also has a significant impact.

Variations in mangrove carbon content are influenced by various factors, including DBH (Diameter Breast Height). The larger the DBH size, the greater the mangrove carbon stock content and vice versa. The smaller the DBH size, the smaller the biomass content, carbon content and CO_2 uptake. Thus, density significantly influences carbon stocks, and DBH size also has a considerable impact.

4. CONCLUSION

This research found that the mangrove density at the three stations was in good condition with a moderate density level; the highest density was at Station I, while the lowest was at Station II. The highest amount of mangrove biomass is at Station I, while the lowest is at Station II. The highest carbon stock is found at Station I, while the lowest biomass is at Station II. The highest CO_2 uptake was at Station I, while the lowest carbon uptake was at Station II.

REFERENCES

[BSN] Badan Standarisasi Nasional. (2011). SNI 7724 – *Pengukuran dan Perhitungan Cadangan Karbon – Pengukuran Lapangan untuk Penaksiran Cadangan Karbon Hutan (Ground Based Forest Carbon Accounting).* Badan Standarisasi Nasional.

[KLH] Kementrian Lingkungan Hidup. (2004). Keputusan Menteri Negara Lingkungan Hidup No. 201 Tahun 2004 tentang Standar Baku Mutu Air Laut dan Biota Laut. Kementerian Lingkungan Hidup Republik Indonesia, Jakarta.

Bengen, D.G. (2000). *Pedoman Teknis Pengenalan dan Pengelolaan Ekosistem Mangrove.* Pusat Kajian Sumberdaya Pesisir dan Lautan. IPB. Bogor.

Bismark, M.E., Subiandono, S., & Heriyanto, N.M. (2008). Keragaman dan Potensi Jenis serta Kandungan Karbon Hutan Mangrove si Sungai Subelen Siberut Sumatera Barat. *Penelitian Hutan dan Konservasi Alam*, 5(3): 297-306.

Cahyaning, S.T., Hartoko, A., & Suryanti, S. (2014). Biomassa Karbon Mangrove pada Kawasan Mangrove Pulau Kemujan Taman Nasional Karimunjawa. *Diponegoro Journal of Maquares*, 3(3): 34-42.

Chanan, M. (2012). Pendugaan Cadangan Karbon (C) Tersimpan di Atas Permukaan Tanah pada Vegetasi Hutan Tanaman Jati (*Tectona grandis Linn.F*) (di RPH Sengguruh BKPH Sengguruh KPH Malang Perum Perhutani II Jawa Timur). *Jurnal Gamma,* 7(2):61-73.

Dharmawan, I.W.S., & Siregar, C.A. (2008). Karbon Tanah dan Pendugaan Karbon Tegakan *Avicennia marina* (Forsk.) Vierh di Ciasem, Purwakarta. *Jurnal Penelitian Hutan dan Konservasi Alam*, 5, 317-328.

Fitrah, M.N. (2019). *Dinamika Perubahan Stok Karbon Biomassa pada Ekosistem Mangrove menggunakan Data Satelit dan Pengukuran Karbon Permukaan di Pulau Bauluang*. Sekolah Pascasarjana. Universitas Hasanuddin. Makassar.

Hanif, H. (2018). *Estimasi Stok Karbon Tersimpan pada Ekosistem Mangrove di Desa Anak Setatah Kecamatan Rangsang Barat Kabupaten Kepulauan Meranti Provinsi Riau*. Universitas Riau. Pekanbaru.

Heriyanto, T., & Amin, B. (2013). Analisis Serapan Karbon Dioksida pada Ekosistem Hutan Mangrove di Pesisir Pantai Kelurahan Purnama Kota Dumai Provinsi Riau. *Prosiding Seminar Nasional*

Konservasi dan Proteksi Lingkungan. *Universitas Riau. Pekanbaru*.

Komiyama, A., Ong, J.E., & Poungparn, S. (2005). Allometry, Biomass, and Productivity of Mangrove Forest: A Review. *Aquatic Botany,* 89: 128-137.

Lestari, S., Dewantara, I., & Hardiansyah, G. (2020). Estimasi Karbon Tersimpan di Atas Permukaan Tanah (*above Ground*) di Kawasan Mempawah Mangrove Park Kabupaten Mempawah. *Jurnal Tengkawang*, 10(1): 1-10.

Mandari, D.Z., Gunawan, H., & Isda, I. (2016). Penaksiran Biomassa dan Karbon Tersimpan pada Ekosistem Hutan Mangrove di Kawasan Bandar Bakau Dumai. *Jurnal Riau Biologia*, 1(3): 17-23.

Oktaviona, S. (2017). *Estimasi Stok Karbon Tersimpan pada Ekosistem Hutan Mangrove di Jorong Ujuang Labuang Kabupaten Agam Provinsi Sumatera Barat*. Fakultas Perikanan dan Kelautan Universitas Riau. Pekanbaru.

Panji, B.P., Nuraini, R.A., & Supriyantini, E. (2017). Estimation Carbon Stock on Mangrove Vegetation at Mangrove Area of Ujung Piring Jepara District. *International Journal of Marine and Aquatic Resource Conservation and Coexistence,* 2(1): 38-45.

Tanjung, A. (2014). *Rancangan Percobaan*. Penerbit Tantramesta Asosiasi Direktori Indonesia. Bandung

Trissanti, V.N., Amalo, L.F., Handayani, Nugroho, D., Yuliani, A.R., & Mulyana, M. (2022). The Estimation of Biomass and Carbon Stocks in Mangrove Forest Ecosystem of Karawang Regency, West Java. *IOP Conference Series Earth and Environmental Science*, 1109(1):012099