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ANALYSIS OF MANGROVE FOREST DENSITY WITH ESTIMATION OF BLUE CARBON ABSORPTION IN THE FOREST TOURISM AREA OF PULAU BURUNG VILLAGE, TANAH BUMBU REGENCY, SOUTH KALIMANTAN

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ABSTRACT
Pulau Burung Village has a mangrove forest area which the Tanah Bumbu Regency Government has been processing as a Nature Tourism Park since 2019. Mangrove forests are able to reduce the amount of carbon in the air by absorbing a certain amount of carbon dioxide through the process of photosynthesis. This research uses a purposive sampling method and a non-destructive descriptive method. The highest level of density is at stations 2 and 3, which are classified as good with very dense criteria. Meanwhile, station 3 is classified as good with moderate criteria based on KEPMENLH No. 201 of 2004. The estimated CO_2 carbon absorb in the Mangrove Forest Tourism Area of Pulau Burung Village is the largest at station 2 with a value of 3,823.43 tons/ha, then station 3 is 2,857. 98 tons/ha, and the lowest was at station 1 with a value of 1,036.45 tons/ha. The mangrove ecosystem in the Pulau Burung Village Mangrove Forest Tourism Area has an area of 34 ha with total carbon storage of 23,833.58 tons C and estimated CO_2 absorb of 87,469.25 tons. Density and estimates of carbon absorb have a positive relationship with a person correlation value of 0.973 or it can be said to have a very strong relationship or correlation.

KEY WORDS
Mangrove, biomass, blue carbon, pulau burung.

Pulau Burung Village has a mangrove or mangrove forest area which the Tanah Bumbu Regency Government has processed as a Nature Tourism Park since 2019, covering an area of approximately 545 ha in accordance with the Decree of the Minister of Environment and Forestry No. 652/MENLHK/SETJEN/PLA.2/8/2019. Pulau Burung Nature Tourism Park has had management blocks arranged, this is in accordance with the Decree of the Director General of Natural Resources and Ecosystem Conservation Number SK.97/KSDAE/SET/KSA.0/3/2020 dated 16 March 2020 concerning Nature Tourism Park Management Blocks Burung Island and Suwangi Island, Tanah Bumbu Regency, South Kalimantan Province.

This area is a research object to explore the level of mangrove density, with certain stations being the focus of analysis. A high level of density can indicate conditions that support healthy and productive mangrove growth. Therefore, an in-depth understanding of mangrove density in Pulau Burung Village is the main basis for identifying its potential contribution to carbon sequestration.

Global warming is one of the current world issues, characterized by an increase in the average temperature of the earth's surface associated with greenhouse gases. CO_2 is one of the greenhouse gases that cause global warming and climate change. Scientists state that global warming is caused by human (anthropogenic) activities in burning fossil fuels, such as coal, oil and natural gas, which have the potential to release carbon dioxide, CO_2 and other gases known as greenhouse gases into the atmosphere.

The coastal ecosystem that has the highest ability to absorb CO_2 is mangrove forests. Mangrove forests are able to reduce the amount of carbon in the air by absorbing a certain amount of carbon dioxide through the process of photosynthesis. Carbon dioxide storage in mangroves will be stored in the form of tree biomass. The amount of biomass from mangroves itself greatly influences the value of carbon dioxide absorbed. Each mangrove species has a different biomass value; this is influenced by the density, tree diameter and tree height as well as the density of the mangrove itself.

This research aims to determine the level of mangrove density following KEPMENLH guidelines no. 201 of 2004, as well as estimates of blue carbon absorb in the mangrove ecosystem in the Mangrove Forest Tourism Area of Pulau Burung Village, so that it can provide an idea of how effective mangrove forests are in storing carbon. Apart from that, this research also aims to determine the relationship between density and carbon absorbs estimates. According to Tony F. et al 2022, that the results of research in Mekarsari Village, Kintap District, Tanah Laut Regency have a total biomass value of 98.52 tons/ha and a total blue carbon reserve of 84.72 tons C/ha.

The importance of the relationship between mangrove density and carbon absorb estimates will be the main focus of this research. By understanding this relationship, we can evaluate the extent to which mangrove density can be an indicator of effectiveness in the carbon sequestration process. It is hoped that this research will provide a valuable contribution to further understanding the role of mangrove ecosystems in maintaining carbon balance in this region and provide a basis for environmental conservation and sustainability efforts.

METHODS OF RESEARCH

This research was carried out in August 2023 - January 2024. The research location was carried out in the Mangrove Forest Tourism Area (Special Block) Pulau Burung Village, Simpang Empat District, Tanah Bumbu Regency.

Determining the observation location and taking research samples was carried out by conducting a preliminary survey in several Mangrove Forest Tourism Areas in Pulau Burung Village. This preliminary survey was carried out by considering several things such as the presence of mangroves in a location, the size of the mangroves, and the density of the mangroves.

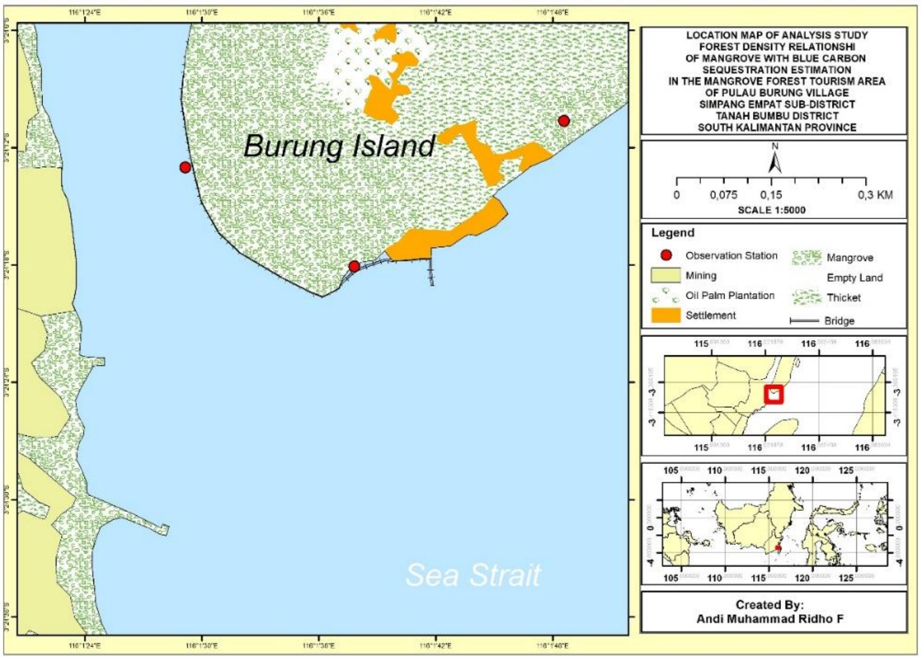

Figure 1 – Map of research locations

The plot created is a plot with a size of 10x10 m; each station has 3 observation plots which are located perpendicularly from the sea towards the mainland with a distance of 10m between plots. The objects observed in the plot are mangrove type, stand diameter (DBH), tree height, and environmental parameter measurements.

Measuring mangrove density begins with making a transect using the Line Transect method. The placement of transect is adjusted to the condition of the mangroves in the field. Then count the total number of mangroves stands and each type contained in transect to determine the level of mangrove density and compare it with the standard criteria and guidelines for determining mangrove damage based on KEPMEN LH No. 201 of 2004.

In this research to estimate biomass and carbon stocks in mangroves used a (non-destructive) method or a method without harvesting. This method was chosen because it takes into account the condition of the Mangrove Forest on Burung Island which is a natural tourist area. The method without harvesting for estimating biomass can be done by recording all types of mangroves found along with the diameter of the mangrove.

Analysis for estimating mangrove biomass and carbon stock was carried out using a non-destructive method using an allometric approach. This research uses general allometric equations that have been developed by Komiyama et al (2005).

After the total biomass is obtained, the stored carbon is determined using the percentage value of carbon content. Based on SNI 7724:2011, the percentage value of carbon content is 47%. Calculation of carbon stocks per hectare can use the equation from SNI 7724:2011 as follows:

$$C_n = \frac{C_x}{1000} \text{ x } \frac{1000}{l_{plot}}$$

Where: Cn - Carbon content per hectare (ton/ha); Cx - Carbon content in each plot (kg); Lplot - Plot area (m^2).

According to Murdiyarso et al (2015), the potential absorption of carbon dioxide gas (CO_2) is obtained by calculating the multiplication of carbon content by the amount of CO_2 absorption.

Analysis of the relationship between density and carbon absorb estimates using Pearson correlation analysis, which is a statistical method used to measure the extent of the linear relationship between two numerical variables. The main goal of Pearson correlation analysis is to determine how closely and in what direction two variables are related to each other. This method produces a Pearson correlation coefficient, the value of which ranges from -1 to +1:

- A correlation of +1 indicates a positive perfect linear relationship between two variables. This means that when one variable increases, the other variable also increases proportionally;
- A correlation of -1 indicates a negative perfect linear relationship between two variables. That is, when one variable rises, the other variable falls proportionally;
- A correlation of 0 indicates there is no linear relationship between two variables.

RESULTS AND DISCUSSION

The results of research conducted in October 2023 found several types of mangroves found in the Mangrove Forest Tourism Area of Pulau Burung Village. The composition of mangrove species and density levels found in the observation plot can be seen in Table 1.

Environmental parameters have a crucial role in influencing mangrove growth, but at the same time they can also have significant negative impacts. Therefore, awareness of the importance of maintaining environmental balance for mangrove growth is very important.

The level of mangrove density at the research location is classified as good. Mangrove density is directly related to ecosystem diversity and its ecological function in protecting coastlines, providing food for existing biota, and preserving the environment.

It can be seen that station 2 has the highest density level consisting of 5 types of mangroves dominated by the Rhizopora apiculate type at 1266 individuals/ha with a total of 3000 individuals/ha. Then station 3 which consists of 3 types of mangroves dominated by the Avicennia alba type with 1000 individuals/ha with a total of 1766 individuals/ha, based on KEPMENLH No. 201 of 2004 is classified as good with very dense criteria. Meanwhile, station 1 shows the lowest density level with 1066 individuals/ha, which only consists of 2 types of mangroves and is dominated by the Rhizopora apiculate type at 966 individuals/ha, classified as good with medium criteria.

Table 1 – Mangrove Density Levels

Station	Type	Amount	Type Density (Di/ha)	Relative Density of Types (RDi %)
1	*Rhizophora aviculata*	29	966	90,6
	Avicenia alba	3	100	9,4
	Total	32	1066	100
2	*Rhizophora aviculata*	38	1266	42,2
	Rhizophora mucronata	18	600	20
	Avicennia alba	20	667	22,2
	Sonneratia alba	6	200	6,6
	Bruguiera Parviflora	8	267	9
	Total	90	3000	100
3	*Rhizophora aviculata*	16	533	30,2
	Avicenia alba	30	1000	56,6
	Bruguiera Parviflora	7	233	13,2
	Total	53	1766	100

Source: Primary data, 2023.

Table 2 – Environmental Parameters

Station	Plots	Temperature (^{0}C)	pH (mg/l)	DO (mg/l)	Salinity(ppt)	Soil pH
1	1	31	7,8	5,5	24	4
	2	30	7,6	5,8	25	4
	3	31	7,8	5,9	23	4
	Average	30,66	7,73	5,73	24	4
2	1	32	8,5	6,2	25	6,5
	2	32	8,5	6,3	26	6,5
	3	32	8,4	6,2	25	6,5
	Average	32	8,46	6,23	25,33	6,5
3	1	30	8	6	28	6
	2	31	8,2	5,8	28	6
	3	32	8	6,2	27	6
	Average	31	8,06	6	27,66	6

Source: Primary data, 2023.

There is complexity in the role of environmental parameters on mangrove growth. Naturally, parameters such as salt content, salinity, nutrient availability and sunlight levels are key factors that regulate the growth and development of mangrove ecosystems. However, an imbalance in these factors, such as an excessive increase in salt levels or a decrease in nutrients, can have detrimental effects.

Environmental degradation such as climate change, uncontrolled human activities, and ecosystem damage can be detrimental factors for mangrove growth. Uncontrolled fluctuations in the environment can disrupt mangrove ecosystems, inhibit their growth, and can even threaten their survival.

Biomass can be defined as material originating from living organisms which can be used as energy for organisms and is expressed in units of tons/ha. The use of tons per hectare (ton/ha) in assessing mangrove stand biomass helps in measuring and comparing the amount of carbon stored in mangrove ecosystems in certain areas, and also provides important information regarding the potential of these ecosystems in absorbing carbon dioxide from the atmosphere Estimation of standing biomass Mangroves at each station can be seen in Figure 2.

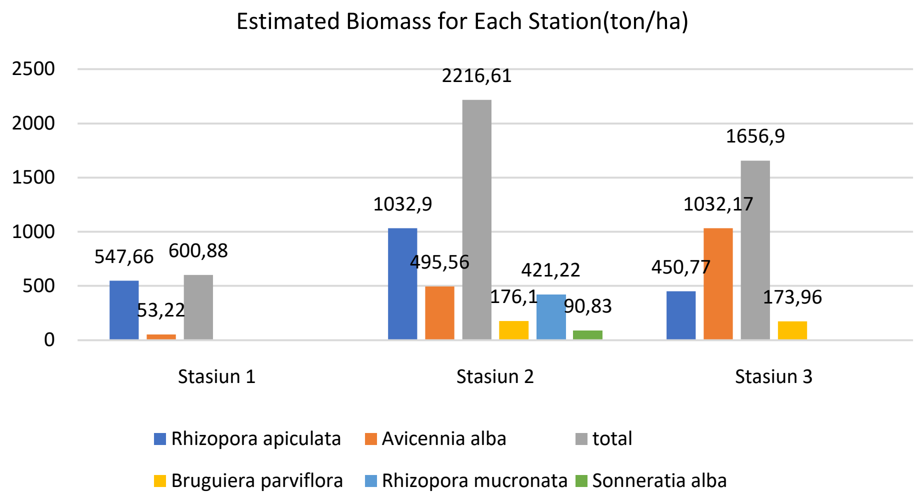

Figure 2 – Estimated Standing Biomass for Each Station

From the picture above, it can be concluded that the highest total biomass value is at station 2 at 2,216.61 tons/ha and at station 3 at 1,656.9 tons/ha. Meanwhile, the lowest total biomass value was at station 1, which was only 600.88 tons/ha. Several factors that cause the high amount of biomass content at this station are due to tree height, trunk diameter and number of trees. The higher and larger the stem circumference, the greater the biomass value. The following is an estimate of stand biomass by type.

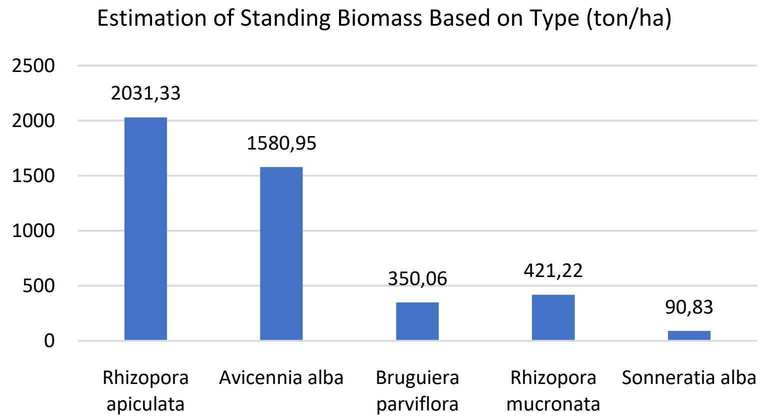

Figure 3 – Estimated Standing Biomass Based on Type

Based on each type of stand, the Rhizophora aviculata species had the highest biomass of all mangrove types found, namely 2,031.33 tons/ha. The smallest amount of standing biomass is the Sonneratia alba type, amounting to 90.83 tons/ha.

Rhizophora aviculata has a large amount of biomass because this type dominates especially in ecotourism areas. Meanwhile, the Sonneratia alba type is found in small numbers with a small average stem circumference value.

Blue carbon stock refers to the total amount of carbon stored by mangrove plants. Calculation of blue carbon stocks involves measuring and quantitatively estimating the total amount of plant biomass. Carbon is a chemical element found in nature. The largest carbon stock on Earth is carbon dioxide (CO_2). Blue carbon is carbon that is absorbed and stored in the ocean and coastal ecosystems.

The presence of carbon in the mangrove ecosystem is one of the most important steps to reduce carbon emissions which cause air temperatures to rise. Estimates of carbon storage at each station based on stand value can be seen in Figure 6.

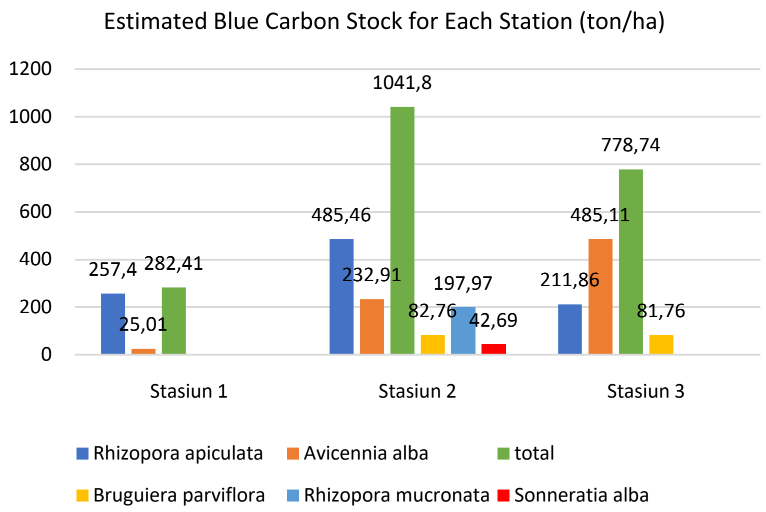

Figure 4 – Estimated Blue Carbon Stock for Each Station

Based on Figure 4 above, station 2 has the largest carbon stock with a value of 1,041.8 tons/ha, then station 3 with a carbon stock value of 778.74 tons/ha. Meanwhile, station 1 has the smallest carbon stock value, namely 282.41 tons/ha. According to Hairiah, (2007) the amount of C stored can vary depending on the level of diversity and density as well as the type of soil and its management.

The estimation results of carbon storage in mangrove stands at the research location have varying values which are influenced by differences in the number of species found, the total biomass of the species, and the diameter of the vegetation stem rings. The Rhizophora aviculata type dominates and is always found at every station. The carbon deposits of the Rhizophora aviculata type have the largest amount. Apart from that, there is also a type of Avicennia alba which is always found at every observation station, making this type have quite a large amount of carbon stock.

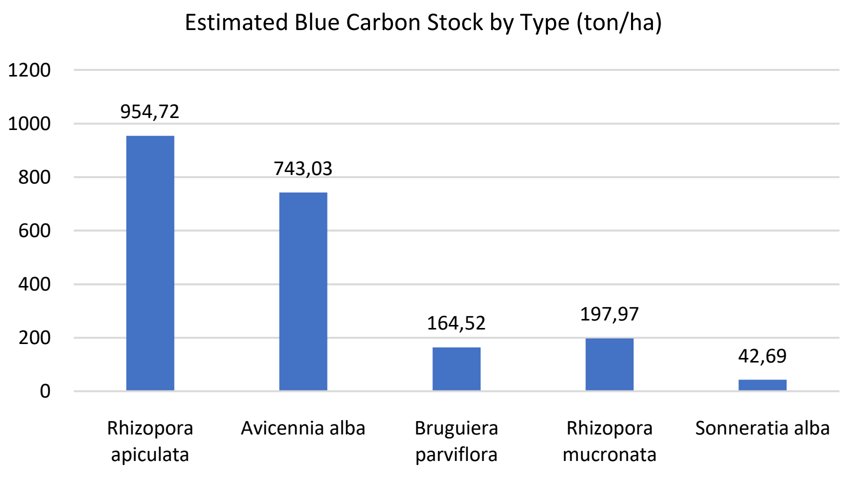

Figure 5 – Estimated Blue Carbon Stock Based on Mangrove Type

From the graphic image above, it can be seen that the highest carbon stock is found in the Rhizopora apiculate type at 954.72 tons/ha, then the Avicennia alba type at 743.03 tons/ha and the smallest is in the Sonneratia alba type at 42.69 tons/ha. Ha.

Several factors that cause differences in the amount of carbon deposits found in these stands are the number of species found and also the size of the trunk ring diameter.

Rhizophora aviculata and Avicenia alba are the most commonly found species, so the accumulation of carbon storage value in these species will be much greater than the others.

According to Anshary (2021), the difference in the amount of carbon stored is due to the amount of carbon stored being directly proportional to the amount of biomass found in the vegetation and the large amount found. Apart from that, according to Gardner et al (1985), the level of carbon storage can be influenced by the amount of forest biomass which is very dependent on the results obtained during photosynthesis. Therefore, it can be concluded that the greater the trunk circumference of the stand, the more types of plants found, this will affect the amount of carbon stored at each station and each type of plant.

From the carbon storage results that have been obtained in the mangrove ecosystem, we can then find out the estimated value of CO_2 absorb in.

The mangrove ecosystem starts from the estimated CO_2 absorb in the stands of each station and also the estimated value of CO_2 absorbs for each type of mangrove.

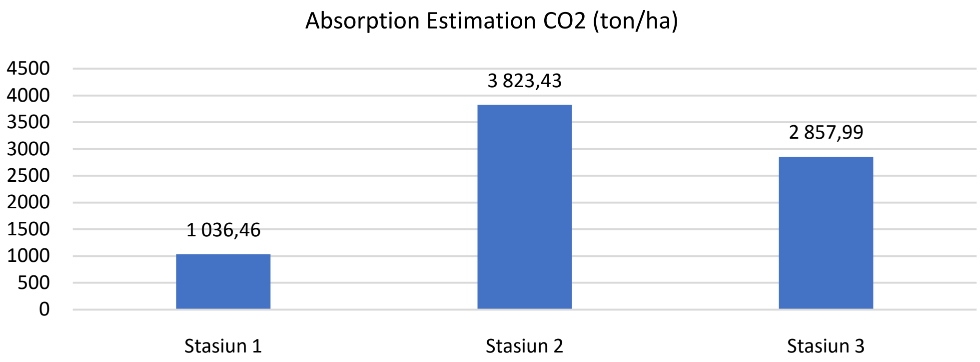

Figure 6 – Estimated CO2 Absorption for Each Station

The largest accumulated stand CO2 absorption value for each station is station 2 with a total estimated CO_2 absorption value of 3,823.43 tons/ha, then station 3 is 2,857.99 tons/ha, and the lowest was at station 1 with a total estimated CO_2 absorption value of only 1,036.46 tons/ha.

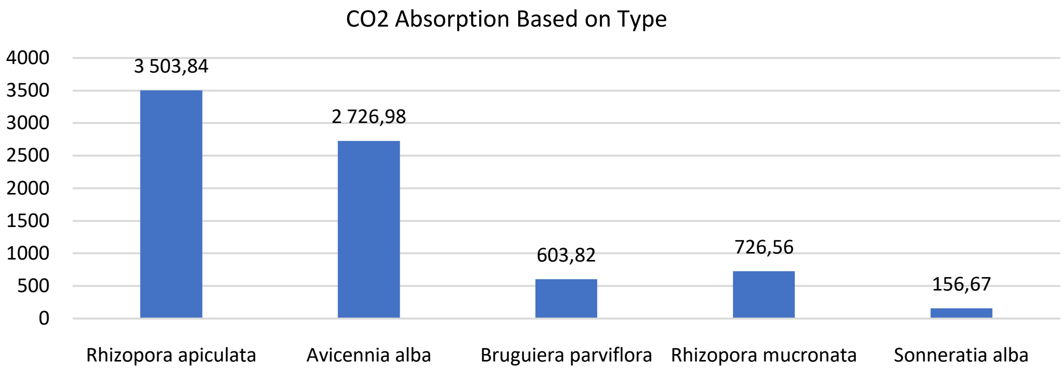

Figure 7 – Estimated CO2 Absorption for Each Mangrove Type

The highest accumulated CO_2 absorption value for stands of each type of mangrove is the Rhizopora apiculata type with a total estimated CO_2 absorption value of 3,503.84 tons/ha, then the Avicennia alba type with a value of 2,726.98 tons/ha. And the lowest estimated level of CO_2 absorption is in the Sonneratia alba type with a value of only 156.67 tons/ha.

This research then discusses the total of all CO_2 absorption in the mangrove ecosystem in the Mangrove Forest Tourism Area of Pulau Burugn Village. The calculation is carried out by multiplying the total value of vegetation carbon storage by the CO_2 conversion value.

Table 3 – Estimated Total CO_2 Absorption in the Mangrove Forest Tourism Area of Pulau Burung Village

Mangrove Area	Estimated Carbon Stocks Per Hectare	Total Carbon Stock (ton C)	CO_2 absorption (ton)
34 ha	700,98 ton/ha	23.833,58	87.469,25

Source: Primary data, 2023.

It can be concluded that carbon stocks are influenced by many things, including varying amounts in different locations. This condition can be caused by limiting factors such as temperature and rainfall (Ariani et al., 2016). Apart from that, it is suspected that temperature and water quality levels are factors that can cause differences in the amount of biomass and blue carbon stock savings.

Mangroves' ability to absorb and store carbon makes them play a role in reducing CO_2 concentrations in the atmosphere and contribute to climate change mitigation. Apart from that, mangrove ecosystems also have an important role in maintaining environmental sustainability, protecting coastlines from abrasion, providing habitat for various species, and supporting the lives of local communities who depend on this ecosystem.

Research on the relationship between density and carbon absorption estimates has been carried out using the Pearson correlation analysis method with the help of the SPSS application.

Table 4 – Correlation Test of Density Relationship with CO2 Absorption Estimates

Correlations

		Density of individuals per hectare	Estimation of CO^2 sequestration in tons per hectare
Density of individuals per hectare	Pearson Correlation	1	0.973**
	Sig. (2-tailed)		0.000
	N	13	13
Estimation of CO^2 sequestration in tons per hectare	Pearson Correlation	0.973**	1
	Sig. (2-tailed)	0.000	
	N	13	13

It can be seen that there is a significant relationship between density and estimated carbon absorption. This is indicated by the significance value (Sig.) which is smaller than 0.05. Furthermore, the Pearson correlation coefficient between density and estimated carbon absorption is 0.973, indicating a very strong relationship between the two variables.

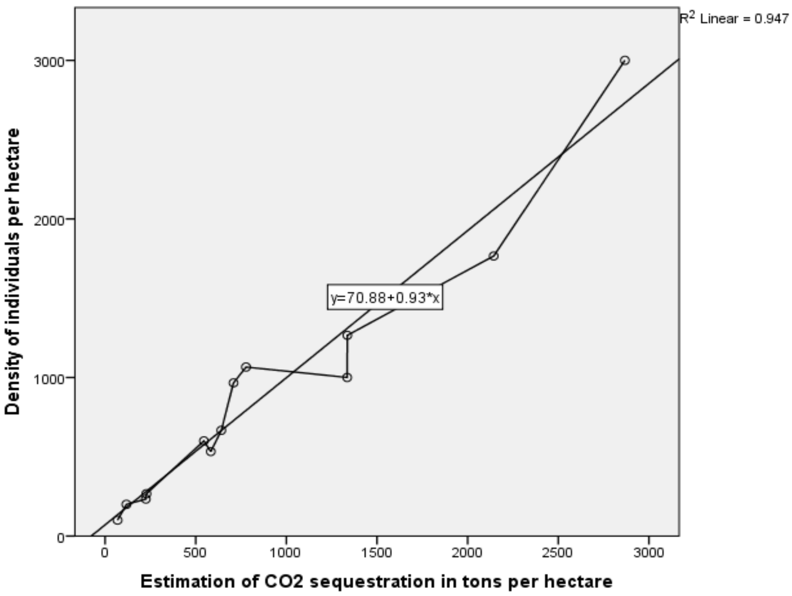

Figure 8 – Correlation Test

The sloping line or ascending line or line with a positive slope is clearly depicted. This line indicates that each increase in one variable is followed by an increase in the other variable. Therefore, the relationship between density and estimated carbon absorption shows a positive correlation, which is clearly reflected in Figure 8. The findings from this study confirm that the higher the density level, the greater the estimated CO_2 absorption in the mangrove ecosystem, directly illustrating the relationship strong relationship between these two variables.

CONCLUSION

The highest level of density is at stations 2 and 3, which are classified as good with very dense criteria. Meanwhile, station 3 is classified as good with medium criteria based on KEPMENLH No. 201 of 2004.

The highest estimate of CO_2 carbon absorption in the Mangrove Forest Tourism Area of Pulau Burung Village is at station 2 with a value of 3,823.43 tons/ha, then station 3 is 2,857.98 tons/ha, and the lowest is at station 1 with a value of 1,036.45 ton/ha. The mangrove ecosystem in the Pulau Burung Village Mangrove Forest Tourism Area has an area of 34 ha with total carbon storage of 23,833.58 tons C and estimated CO_2 absorption of 87,469.25 tons.

Density and estimates of carbon absorption have a positive relationship with a person correlation value of 0.973 or it can be said to have a very strong relationship or correlation.

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