ANALYSIS OF CARBON STOCK CONTENT IN MANGROVE ECOSYSTEMS IN JEROWARU, EAST LOMBOK REGENCY

Harry Irawan Johari [1)] and Nurul Isnaeni Rahmat [2)]

[1), 2)] *Muhammadiyah of Mataram University*
harryijohari@gmail.com

ABSTRACT

Mangrove ecosystems play a crucial role in climate change mitigation due to their ability to absorb and store carbon. The coastal area of Jerowaru, East Lombok Regency, has significant potential for mangrove ecosystem management. However, data on carbon content in mangroves in this region is still limited. Therefore, this study aims to analyze the carbon content in mangroves in the area. The objectives of this study include identifying the carbon content in various mangrove species in Jerowaru, East Lombok Regency, and evaluating the influence of biometric variables such as Diameter at Breast Height (DBH), tree height, and biomass on carbon content. This study uses a quantitative approach through direct field measurements and laboratory analysis. Mangrove samples were taken from several observation plots selected using purposive sampling based on mangrove density and species type. The variables measured include mangrove species, DBH, tree height, and biomass. Carbon content was calculated using scientifically validated allometric methods. Data were analyzed using analysis of covariance (ANCOVA) to assess the impact of biometric variables on carbon content. The results showed that carbon content varied among mangrove species. The species Rhizophora apiculata had a higher carbon content compared to Avicennia, Sonneratia alba, Ceriops tagal, and Avicennia rumphiana. Diameter at Breast Height (DBH) had a significant effect on carbon content ($p < 0.05$), while tree height and biomass also showed a positive effect, although not all were significant. The R-square (R^2) value of the resulting model was 84.3%, indicating that 84.3% of the variation in carbon content can be explained by the variables in the model. This study reveals that mangrove species, DBH, tree height, and biomass contribute to carbon content in mangroves in the Jerowaru area, East Lombok Regency. The highest carbon content was recorded in Rhizophora apiculata. These findings emphasize the importance of sustainable mangrove ecosystem management to support climate change mitigation efforts. The results of this study can serve as a reference for coastal ecosystem management policies and mangrove conservation in the East Lombok area.

Keywords: carbon content, mangroves, Diameter at Breast Height (DBH), biomass, allometric.

1. INTRODUCTION

The mangrove ecosystem is one of the productive ecosystems in coastal areas (Sukuryadi et al., 2024). The mangrove ecosystem plays a crucial role in maintaining the ecological balance of coastal areas (Rahmadi et al., 2023). In addition to serving as a habitat for various species of flora and fauna, mangroves also function as coastal erosion barriers, waste filters, and absorbers of carbon dioxide from the atmosphere (Kumar et al., 2024). In the context of global climate change, the role of mangroves as carbon sinks has received increasing attention, given their ability to store significant amounts of carbon (Taillardat et al., 2018). This makes mangroves a key element in the urgent efforts for climate change mitigation.

East Lombok Regency, particularly the Jerowaru coastal area, has a mangrove area of 39.6 hectares with great potential for carbon storage. The mangrove ecosystem in this region not only supports biodiversity but also acts as a natural protector against coastal erosion and saltwater intrusion (B. Barbier et al., 2011). However, human activities such as land conversion for shrimp farming, settlement development, and fisheries have caused the degradation of the mangrove ecosystem in the area. This damage has led to a decrease in the mangrove's capacity to absorb and store carbon, which ultimately affects climate change mitigation efforts.

The measurement of carbon content in the mangrove ecosystem in Jerowaru is important to assess the contribution of this ecosystem to carbon emission reduction. Data on carbon content can be used as a basis for sustainable mangrove forest management (Wolswijk et al., 2022). Moreover, this information is also relevant to support climate change mitigation policies at both the national and international levels, such as Ecosystem-Based Management policies and the Reducing Emissions from Deforestation and Forest Degradation (REDD+) program (Nalau & Becken, 2018).

Effective mangrove ecosystem management requires a data-driven approach (Fanous et al., 2023). Carbon content analysis can be conducted through biomass measurement methods and carbon stock analysis (Vashum & Jayakumar, 2012). Mangrove biomass includes roots, trunks, and leaves, all of which have the potential to store carbon(Donato et al., 2011). Through carbon content measurement in biomass, environmental managers can determine the extent of the mangrove ecosystem's contribution to carbon sequestration (Sitoe et al., 2014). This approach also allows for comparisons between regions and helps identify priority areas for conservation.

Several previous studies have shown that the carbon storage potential in mangrove ecosystems is higher than in terrestrial forest ecosystems. (Donato et al., 2012) revealed that the carbon content in mangrove ecosystems can reach 1,023 MgC/ha, which is significantly higher than in other tropical forest ecosystems. This is due to the high organic carbon content in mangrove sediments, which can persist for long periods. Thus, mangroves not only act as carbon absorbers but also as long-term carbon storage sites.

In Indonesia, mangrove ecosystem management has been regulated through national policies, such as Presidential Regulation No. 73 of 2012 on the National Strategy for Mangrove Ecosystem Management and the National Medium-Term Development Plan (RPJMN), which emphasizes the importance of mangrove ecosystem restoration. However, the implementation of these policies faces various challenges, including monitoring, participatory management, and community-based utilization. Therefore, accurate and up-to-date data on carbon stocks in mangrove ecosystems is needed to support effective policy-making.

The Jerowaru area in East Lombok Regency is one of the regions facing these challenges. With a relatively large mangrove ecosystem area, the potential for carbon storage in this region is very high. However, until now, research on carbon content in this area has been limited. The available data is general and does not include detailed information, such as the differences in carbon content across mangrove species, sediment depth, and the impact of human activities on carbon storage capacity.

To address these issues, this study aims to analyze the carbon content in the mangrove ecosystem in the Jerowaru area of East Lombok Regency. This analysis is conducted through a quantitative approach with direct field measurements and laboratory analysis. Biometric measurements such as Diameter at Breast Height

(DBH), tree height, and biomass are used to evaluate the influence of these variables on carbon content (Asrat et al., 2020). Scientifically validated allometric methods and analysis of covariance (ANCOVA) are used to identify relationships between these variables.

This study holds significant importance in supporting climate change mitigation efforts through an ecosystem-based approach. By determining the carbon content in the mangrove ecosystem in Jerowaru, the region's potential to support national and global programs related to carbon emission reduction can be identified. Furthermore, this research can serve as a reference for local governments and communities in managing natural resources sustainably, particularly in the management of coastal ecosystems that are sensitive to climate change and human activities.

Through a science-based approach, this research is expected to make a significant contribution to more effective coastal ecosystem management. The findings of this study can serve as a foundation for local governments, coastal area managers, and other stakeholders to formulate more effective policies, such as mangrove rehabilitation programs, coastal ecosystem conservation, and the development of carbon-based Payment for Ecosystem Services (PES) schemes..

2. RESEARCH METODOLOGY

This study aims to analyze the carbon content in the mangrove ecosystem of Jerowaru, East Lombok Regency, which plays a crucial role in climate change mitigation due to its ability to absorb and store carbon. Despite the area's significant potential for mangrove ecosystem management, data on the carbon content in the mangroves of this region remains limited. Therefore, the objectives of this research are to identify the carbon content in various mangrove species in the Jerowaru area and evaluate the influence of biometric variables, such as Diameter at Breast Height (DBH), tree height, and biomass, on carbon content.

This study hypothesizes that differences in mangrove species and biometric variables significantly contribute to variations in carbon storage. The research also provides valuable insights into the management of mangrove ecosystems in East Lombok and their role in climate change mitigation.

This study uses a quantitative approach with direct field measurements and laboratory analyses to assess the carbon content in the mangrove ecosystem. The research involves the following steps:

1. Study Area and Sampling :
    a. The study is conducted in the Jerowaru area, East Lombok Regency, which is home to various mangrove species.
    b. Purposive sampling is used to select sample plots based on mangrove density and species type. The sample plots are chosen to ensure representation of different mangrove species, including *Rhizophora apiculata, Avicennia, Sonneratia alba, Ceriops tagal,* and *Avicennia rumphiana.*

2. Data Collection :
    a. Field measurements are taken for various biometric variables, including:
    b. Diameter at Breast Height (DBH) : The diameter of the mangrove tree trunk measured at 1.3 meters above ground level.
    c. Tree Height: The height of individual mangrove trees.
    d. Biomass: The above-ground biomass of mangrove trees is estimated using allometric equations specific to each mangrove species.

e. The carbon content in biomass is calculated using scientifically validated allometric equations, which estimate biomass and subsequently carbon content based on tree dimensions and species.

3. Laboratory Analysis :

Samples of mangrove biomass (branches, leaves, and roots) are collected and analyzed in the laboratory to determine the carbon content through combustion or other carbon quantification methods.

4. Data Analysis :

a. Analysis of Covariance (ANCOVA) is used to analyze the relationship between biometric variables (DBH, tree height, and biomass) and carbon content. This statistical test evaluates the impact of these variables on carbon content while controlling for other factors.
b. The coefficient of determination (R^2) is calculated to assess the proportion of variation in carbon content explained by the model's variables.

3. RELATED RESEARCH/LITERATUR REVIEW

3.1. Role of Mangrove Ecosystems in Carbon Sequestration

Mangrove ecosystems are considered one of the most effective carbon sinks due to their high primary productivity and large amounts of organic carbon that they accumulate in their biomass and sediments (Pelluso et al., 2014). According to (Donato et al., 2012), mangrove ecosystems store carbon at rates much higher than terrestrial forests, with carbon content in mangrove sediments reaching up to 1,023 MgC/ha. This is primarily due to the high carbon content in mangrove soils, which are anaerobic and slow down the decomposition process, allowing carbon to be stored for long periods. The export of dissolved inorganic carbon (DIC) and alkalinity in subtropical mangrove ecosystems contributes approximately 1.7 times more than burial as a long-term carbon sink. The methane flux generated offsets around 6% of burial, while nitrous oxide uptake reaches about 0.5% of burial. Additionally, the export of dissolved organic carbon and particulate organic carbon to coastal zones also shows significant contributions, which, when combined, can produce an atmospheric carbon sink comparable to burial (Maher et al., 2018). Mangroves have the unique ability to store carbon both in aboveground biomass (in the form of trees, roots, and leaves) and in the sediments below the ground. Long-term carbon storage in mangrove sediments helps reduce atmospheric CO2 concentrations, playing a vital role in climate change mitigation (Murdiyarso et al., 2015).

3.2. Variability of Carbon Stocks Among Mangrove Species

Different mangrove species have varying carbon storage capacities, depending on their growth patterns, root structures, and biomass production. Rhizophora species, such as Rhizophora apiculata, are known to have very high biomass production and are significant contributors to carbon sequestration in mangrove ecosystems (Alongi, 2014). This is supported by research from (Duarte et al., 2013), who found that species like Rhizophora apiculata store more carbon both in biomass and sediments compared to other species such as Avicennia or Sonneratia.

A study by (Donato et al., 2011) further reinforces these findings, showing that the aboveground biomass of Rhizophora mangroves is consistently higher, leading to greater carbon storage potential compared to other species. This is significant in understanding how the species composition in mangrove areas, such as in Jerowaru, may influence overall carbon sequestration. The carbon content in mangrove tree biomass is controlled by species and compartments, but not by tidal frequency (physiographic types). Carbon content in the wood parts is similar across species, while R. mangle differs from A. schaueriana and L. racemosa in their green parts and roots. Allometric models are based on species-specific biomass allocation in wood and green parts. Similar methods have been developed for converting root biomass into carbon stocks in mixed forests, where carbon content equilibrium is calculated from the relative dominance of each species' basal area (Pelluso et al., 2014).

3.3. Biometric Variables and Their Influence on Carbon Stocks

Biometric variables such as Diameter at Breast Height (DBH), tree height, and biomass are commonly used to estimate carbon content in mangrove ecosystems. The relationship between DBH, height, and carbon content is well-documented in the literature (Hossain et al., 2012). (Meng et al., 2021) used DBH and tree height to estimate carbon stocks in mangrove forests and found a significant correlation between these variables and carbon content, with DBH being the most influential factor. (Aye et al., 2022) showed that DBH is a strong predictor of carbon stocks in mangrove ecosystems. Furthermore, biomass estimation using allometric equations (Vorster et al., 2020) provides a reliable method for calculating carbon content based on tree dimensions. These equations can be applied to mangrove ecosystems in Jerowaru, where species-specific allometric models can be used to estimate carbon storage.

3.4. Carbon Content in Mangrove Ecosystems in Indonesia

Indonesia is home to some of the largest mangrove forests in the world, and several studies have focused on carbon storage in its mangrove ecosystems. Indonesia’s mangrove ecosystems have a total carbon stock capacity of about 2.6 billion tons of carbon, making them crucial for global climate change mitigation efforts (Buditama, 2016). Local studies, such as those conducted by (Syukur & Santoso, 2021), highlight the role of Lombok’s mangrove forests in carbon sequestration. However, the carbon stock content in the Jerowaru region has not been extensively studied, indicating an important research gap. Research by (Gazali et al., 2023) shows that mangroves in the coastal areas of Lombok have varying carbon stock levels, with some areas showing high carbon sequestration potential. These findings suggest that understanding the carbon content in the Jerowaru mangrove ecosystem is crucial for sustainable management and climate change mitigation in the region.

3.5. Implications for Climate Change Mitigation and Conservation

Findings from previous research emphasize the importance of preserving mangrove ecosystems to enhance carbon storage and mitigate climate change. Mangroves not only sequester carbon but also provide important ecosystem services, including coastal protection, habitat for biodiversity, and water filtration (Locatelli et al., 2014). As highlighted by (Torre-castro et al., 2014), effective conservation and restoration efforts for mangroves are essential to maintain their carbon sequestration potential, especially in areas like Jerowaru, which face threats from human activities such as land conversion and overexploitation. In conclusion, the literature underscores the significant role mangrove ecosystems play in carbon sequestration and their potential contribution to climate change mitigation. However, research specifically focusing on the carbon stock content in the Jerowaru mangroves of East Lombok Regency remains limited, and this study aims to fill this gap by analyzing carbon content across various mangrove species and evaluating the influence of biometric variables on carbon storage.

4. RESULTS AND DISCUSSION

4.1. Types of Mangroves

Mangrove species in Jerowaru, East Lombok, were identified as 5 species from 5 families (Table 1).

Table 1. Types of mangrove species in Jerowaru

Station	Plot	Types of Mangrove Rhizhopora Apiculata	Avicennia	Sonneratia Alba	Ceriop Tagal	Aviccenia Rumphiana
1	1	√				
	2	√				
	3					
2	1		√			
	2	√	√	√	√	√
	3	√		√		
3	1	√		√		√
	2					√
	3	√				

Source: Primary data, 2024

4.2. Carbon Content at Each Station

Station	Plot	Types of mangrove	DBH (Cm)	Height (Cm)	Biomass value (kg/tree)	C Value Ton/Ha
1	1	Rhizhopora Apiculata	4,3	225	7,49	1,34738
		Rhizhopora Apiculata	2,9	250	2,85	0,51329
		Rhizhopora Apiculata	2,3	275	1,62	0,29089
		Rhizhopora Apiculata	3,0	250	3,10	0,55775
		Rhizhopora Apiculata	3,5	300	4,52	0,81369
		Rhizhopora Apiculata	2,4	250	1,79	0,32286
		Rhizhopora Apiculata	3,6	300	4,84	0,87183
		Rhizhopora Apiculata	3,1	280	3,36	0,6044
		Rhizhopora Apiculata	2,9	260	2,85	0,51329
		Rhizhopora Apiculata	2,9	250	2,85	0,51329
		Rhizhopora Apiculata	2,5	275	1,98	0,35682
		Rhizhopora Apiculata	3,8	350	5,53	0,99532
		Rhizhopora Apiculata	7,3	400	27,38	4,92757
		Rhizhopora Apiculata	4,3	375	7,49	1,34738
		Rhizhopora Apiculata	5,0	400	10,83	1,9497
		Rhizhopora Apiculata	4,1	350	6,66	1,19898
		Rhizhopora Apiculata	2,7	250	2,39	0,43086
		Rhizhopora Apiculata	2,5	300	1,98	0,35682
		Total			**99,51**	**17,91**
	2	Rhizhopora Apiculata	3,1	475	3,36	0,6044
		Rhizhopora Apiculata	2,7	475	2,39	0,43086
		Rhizhopora Apiculata	5,8	475	15,58	2,80473
		Rhizhopora Apiculata	2,9	475	2,85	0,51329
		Rhizhopora Apiculata	5,0	475	10,83	1,9497

		Rhizhopora Apiculata	4,5	475	8,37	1,50613
		Rhizhopora Apiculata	4,0	475	6,27	1,1286
	3					
		Total			**49,65**	**8,94**

Station	Plot	Types of mangrove	DBH (Cm)	Height (Cm)	Biomass value (kg/tree)	C Value Ton/Ha
	1	Avicennia	3,0	190	3,10	0,55775
	2	Sonneratia Alba	22,0	400	314,61	3,53933
		Sonneratia Alba	24,0	450	382,97	4,30847
		Sonneratia Alba	23,5	350	365,18	4,10827
		Sonneratia Alba	17,5	700	187,57	2,11014
		Ceriop Tagal	12,6	650	104,26	4,6918
		Sonneratia alba	13,5	600	104,34	4,69526
		Ceriop Tagal	15,0	500	159,82	7,19209
		Aviccenia Rumphiana	3,0	250	3,48	0,62728
		Aviccenia Rumphiana	3,2	250	4,03	0,72578
		Aviccenia Rumphiana	2,7	300	2,75	0,49436
		Aviccenia Rumphiana	3,1	300	3,75	0,67553
		Ceriops Tagal	5,3	300	12,61	2,27002
		Aviccenia Rumphiana	2,8	250	2,98	0,53671
		Rhizophora apiculata	7,5	400	29,25	5,26492
		Rhizophora apiculata	4,8	100	9,80	1,76414
		Rhizophora apiculata	5,3	400	12,49	2,24889
2		Rhizophora apiculata	3,2	400	3,63	0,65329
		Rhizophora apiculata	3,6	400	4,84	0,87183
		Aviccenia	2,5	500	2,31	0,41544
		Ceriops Tagal	4,4	400	7,92	1,42545
		Ceriops Tagal	2,8	450	2,62	0,47101
		Total			**1.724,32**	**49,65**
	3	Sonneratia alba	50,0	600	2.011,71	22,63
		Rhizhopora Apiculata	4,3	350	7,49	1,35
		Rhizhopora Apiculata	3,0	300	3,10	0,56
		Rhizhopora Apiculata	3,5	350	4,52	0,81
		Rhizhopora Apiculata	3,3	350	3,91	0,70
		Rhizhopora Apiculata	2,5	250	1,98	0,36
		Rhizhopora Apiculata	3,0	350	3,10	0,56
		Rhizhopora Apiculata	3,0	350	3,10	0,56
		Rhizhopora Apiculata	6,5	400	20,60	3,71
		Rhizhopora Apiculata	7,7	400	31,20	5,62
		Rhizhopora Apiculata	6,0	400	16,93	3,05

		Rhizhopora Apiculata	5,1	350	11,37	2,05
		Rhizhopora Apiculata	5,5	350	13,68	2,46
		Rhizhopora Apiculata	5,0	350	10,83	1,95
		Rhizhopora Apiculata	4,0	300	6,27	1,13
		Rhizhopora Apiculata	5,0	300	10,83	1,95
		Rhizhopora Apiculata	4,5	300	8,37	1,51
		Rhizhopora Apiculata	4,5	300	8,37	1,51
		Rhizhopora Apiculata	3,7	300	5,18	0,93
		Rhizhopora Apiculata	4,5	250	8,37	1,51
		Rhizhopora Apiculata	3,0	250	3,10	0,56
		Rhizhopora Apiculata	2,5	250	1,98	0,36
		Rhizhopora Apiculata	2,5	300	1,98	0,36
		Rhizhopora Apiculata	4,1	300	6,66	1,20
		Rhizhopora Apiculata	3,9	250	5,89	1,06
		Rhizhopora Apiculata	2,5	250	1,98	0,36
		Total			**2.212,50**	**58,77**

Station	Plot	Types of mangrove	DBH (Cm)	Height (Cm)	Biomass value (kg/tree)	C Value Ton/Ha
	1	Sonneratia Alba	22,9	750	344,45	3,88
		Rhizophora apiculata	12,3	400	98,28	4,42
		Avicennia rumphiana	12,8	400	92,51	4,16
		Avicennia Rumphiana	6,0	250	16,69	3,00
		Avicennia Rumphiana	3,0	350	3,48	0,63
		Avicennia Rumphiana	5,0	350	11,06	1,99
		Avicennia Rumphiana	4,5	400	8,71	1,57
		Avicennia Rumphiana	4,5	400	8,71	1,57
		Rhizopora Apiculata	5,0	400	10,83	1,95
		Rhizopora Apiculata	4,8	350	9,80	1,76
3		Rhizopora Apiculata	4,7	400	9,31	1,68
		Rhizopora Apiculata	5,0	350	10,83	1,95
		Rhizopora Apiculata	5,0	350	10,83	1,95
		Avicennia Rumphiana	3,0	250	3,48	0,63
		Avicennia Rumphiana	8,0	400	31,98	5,76
		Avicennia Rumphiana	3,5	350	4,94	0,89
		Avicennia Rumphiana	6,5	400	20,00	3,60
		Avicennia Rumphiana	2,5	350	2,31	0,42
		Total			**698,21**	**41,80**
	2	Avicennia rumphiana	13,0	400	95,81	1,08
		Avicennia Rumphiana	3,0	250	3,48	0,63

	Avicennia Rumphiana	7,0	300	23,65	4,26
	Avicennia Rumphiana	8,3	300	34,75	6,26
	Avicennia Rumphiana	7,5	300	27,64	4,98
	Avicennia Rumphiana	6,8	300	22,15	3,99
	Avicennia Rumphiana	4,6	300	8,83	1,59
	Total			**216,32**	**22,77**
3	Rhizopora apiculata	12,9	500	110,45	4,97
	Rhizopora apiculata	12,0	350	92,52	4,16
	Rhizopora apiculata	3,8	300	5,53	1,00
	Rhizopora apiculata	4,0	350	6,27	1,13
	Rhizopora apiculata	5,0	350	10,83	1,95
	Rhizopora apiculata	4,0	350	6,27	1,13
	Rhizopora apiculata	3,6	300	4,84	0,87
	Rhizopora apiculata	3,7	300	5,18	0,93
	Rhizopora apiculata	2,9	300	2,85	0,51
	Rhizopora apiculata	8,0	400	34,26	6,17
	Rhizopora apiculata	3,5	300	4,52	0,81
	Rhizopora apiculata	4,5	300	8,37	1,51
	Rhizopora apiculata	8,6	350	40,90	7,36
	Rhizopora apiculata	4,5	300	8,37	1,51
	Rhizopora apiculata	4,0	300	6,27	1,13
	Total			**347,43**	**35,14**

Based On The Calculation Results, The Species With The Highest Carbon Content Are Ceriops Tagal (7.19% C), Avicennia Rumphiana (6.26% C), And Rhizophora Apiculata (6.17% C).

ANALYSIS OF COVARIANCE (ANCOVA) TEST

Tests of Between-Subjects Effects

Dependent Variable: Nilai_Karbon

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	630,837[a]	12	52,570	44,907	,000	,843
Intercept	12,898	1	12,898	11,018	,001	,099
Jenis	76,637	7	10,948	9,352	,000	,396
DBH	65,092	1	65,092	55,604	,000	,357
Biomassa	3,938	1	3,938	3,364	,070	,033
Tinggi	2,865	1	2,865	2,448	,121	,024
Stasiun	3,466	2	1,733	1,481	,232	,029
Error	117,063	100	1,171			
Total	1236,816	113				

Corrected Total	747,901	112				

a. R Squared = ,843 (Adjusted R Squared = ,825)

Based On The Results Of The Analysis Of Covariance (Ancova) Test, It Was Found That The Variables Significantly Influencing Carbon Value Are Mangrove Species And Stem Diameter (Dbh). Mangrove Species Showed A Significance Value (P = 0.000) With A Contribution Of 39.6% (Partial Eta Squared = 0.396). Meanwhile, Dbh Also Had A Significant Effect On Carbon Value With A Significance Value (P = 0.000) And A Contribution Of 35.7% (Partial Eta Squared = 0.357).

On The Other Hand, Several Variables Did Not Have A Significant Effect On Carbon Value. These Variables Include Biomass (P = 0.070), Tree Height (P = 0.121), And Measurement Station (P = 0.232). This Indicates That These Three Variables Do Not Contribute Significantly To Influencing Carbon Value.

The Ancova Model Used Has An R-Squared Value Of 0.843, Indicating That 84.3% Of The Variation In Carbon Value Can Be Explained By The Variables In The Model. The Remaining 15.7% Is Influenced By Other Factors Not Included In The Model. This High R-Squared Value Demonstrates That The Model Has Excellent Predictive Ability.

Overall, This Ancova Model Can Explain Most Of The Variation In Carbon Value. The Most Dominant Variables Influencing Carbon Value Are Mangrove Species And Stem Diameter (Dbh), As Both Variables Have The Highest Contribution Compared To The Others.

5. CONCLUSION

1. The mangrove ecosystem in the Jerowaru area has varying carbon content, depending on mangrove species, stem diameter (DBH), and local environmental factors. Certain mangrove species, such as Ceriops tagal, have higher carbon content compared to other species. The variables significantly influencing carbon content are mangrove species and stem diameter (DBH). The ANCOVA test results show that mangrove species contribute 39.6%, while stem diameter (DBH) contributes 35.7% to carbon content. In contrast, variables such as biomass, tree height, and measurement station do not have a significant effect.
2. The ANCOVA model used in this study has an R-squared value of 0.843. This indicates that 84.3% of the variation in carbon content can be explained by the variables included in the model, while the remaining 15.7% is influenced by other factors not included in the model. Mangrove species and stem diameter (DBH) are the most dominant factors influencing carbon content. This suggests that the management of the mangrove ecosystem in Jerowaru needs to consider the composition of mangrove species and the management of stem diameter growth to enhance carbon sequestration potential.

REFERENCE

Alongi, D. M. (2014). *Carbon Cycling and Storage in Mangrove Forests*. https://doi.org/10.1146/annurev-marine-010213-135020

Asrat, Z., Eid, T., Gobakken, T., & Negash, M. (2020). Modelling and quantifying tree biometric properties of dry Afromontane forests of south - central Ethiopia. *Trees*, *34*(6), 1411–1426. https://doi.org/10.1007/s00468-020-02012-8

Aye, W. N., Tong, X., & Tun, A. W. (2022). Species Diversity, Biomass and Carbon Stock Assessment of Kanhlyashay Natural Mangrove Forest. *Forests*, *13*(7),

1–16. https://doi.org/10.3390/f13071013
B. Barbier, E., Hacker, S. D., Kennedy, C., W. koch, E., C. stier, A., & R. Silliman, B. (2011). The value of estuarine and coastal ecosystem services. *Ecological Monographs*, *81*(2), 169–193.
Buditama, A. (2016). Blue carbon for reducing the impacts of climate change: An Indonesian case study. *Environmental and Planning Law Journal*, *33*(1), 68–88.
Donato, D. C., Kauffman, J. B., Mackenzie, R. A., Ainsworth, A., & P, A. Z. (2012). *Whole-island carbon stocks in the tropical Paci fi c : Implications for mangrove conservation and upland restoration*. *97*. https://doi.org/10.1016/j.jenvman.2011.12.004
Donato, D. C., Kauffman, J. B., Murdiyarso, D., Kurnianto, S., & Stidham, M. (2011). Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience*, *4*(4), 1–5. https://doi.org/10.1038/ngeo1123
Duarte, C. M., Hendriks, I. E., Moore, T. S., Olsen, Y. S., Steckbauer, A., Ramajo, L., Carstensen, J., Trotter, J. A., & Mcculloch, M. (2013). *Is Ocean Acidification an Open-Ocean Syndrome ? Understanding Anthropogenic Impacts on Seawater pH*. 221–236. https://doi.org/10.1007/s12237-013-9594-3
Fanous, M., Eden, J. M., Remesan, R., & Daneshkhah, A. (2023). Challenges and prospects of climate change impact assessment on mangrove environments through mathematical models. *Environmental Modelling and Software*, *162*(February), 105658. https://doi.org/10.1016/j.envsoft.2023.105658
Gazali, Z., Jannah, S. W., Yulia, B., & Pratiwi, H. (2023). *POTENTIAL OF CARBON SINK IN MANGROVE*. *30*(3), 346–354. https://doi.org/10.11598/btb.2023.30.3.1956
Hossain, M., Raqibul, M., & Siddique, H. (2012). *Allometry , above-ground biomass and nutrient distribution in Ceriops decandra (Griffith) Ding Hou dominated forest types of the Sundarbans mangrove forest , Bangladesh*. 539–548. https://doi.org/10.1007/s11273-012-9274-2
Kumar, P., Das, B., Majik, S., & Bhattacharjee, S. (2024). *Coastal Ecosystem Services : Valuation , Threats , and Sustainable Way Forward*. *24*.
Locatelli, T., Binet, T., Kairo, J. G., King, L., Madden, S., Patenaude, G., Upton, C., & Huxham, M. (2014). *Turning the Tide : How Blue Carbon and Payments for Ecosystem Services (PES) Might Help Save Mangrove Forests*. 981–995. https://doi.org/10.1007/s13280-014-0530-y
Maher, D. T., Call, M., Santos, I. R., Sanders, C. J., & Maher, D. T. (2018). *Beyond burial : lateral exchange is a significant atmospheric carbon sink in mangrove forests*.
Meng, Y., Bai, J., Gou, R., Cui, X., Feng, J., Dai, Z., Diao, X., Zhu, X., & Lin, G. (2021). Relationships between above- and below-ground carbon stocks in mangrove forests facilitate better estimation of total mangrove blue carbon. *Carbon Balance and Management*, *16*(1), 1–14. https://doi.org/10.1186/s13021-021-00172-9
Murdiyarso, D., Purbopuspito, J., Kau, J. B., Warren, M. W., Sasmito, S. D., Donato, D. C., Manuri, S., Krisnawati, H., & Taberima, S. (2015). *The potential of Indonesian mangrove forests for global climate change mitigation*. *5*(December), 1089–1092. https://doi.org/10.1038/NCLIMATE2734
Nalau, J., & Becken, S. (2018). *Ecosystem-based Adaptation to Climate Change : Review of Concepts Ecosystem-based Adaptation to Climate Change : Review of Concepts Griffith Institute for Tourism*. *August*.
Pelluso, D., Hamacher, C., Calderucio, G., Estrada, D., Luiz, M., & Soares, G. (2014). Variability of carbon content in mangrove species : Effect of species , compartments and tidal frequency. *Aquatic Botany*, *120*, 346–351. https://doi.org/10.1016/j.aquabot.2014.10.004
Rahmadi, M. T., Yuniastuti, E., Suciani, A., & Harefa, M. S. (2023). *Indonesian Journal of Earth Sciences Threats to Mangrove Ecosystems and Their Impact on Coastal Biodiversity : A Study on Mangrove Management in Langsa City*.

03(2), 1–14. https://doi.org/10.52562/injoes.2023.627

Sitoe, A. A., Júnior, L., Mandlate, C., & Guedes, B. S. (2014). *Biomass and Carbon Stocks of Sofala Bay Mangrove Forests*. 1967–1981. https://doi.org/10.3390/f5081967

Sukuryadi, Johari, H. I., & Wijaya, A. (2024). Strategi Restorasi Ekosistem Mangrove di Kawasan Desa Lembar Kabupaten Lombok Barat. *Jurnal Ilmu Lingkungan*, *22*(6), 1455–1465. https://doi.org/10.14710/jil.22.6.1455-1465

Syukur, A., & Santoso, D. (2021). *Species diversity and composition , and above-ground carbon of mangrove vegetation in Jor Bay , East Lombok , Indonesia*. *22*(4), 2066–2071. https://doi.org/10.13057/biodiv/d220455

Taillardat, P., Friess, D. A., Lupascu, M., Da, F., & Taillardat, P. (2018). *Mangrove blue carbon strategies for climate change mitigation are most effective at the national scale*.

Torre-castro, M. De, Di, G., & Jiddawi, N. S. (2014). Seagrass importance for a small-scale fishery in the tropics : The need for seascape management. *Marine Pollution Bulletin*, *83*(2), 398–407. https://doi.org/10.1016/j.marpolbul.2014.03.034

Vashum, K. T., & Jayakumar, S. (2012). *Ecosystem & Ecography Methods to Estimate Above-Ground Biomass and Carbon Stock in Natural Forests - A Review*. *2*(4). https://doi.org/10.4172/2157-7625.1000116

Vorster, A. G., Evangelista, P. H., Stovall, A. E. L., & Ex, S. (2020). Variability and uncertainty in forest biomass estimates from the tree to landscape scale: The role of allometric equations. *Carbon Balance and Management*, *15*(1), 1–20. https://doi.org/10.1186/s13021-020-00143-6

Wolswijk, G., Trullols, A. B., Hug, J., Otero, V., Satyanarayana, B., Lucas, R., & Dahdouh-guebas, F. (2022). Can Mangrove Silviculture Be Carbon Neutral ? *Remote Sensing*, *14*.