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Ecological Potential and Estimation of Mangrove Forest Carbon Stock in Kabaena Island, Bombana Regency

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Abstract Mangrove forests are one of the factors that can contribute to suppressing climate change. The phenomenon of the function of mangrove forests changes has an impact on reducing the ability to absorb carbon in the atmosphere. Kabaena Island has a coastline length of ± 200 km which has several mangrove forest spots that are scattered around Kabaena Island with an area of ± 1500 ha. This study aims to determine the ecological potential and carbon stock of mangrove forests in Kabaena Island, Bombana Regency. Data were collected at 75 observation locations in the form of a combination of transects and plots. The research variables are: 1. The variables used to analyze ecological potential consist of diversity index, density, dominance, frequency, important value index and mangrove species. 2. The variable used to analyze the carbon potential of mangrove forests is the estimated value of the biomass content of each mangrove species obtained from calculations using allometric equations. The results showed the vegetation composition at the tree, sapling and seedling levels in Kabaena Island was composed of 9 species belonging to 4 families. The level of diversity at the research location is included in the medium category. Mangrove carbon stocks in Kabaena Island at the tree level reached 10,847.185 kg/ha; at the sapling level it reached 11,950,314 kg/ha and at the seedling level it reached 3,797 kg/ha.

Keywords Carbon Stock, Ecological Potential Mangrove, Kabaena Island

1. Introduction

The increase in greenhouse gas (GHG) emissions that is CO_2, CH_4, N_2O, HFCs, PFCs, and SF_6 as a trigger for global warming has become an international issue in the last two decades. Sukadri [45] states that the largest GHG concentration is found in the CO_2, approximately 75% of the total GHG. The increase of GHG emissions is largely due to deforestation and forest degradation in developing countries as well as industrial emissions from developed countries [1].

FAO [2] released data on total deforestation from 10 developing countries of around 8.22 million ha, of which 1.87 million of this area is deforestation from Indonesia. The rate of deforestation in developing countries is estimated to continue to increase [3], so that large-scale carbon sequestration is required to reduce CO_2 emissions [4], especially in developing countries including Indonesia.

World conference held in Bali at December 2007, placing mangrove forests is one of the factors that can contribute to suppressing climate change. The connection with climate change is the existence of mangrove forests as natural carbon sinks [5]. Mangroves can also store more carbon per hectare [6,7].

Indonesia is one of the largest areas of mangrove forests in the world and rich in carbon content. About 3 million hectares of mangrove forests grow along 95,000 kilometers (23% of the world's mangrove ecosystems) [8]. Mangrove forests have the densest carbon content in the tropics. Store more than three times the average carbon per hectare of inland tropical forest [9]. Indonesia's mangrove forests store five times more carbon per hectare than upland tropical forests. It is estimated that Indonesia's mangrove forests store 3.14 billion metric tons of carbon [10] or equivalent to 1/3 of global coastal carbon stocks [11].

Bombana Regency is one of the districts in Southeast Sulawesi Province which bloomed in 2003 which is divided into 22 sub-districts, including Kabaena Island. The length of the Kabaena Island coastline is ± 200 km which has several large spots of mangrove forest that are scattered around Kabaena Island. The mangrove forest has the potential to get pressure from human activities and development, especially because the coast is an area with a high level of economic activity. This has an impact on converted mangrove forests became very high for aquaculture [12,13,14,15], coastal port infrastructure [16], industry [17,18], housing [18], utilization of forest wood [9,18,19], and agriculture/plantation [20].

Land functions changes that occur in mangrove areas to

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development areas or conversion of coastal areas have an impact on the ecosystem and zoning of mangrove forests [21]. The phenomenon of the function of mangrove forests changes, has an impact on reducing the ability to absorb carbon in the atmosphere. At the same time, carbon stored in mangrove ecosystems is decomposed through a process of decomposition into the atmosphere. This study aims to determine the ecological potential and carbon stocks of mangrove forests in Kabaena Island, Bombana Regency.

2. Methods

This research was conducted from October to November 2020. The research location was in the mangrove forest of Kabaena Island, Bombana Regency, Southeast Sulawesi. The research location can be seen in Figure 1.

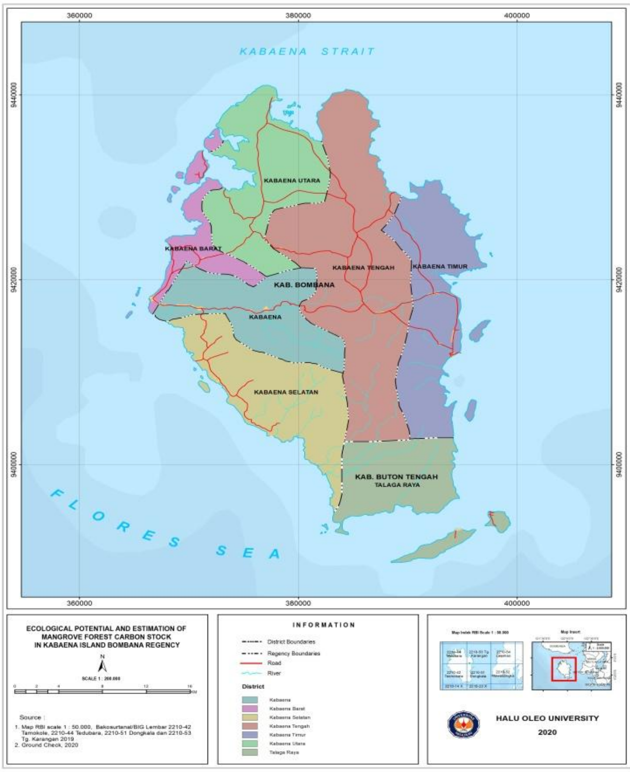

Figure 1. Study Area

The tools and materials used in this research are a set of computers equipped with Microsoft Office 2007 and Microsoft Excel applications, printers, administrative maps of research areas, work maps, global position system, compass, altimeters, machetes, meters, digital camera, stationery and guide book for mangrove introduction [22].

Analysis data. Data were collected at 75 observation locations in the form of a combination of transects and plots. The observation location was placed purposively which was considered representative to represent the condition of the mangrove vegetation in that location. The transect is made from the sea to the land perpendicular to the coastline.

The research variables are: 1. The variables used to analyze ecological potential consist of diversity index, density, dominance, frequency, important value index and mangrove species. 2. The variable used to analyze the carbon potential of mangrove forests is the estimated value of the biomass content of each mangrove species obtained from calculations using allometric equations.

The population in this study were all types of mangrove vegetation on Kabaena Island which were included in the growth rates of trees, saplings and seedlings. The samples in this study were mangroves at the growth rate of trees, saplings and seedlings in the observation plot. The sample placement was carried out purposively by considering the representation of mangrove density and the distribution of mangrove plants in the research location.

Analysis of mangrove ecological potential data using quantitative analysis approaches and qualitative descriptive analysis, as follows [23]:

- Diversity index

$$H^1 = -\sum \left\{ \left(\frac{n_1}{N}\right) \log\left(\frac{n_i}{N}\right) \right\}$$

- Density;

$$\mathrm{K.i} = \frac{\text{Number of individuals}}{\text{Area of all sample plots}}$$

$$\mathrm{KR.i} = \frac{\text{Densitty of species.i}}{\text{Total density of all species}} \times 100\%$$

- Frequency

$$\mathrm{F.i} = \frac{\text{Total of plots sample found species to.i}}{\text{Total of all sample plots}}$$

$$\mathrm{FR.i} = \frac{\text{Frequency of species to.i}}{\text{Total frequency of all species}} \times 100\%$$

Total area cover LBDS = ¼ Πd^2

$$\mathrm{C.i} = \frac{\text{Base area of species to.i}}{\text{Area of all plot of samples}}$$

$$\mathrm{CR.i} = \frac{\text{Dominance of spesies to .i}}{\text{Total dominance of all species}} \times 100\%$$

- Importance Value Index

INP = KR + FR + CR

INP-i = KR-i + FR-i + CR-i

Table 1. Allometric Equations for various Mangrove species

Name of Species	Allometric Model	References
Avicenia alba	$B = 0.079211*D^{2.470895}$	[24]
Avicennia lanata	$B = 0.251\ \rho\ (D)^{2.46}$	[25]
Avicennia marina	$B = 0.1848D^{2.3624}$	[26]
Bruguiera cylindrica	$B = 0.251\ \rho\ (D)^{2.46}$	[25]
Bruguiera gymnorrhiza	$Wtop = 0.186DBH^{2.31}\ R^2 = 0.99, n = 17$	[27]
Rhyzophora apiculata	$B = 0.268*D^{2.345}$	[28]
Rhyzophora mucronata	$B = 0.143*D^{2.52}$	[28]
Sonneratia alba	$B = 0.3841\ (D)^{2.101}$	[28]
Xylocarpus granatum	$B = 0.529*D^{2.204}$	[28]

Potential of Mangrove Carbon Stock. Calculation of mangrove biomass in the field uses biomass estimation non-destructive (with allometric equations), this method does not damage the environment and can be implemented more quickly for a wider forest area.

The calculation of mangrove carbon values uses the following equation [29]:

Carbon Content = Estimated Biomass x 0.46 [29]

3. Results and Discussions

3.1. Mangrove Ecological Potential

The distribution of the sampling plots based on the results of the inventory at the research location, the types of individuals found were distributed at the tree, sapling and seedling levels which were the focus of observation in the study.

Table 2. Distribution of the sample plots for field data

District	Plot Observ.	Plot Measure	Coordinate Points	
			X	X
Kabaena Barat	1	1	369998	9424678
		2	369987	9424624
		3	369953	9424582
	2	4	370696	9424442
		5	370681	9424450
		6	370642	9444470
	3	7	370357	9428837
		8	370292	9428799
		9	370268	9428743
	4	10	370052	9428336
		11	370018	9428361
		12	369982	9428378
	5	13	370093	9428746
		14	370088	9428762
		15	370097	9428794
Kabaena Selatan	1	16	370726	9411753
		17	370931	9411458
		18	370448	9411463
	2	19	370879	9411753
		20	370841	9411756
		21	370843	9411813
	3	22	373123	9408642
		23	373087	9408648
		24	373048	9408663
	4	25	371916	9410262
		26	371934	9410243
		27	371938	9410213
	5	28	371857	9410604
		29	371810	9410609
		30	371780	9410670
Kabaena Tengah	1	31	387953	9424576
		32	387953	9429528
		33	387963	9429539
	2	34	121˚59'22,098	5˚9'53,534
		35	121˚59'22,098	5˚9'33,534
		36	121˚59'21,21	5˚9'32,262
	3	37	381972	9435003
		38	381982	9434984
		39	381987	9434958
	4	40	382545	9434448
		41	382565	9434467
		42	382579	9434484
	5	43	382477	9435659
		44	382492	9435645
		45	382489	9435621
Kabaena Timur	1	46	394477	9414987
		47	394816	9414210
		48	394782	9414222
	2	49	394648	9417042
		50	394663	9417041
		51	394675	9417091
	3	52	394844	9417518
		53	394845	9417593
		54	394839	9417643
	4	55	393649	9419519
		56	393627	9419542
		57	393601	9419561
	5	58	394050	9414423
		59	394034	9418442
		60	394017	9418464
Kabaena Utara	1	61	376120	9434934
		62	376103	9434946
		63	376020	9434950
	2	64	377948	9436649
		65	377941	9436671
		66	377957	9436682
	3	67	377454	9437145
		68	377391	9437195
		69	377325	9437192
	4	70	377154	9438271
		71	377127	9438234
		72	377140	9438343
	5	73	377445	9439310
		74	377367	9439270
		75	377404	9439182

In the implementation of field data collection in this study, measurements were carried out on 75 sample plots which were spread over five districts. Placement of sample plots was carried out by considering the principles of representation and field effectiveness. So that all mangrove areas on Kabaena Island can be represented. The following shows the distribution of the location of the sample plots in the study locations in Table 2.

The results of the inventory carried out on 75 observation plots showed that on Kabaena Island there were nine types / species of mangroves consisting of four families. The identified mangrove species as a whole can be seen in Table 3. The Rhizophoraceae and Avicenniaceae families are families and the totaly highest of species is found at the tree and sapling levels.

This is thought to be because this area is supported by a fairly good environment for mangrove growth and thrive. Environmental factors such as tides, salinity, temperature, soil pH, oxygen and nutrient content are very influential on mangrove growth as seen in the composition and structure of mangrove plants [30].

Table 3. Recapitulation of Mangrove Species Found on Kabaena Island

Name of Species	Family	Vegetation Level		
		Tree	Sapling	Seedling
Avicenia alba	Aveceniaceae	√	√	√
Avicennia lanata	Aveceniaceae	√	√	-
Avicennia marina	Aveceniaceae	√	√	-
Bruguiera cylindrica	Rhizophoraceae	√	√	-
Bruguiera gymnorrhiza	Rhizophoraceae	√	√	-
Rhyzophora apiculata	Rhizophoraceae	√	√	√
Rhyzophora mucronata	Rhizophoraceae	√	√	-
Sonneratia alba	Soneratiaceae	√	√	-
Xylocarpus granatum	Meliaceae	√	√	-

3.2. Analysis of Mangrove Communities

The results of vegetation analysis at the growth rates of trees, saplings and seedlings are presented in Table 4, Table 5 and Table 6.

Table 4. Results of Analysis of Mangrove Vegetation at Tree Level in Kabaena Island, Bombana Regency

Name of Species	H'	K	D	F	INP
Avicenia alba	0.21	135.00	3.51	0.60	31.76
Avicennia lanata	0.03	8.67	0.14	0.24	6.44
Avicennia marina	0.09	41.67	0.82	0.25	10.63
Bruguiera cylindrica	0.21	139.67	3.60	0.53	30.77
Bruguiera gymnorrhiza	0.18	108.00	2.11	0.49	23.79
Rhyzophora apiculata	0.35	795.00	16.31	0.91	114.55
Rhyzophora mucronata	0.33	338.33	7.69	0.68	57.59
Sonneratia alba	0.14	76.67	1.78	0.61	23.72
Xylocarpus granatum	0.00	1.00	0.03	0.03	0.74
Total	1.54	1644	35.98	4.35	300

Table 5. Results of Analysis of Mangrove Vegetation at sapling Level at Kabaena Island, Bombana Regency

Name of Species	H'	K	D	F	INP
Avicenia alba	0.13	485.33	2.09	0.39	19.02
Avicennia lanata	0.03	74.67	0.43	0.11	4.49
Avicennia marina	0.24	1232.00	5.73	0.19	26.25
Bruguiera cylindrica	0.10	352.00	1.92	0.41	18.36
Bruguiera gymnorrhiza	0.17	746.67	3.02	0.36	22.18
Rhyzophora apiculata	0.33	6416.00	28.16	0.85	130.18
Rhyzophora mucronata	0.30	2074.67	10.70	0.65	55.86
Sonneratia alba	0.13	480.00	2.44	0.49	22.68
Xylocarpus granatum	0.01	10.67	0.06	0.03	0.97
Total	1.45	11872.00	54.56	3.48	300

Table 6. Results of Analysis of Mangrove Vegetation at Seedling Level in Kabaena Island, Bombana Regency

Name of Species	H'	K	D	F	INP
Avicenia alba	0.34	66.66	0,019	0.013	83.33
Rhyzophora apiculata	0.34	66.66	0,019	0.027	116.66
Total	0.693	133.33	0,038	0.04	200

Note: H' = Diversity index; K= Density; D = Dominance; F = Frequency; INP = Importance Value Index

3.2.1. Diversity Index

The results of the calculation of the index Shannon Wiener obtained the value of vegetation diversity (H ') at tree levels of 1.54 and saplings of 1.45 and seedlings of 2.29. Shannon-Wiener in [31] suggests that if the value of H '=> 3 indicates that species diversity is high, H' = 1 ≤ H '≤ 3 indicates diversity moderate, and H' = <1 indicates diversity low. Based on this classification, for the diversity index parameter, the species diversity at the research location is classified as criteria moderate.

Indriyanto [17] states that species diversity can be used to measure community stability, namely the ability of a community to keep itself stable even though there are disturbances to its components. This concept is used to measure the ability of a community in a habitat to balance its components due to disturbances that arise [32]. Habitat stability is an important factor regulating species diversity [33].

3.2.2. Density

The results of the vegetation analysis show that for all tree growth rates, saplings and seedlings are in the very dense category. At the tree level, the species density ranged from 1.00 - 795.00 ind.ha-1 with a total density of 1644 ind.ha-1. At the sapling level, the species density ranged from 10.67 to 6416.00 ind.ha-1 and the total density reached 11872.00 ind.ha-1. At the seedling level, the species density was 66.66 ind.ha-1-1 and the total density was 133.33 ind.ha -1. Decree of the State Minister for the Environment No. 21 of 2004 explains that the quality standard criteria for mangrove density are solid density ≥ 1,500 ind / ha, moderate ≥ 1,000 - 1,500 ind / ha and rarely <1,000 ind / ha.

This gives an indication of the large number of individuals found in spatial unity in the research location, which means that the condition of the mangrove vegetation on Kabaena Island is still very good.

Tables 4, 5 and 6 also show that the species with the highest density values at both the tree and sapling levels was Rhizophora apiculata. This indicates that this type is the type with the highest number of individuals as well as describing the type of character at the research location. The high density value also indicates a very good reproductive ability in this species. The high density of mangrove vegetation indicates that the vegetation community is in an undisturbed condition.

3.2.3. Dominance

In the aspect of dominance, of the 9 species found in the study location, there are 3 species at the tree level and 2 species at the sapling level which have a dominance value of less than 1 m / ha. This shows that overall the species found in the study location generally have a fairly large diameter.

At the tree level and sapling level,species Rhizophora apiculata had the highest growth rate dominance values, namely 16.31% and 28.16%. This is because Rhizophora apiculata can compete to obtain more nutrients than other types so that the growth of the stems becomes bigger and the canopy is broad. This indicates that this species has the most space occupation compared to other species in the study location which is indicated by the large size of the stem diameter in that species. The dominant species are those that can utilize the environment they occupy more efficiently than other species in the same place. The dominance of mangrove species is different from each type. The larger the stem size will expand its dominance, and vice versa. Species that have a relatively low dominance value reflects their inability to tolerate environmental conditions.

3.2.4. Frequency

Frequency provides information about the distribution and adaptability of each type of mangrove in the research location. The species at the tree level as a whole are in the very low to very high frequency range (3% - 91%). At the sapling level it is also in the very low to high range (3% - 85%). However, the seedlings were in the very low frequency range (1.3% - 2.7%). The classification proposed by Raunkiaer in Indrianto[23], class A (0 - 20%) is very low, class B (21 - 40%) is low, class C (41 - 60%) is moderate, class D (61 - 80%) is classified as high, and class E (81 - 100%) is classified as very high.

The highest frequency at tree and sapling levels was Rhizophora apiculata with the percentage of frequency values, respectively, 0.91% and 0.85% (in the very high frequency range). This indicates that this species is the species with the highest adaptability and the widest distribution in the study area. The other 8 types are in the low to high frequency range.

This is due to the distribution of Rhizophora apiculata seeds evenly in each zone and the ability of the seeds to survive in the environment is better than the ability of other mangrove species. Pramudji [34], stated that the mud and soft ground covered by mangrove species Rhizophora apiculata, Rhizophora mucronata, Lumnitzera littorea with uniform distribution and wide. Bengen [35] also argues that the specific life cycle of the mangrove species (Rhizophora sp) with seeds that can germinate while still in the parent plant greatly supports the broad distribution process of this species in the mangrove ecosystem. Ferianita [36] states that frequency is used as a vegetation parameter which can indicate the distribution or distribution of plant species in the ecosystem. The frequency value also shows the adaptability of the species to environmental conditions. This is in line with the opinion of Djoko [37] that the distribution of plant species in the community is a different response from these species to differences in micro-habitats.

3.2.5. Importance Value Index

The structure of the mangrove vegetation community can be determined by determining the importance value index and diversity index of the constituent mangrove forest communities. Importance value shows the importance of a plant species whether or not it affects the community and ecosystem [38]. Based on the analysis of the Importance Value Index (IVI) at the tree, sapling and seedling levels, the mangrove species Rhizophora apiculata occupied the highest percentage value compared to other species, respectively, namely 114.55%, 130.18% and 116.66%. [33] that a species is said to play an important role in the ecosystem if the INP value => 15 (on tree and pole size) and the INP value => 10 (sapling and seedling levels). Prasetyo [39] explains that mangrove areas that have importance value index high that the mangroves in the area are in good condition and have not changed, on the other hand, if this condition is reduced or turned into land due to sedimentation and damage due to human activity, rehabilitation is necessary so that it is balanced maintained ecosystem.

In terms of the effect of species on the ecosystem, at the tree level there are 6 species that show a strong influence in the community, namely these species have an IVI value of 15. These species are Avicennia alba, Bruguiera cylindrica, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata and Sonneratia alba. For sapling level, there are 7 species that show a strong influence in the community, namely species that have an IVI value of 10. These species are Avicennia alba, Avicennia marina, Bruguiera cylindrica, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata and Sonneratia alba. As well as the level of seedlings, species Avicennia alba and Rhizophora apiculata show strong influence in the community.

This illustration shows that at the research location, these species are very important in maintaining the stability of the mangrove ecosystem. This is because these species are relatively abundant compared to other types, have greater adaptability and distribution capacity and relatively greater control of space than other types. If there is pressure on these species, the stability of the mangrove forest community will be disturbed. Plants with high IVI have better adaptability, competitive power and reproductive capacity than other plants in a certain area. A low IVI indicates that these species have the potential to disappear from the ecosystem under stress due to their very small numbers, low reproduction and narrow distribution.

3.3. Analysis of Mangrove Carbon Stocks

Carbon stores describe how much a tree stores carbon. The size of the carbon storage depends on the amount of biomass contained in the tree [40]. Through the process of photosynthesis, plants absorb CO_2 in the air as raw material for photosynthesis and will be converted into biomass stored in plant parts. This study uses the value of carbon stock from the measurement of tree trunk biomass converted to organic carbon. Carbon stock in mangrove forests at sapling level reaches 11,950,314 kg / ha and at seedling level reaches 3,797 kg / ha. The results of the calculation of mangrove carbon storage are presented in Tables 7 and 8.

Table 7. Total mangrove carbon stock for each district on Kabaena Island, Bombana Regency

District	Name of Species	Carbon Stock (kg/ha)		
		Tree	Sapling	Seedling
Kabaena Barat	Avicenia alba	30.179	43.971	-
	Avicennia lanata	-	101.838	-
	Avicennia marina	66.823	6.424	-
	Bruguiera cylindrica	215.414	148.336	-
	Bruguiera gymnorrhiza	25.621	116.378	-
	Rhyzophora apiculata	1151.107	1859.395	-
	Rhyzophora mucronata	493.223	580.009	-
	Sonneratia alba	107.214	117.431	-
Kabaena Selatan	Avicenia alba	457.772	80.403	0.922
	Bruguiera cylindrica	1202.631	308.691	-
	Rhyzophora apiculata	1738.851	370.648	1.438
	Sonneratia alba	43.139	-	-
Kabaena Tengah	Avicenia alba	11.638	37.648	-
	Avicennia marina	0.916	4.575	-
	Avicennia lanata	3.845	-	-
	Bruguiera cylindrica	17.574	18.519	-
	Bruguiera gymnorrhiza	217.438	163.720	-
	Rhyzophora apiculata	905.904	1904.276	1.438
	Rhyzophora mucronata	68.925	131.933	-
	Sonneratia alba	32.368	95.092	-
	Xylocarpus granatum	-	8.014	-
Kabaena Timur	Avicenia alba	29.398	9.203	-
	Avicennia marina	10.053	21.552	-
	Avicennia lanata	49.268	51.672	-
	Bruguiera cylindrica	141.761	40.733	-
	Bruguiera gymnorrhiza	123.463	92.828	-
	Rhyzophora apiculata	1179.234	993.255	-
	Rhyzophora mucronata	988.482	533.707	-
	Sonneratia alba	127.744	112.006	-
	Xylocarpus granatum	3.117	8.014	-
Kabaena Utara	Avicenia alba	14.383	26.287	-
	Avicennia marina	4.443	9.387	-
	Avicennia lanata	116.632	928.225	-
	Bruguiera cylindrica	41.334	63.236	-
	Bruguiera gymnorrhiza	61.401	106.763	-
	Rhyzophora apiculata	341.916	1835.175	-
	Rhyzophora mucronata	730.803	828.783	-
	Sonneratia alba	103.079	195.214	-
	Xylocarpus granatum	3.102	-	-

Table 8. Mangrove carbon stocks in Kabaena Island, Bombana Regency

Name of Species	Carbon Stock (kg/ha)		
	Tree	Sapling	Seedling
Avicenia alba	543.371	197.513	0.922
Avicennia lanata	56.042	132.777	-
Avicennia marina	182.428	990.895	-
Bruguiera cylindrica	1618.713	579.514	-
Bruguiera gymnorrhiza	427.923	479.688	-
Rhyzophora apiculata	5317.012	6959.725	2.875
Rhyzophora mucronata	2281.434	2074.432	-
Sonneratia alba	413.544	519.742	-
Xylocarpus granatum	6.719	16.028	-

Measurement of carbon dioxide uptake can be carried out using the carbohydrate method, because the mass amount of carbon dioxide in the photosynthesis process is directly proportional to the amount of carbon in carbohydrates.

About 46% of the biomass of a tree is carbon [29]. The greater the value of the biomass in a stand, the greater the carbon storage. According to [41] the carbon content in plants illustrates how much the plant can bind CO_2 from the air for photosynthesis. Plants absorb CO_2 from the air and then convert it into organic material through the process of photosynthesis which is used for growth.

4. Conclusions

The results of the study concluded that the vegetation composition at the tree, sapling and seedling levels in Kabaena Island was composed of 9 species belonging to 4 families. Family Rhizophoraceae and Aviceniaceae is the family with the largest number of species. Avicennia alba, Bruguiera cylindrica, Bruguiera gymnorrhiza, Rhizophora apiculata, Rhizophora mucronata and Sonneratia alba are species with strong influence in their ecosystem. The level of diversity at the research location is included in the medium category. Mangrove carbon stocks in Kabaena Island at the tree level reached 10,847.185 kg / ha; at the sapling level it reached 11,950,314 kg / ha and at the seedling level it reached 3,797 kg / ha.

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