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Vegetation Structure, Biomass and Carbon Stock of Mangrove Forest in Eastern Pohuwato District, Marisa Sub-District

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ABSTRACT

Mangrove forests are forests that have the potential to mitigate climate change from the effects of global warming, because mangroves can absorb CO_2 in the atmosphere. Mangrove areas in the coastal area of East Pohuwato Regency, Marisa District are quite numerous and have the potential to absorb carbon, so that with a large enough carbon absorption can be able to reduce the levels of CO_2 contained in the air. This study aims to identify vegetation structure, biomass, and carbon stocks in the coastal area of East Pohuwato Regency, Marisa District. The study showed that there were 8 types of mangroves, including Soneratia alba, Rhizophora mucronata, Ceriops decandra, Ceriops tagal, Avicennia marina, Rhizophora stylosa, Sonneratia caseolaris, Rhizophora apiculata. The highest IVi value was found in the Ceriops decandra species with an IVi value of 119.21 in the tree category, then for the sapling category which had the highest IVi value found in the Rhizophora apiculata species of 98.6, for the seedling level the IVi value was found in the Rhizophora apiculata species of 80.23%. The total biomass value is 37,027.2 Kg/ha and the carbon contained in the mangrove forest of East Pohuwato Regency, Marisa District is 18,535.7 Kg C/ha with carbon dioxide absorption of 68027.5 Kg CO_2/ha.
Keyword: biomass, carbon stock, mangrove forest

1. INTRODUCTION

Mangroves are halophytic plants that live in tidal coastal areas, are habitats for various types of microorganisms that are tolerant of extreme environmental conditions, and are places that have ecological, physical and economic functions for fauna life (Yuliasamaya, 2014). The existence of mangrove forests can provide various benefits as a source of materials that can be consumed by the community and so on. Mangrove forests can absorb more carbon from the air through the process of photosynthesis, namely CO_2 from the atmosphere is bound by vegetation and stored in the form of biomass. The mangrove forest area in the coastal area of Pohuwato Regency has an area of 4,244.31 km^2 or about 34.75% of the area of Gorontalo Province (Baderan, 2017). Administratively, this district consists of seven sub-districts with the district capital of Marisa. Mangroves are spread almost evenly throughout the coastal area of Pohuwato Regency. From the results of satellite image interpretation as reported by Ridha Damanik, the mangrove cover area in this district is 7,420.73 Ha, much reduced from the cover area in 1988, which was around 13,243.33 Ha of biomass. The Gorontalo Region XV Forest Area Consolidation Center reported that the mangrove area in Pohuwato district in 2017-2019 decreased to 5,001.47 Ha. The amount of carbon stored in the mangrove forest can be described by the amount of atmospheric CO_2 absorbed by the mangrove forest and converted into vegetation biomass (Iswandar, 2017). Any increase in biomass will be followed by an increase in the amount of carbon and the amount of carbon sequestered from the environment. This shows that mangrove forest areas can reduce carbon emissions, so a study was conducted that aims to determine the vegetation structure, biomass, and carbon stocks of mangrove forests in eastern Pohuwato district, Marisa sub-district.

2. RESEARCH METHOD

The research was conducted in the mangrove forest area of East Pohuwato Regency, Marisa District. Geographically, this research location is located at coordinates 0°27'3" LU. 121°56'36 "BT (Djafar Amna, 2014). Details of the geographical location of the study are shown in the form of a map in Figure 1.

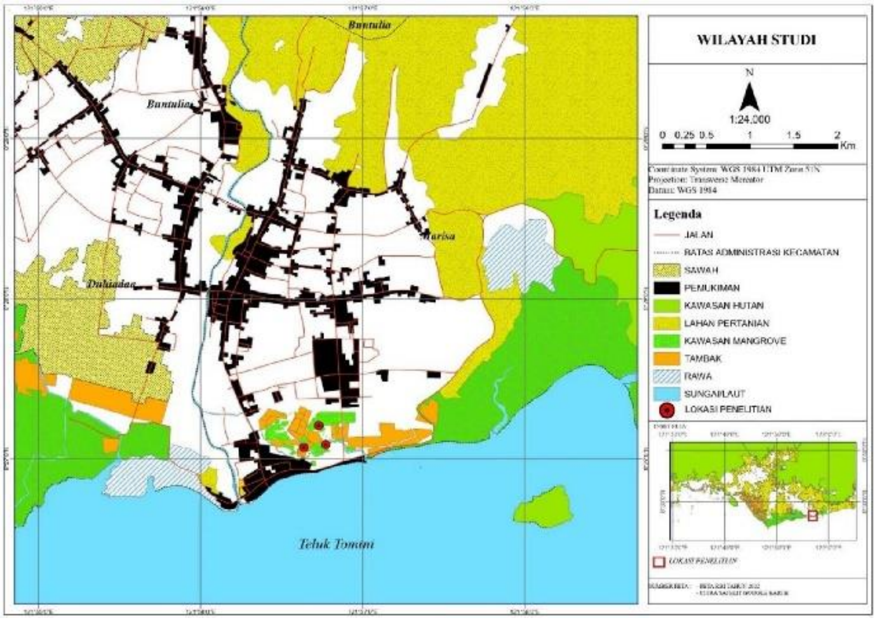

Figure 1 Geographical location of the study

This study used the transect method along 150 meters using role meters with the size of each plot/quadrant 20 x 20 m, 10 x 10 m and 5 x 5 m at 3 stations. At stations 1-3, Diameter at Breast Height (DBH) measurements were made for the tree level (stem diameter ≥ 10 cm) with a size of 20x20 m, stake level (stem diameter 2.1 cm -10 cm) with a size of 10x10 m, seedling level (stand height ≤ 2 cm) with a size of 5x5 m. Measuring the soil pH of the sample area became the basis of the research. Measuring the soil pH of the sample area that became the research location using a Soil Tester. Measuring the ambient temperature of the sample area that became the research location using a Thermometer. Measuring the salinity of water in each sampling area using a Salino Meter. Sampling of mangrove species is done by calculating the value of biomass in the subsurface (stem). In this method, the measurement of tree samples is measured parallel to the diameter at breast height (DBH), which is 1.3 m above ground level. Furthermore, data processing to calculate the biomass below the surface (stem) using the allometric formula (Baderan, 2017; Amanda, 2021).

3. RESULTS AND ANALYSIS

3.1 Mangrove Vegetation Structure and Tree Level Importance Index

The results of the identification of mangrove species found there are 8 types of mangroves found at the research site seen from the level of trees, saplings, and seedlings namely Soneratia alba, Rhizophora mucronata, Ceriops decandra, Ceriops tagal, Avicennia marina, Avicennia alba, Sonneratia caseolaris, Rhizophora apiculate. The species found are included in the Division Magnoliophyta, Class Magnoliopsida, which is divided into 3 orders, namely Scrophulariales, Myrtales, Rhizophorales, and divided into four families, namely Acanthaceae, Senneratiaceae, Lythraceae, Rhizophoraceae, and four genera, namely Avicennia, Sonneratia, Ceriops, and Rhizophora.

The structure of mangrove vegetation in East Pohuwato Marisa District at the tree level at station I is dominated by *Rhizophora apiculate* species with an INP value of 105.85%, frequency 0.2, density 0.001, and dominance of 2532.64. At station II did not find mangrove tree species. The results also showed the highest dominance of tree mangroves, namely the *Rhizophora apiculata* species.

Table 1. Mangrove vegetation structure and important value index at tree level station I

No.	Species	F	FR (%)	K	KR (%)	D	DR (%)	INP (%)
1	Rhizophora apiculate	0.2	33.3	0.001	22.2	2532.64	50.3	105.85
2	Sonneratia alba	0.2	33.3	0.0015	33.3	1267.91	25.18	91.84
3	Rhizophora mucronata	0.2	33.3	0.002	44.4	1233.75	24.5	102.27

Note:

F = frequency
FR = relative frequency
K = density
KR = relative density
D = diameter at breast height (cm)
DR = relative dominance
INP = Important Value Index

Table 2. Mangrove vegetation structure and important value index at tree level station III

No.	Species	F	FR (%)	K	KR (%)	D	DR (%)	INP (%)
1	Ceriops tagal	0.2	33.3	0.001	40	548.48	33.54	93.9
2	Sonnerita alba	0.2	33.3	0.0005	20	336.38	20.57	86.87
3	Ceriops decandra	0.2	33.3	0.001	40	750.39	45.88	119.21

Mangrove vegetation structure at station III is dominated by Ceriops decandra with the highest INP value of 119.21%, frequency of 0.2, density of 0.001, and dominance of 750.39 (Table 2). This shows that Ceriops decandra is an important species in the mangrove ecosystem. High INP values are closely related to substrate conditions that are suitable for some mangrove stands such as Ceriops decandra. Ceriops decandra is tolerant of the surrounding environment and can grow well on the edge of mangroves inland and low salinity areas so that it dominates the mangrove area at station III.

3.2 Vegetation Structure and Importance Index, Value of Mangrove at Stake Level

The structure of mangrove vegetation in East Pohuwato Marisa District at the sapling level at station I is dominated by Rhizophora apiculate species with an INP value of 98.6%, frequency 1.

While Sonneratia alba is a tree-level mangrove species with the lowest INP value at each station, but found at both stations because it has the same frequency value as other species, which is 0.2. Sonneratia alba is one of the most abundant tree species and is often found in mangrove forest areas. Sonneratia alba is the dominant species in the coastal tidal zone. This can occur because the species is able to adapt to various types of substrates so that it has the highest frequency of occurrence at each observation station. density 019, and dominance of 5273.87. These results indicate that Rhizophora apiculate at the sapling level is the main constituent of mangrove vegetation at station I because it has a large frequency of occurrence, with a high level of density and dominance. The most common mangrove found in the sapling category is Rhizophora apiculate. The high density and dominance value of a mangrove species is because each mangrove species

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Table 3. Mangrove Vegetation Structure and Important Value Index at Stake level Station I

No.	Species	F	FR (%)	K	KR (%)	D	DR (%)	INP (%)
1	Rhizophora apiculata	1	17,2	0,19	40,4	5273,87	40,94	98,6
2	Ceriops decandra	0,8	13,8	0,076	16,1	1868,99	14,51	44,47
3	Rhizophora mucronata	1	17,2	0,058	12,3	1471,7	11,42	41
4	Sonneratia alba	1	17,2	0,054	11,4	1504,35	11,67	40,39
5	Avicennia alba	1	17,2	0,042	8,9	1344,4	10,43	36,6
6	Ceriops tagal	1	17,2	0,05	10,6	1423,39	11,05	38,92

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Table 4. Mangrove Vegetation Structure and Important Value Index at Stake level Station II

No.	Species	F	FR (%)	K	KR (%)	D	DR (%)	INP (%)
1	Soneratia alba	1	18,5	0,064	21,3	2220,69	23,71	63,55
2	Rhizophora mucronata	1	18,5	0,056	18,6	1833,91	19,58	56,75
3	Ceriops decandra	1	18,5	0,068	22,6	2098,32	22,4	63,57
4	Ceriops tagal	0,6	11,1	0,02	6,6	555,17	5,92	23,69
5	Avicennia marina	0,2	3,7	0,008	2,6	247,92	2,64	9
6	Rhizophora stylosa	0,4	7,4	0,012	4	303,10	3,23	14,63

Table 4 shows the structure of mangrove vegetation at the sapling level at station II which is dominated by *Ceriops decandra* and *Soneratia alba* species with an INP value of 63%, frequency 1, density 0.06 and dominance of 220.69. These results indicate that the two species are the main constituents of the mangrove vegetation structure in the study site because they have high frequency, density and dominance values. *Ceriops decandra* and *Soneratia alba are* found together in one station and are species with high density, dominance and INP values. INP shows the level of importance that describes a plant species as the main constituent of vegetation in the community and ecosystem. INP provides an overview of the influence of mangrove species on the mangrove community. Table 5 shows the structure of mangrove vegetation at the sapling level at station III which is dominated by *Soneratia alba* species with an INP value of 77.84%, frequency 1, density 0.14 and dominance of 4718.77. These results indicate that the *Soneratia alba* species is the main constituent of vegetation because it has a high INP. The highest INP value in the analysis of mangrove vegetation at the sapling level is *Sonneratia alba*. INP of plant species in a community is one parameter that shows the role of these species in the community. The greater the INP value of a species, the greater the level of mastery of the community and vice versa. The magnitude of the INP value also illustrates the level of influence of a vegetation type on ecosystem stability. Generally, species that have high INP values such as *Sonneratia alba are* able to adapt to areas that have high soil temperatures and soil acidity so that they can grow and develop well.

Table 5. Mangrove Vegetation Structure and Important Value Index at the Stake level of Station III

No.	Species	F	FR (%)	K	KR (%)	D	DR (%)	INP (%)
1	Ceriops tagal	0,4	8,69	0,048	9,52	670,3	4,02	22,23
2	Sonneratia alba	1	21,7	0,14	27,77	4718,77	28,34	77,84
3	Ceriops decandra	1	21,7	0,128	25,39	4469,19	26,84	73,96
4	Rhizophora apiculata	1	21,7	0,076	15,07	2738,29	16,45	53,25
5	Rhizophora mucronata	1	21,7	0,11	21,82	3999,06	24,02	67,57
6	Avicennia alba	0,2	4,34	0,002	0,39	49,76	0,29	5,02

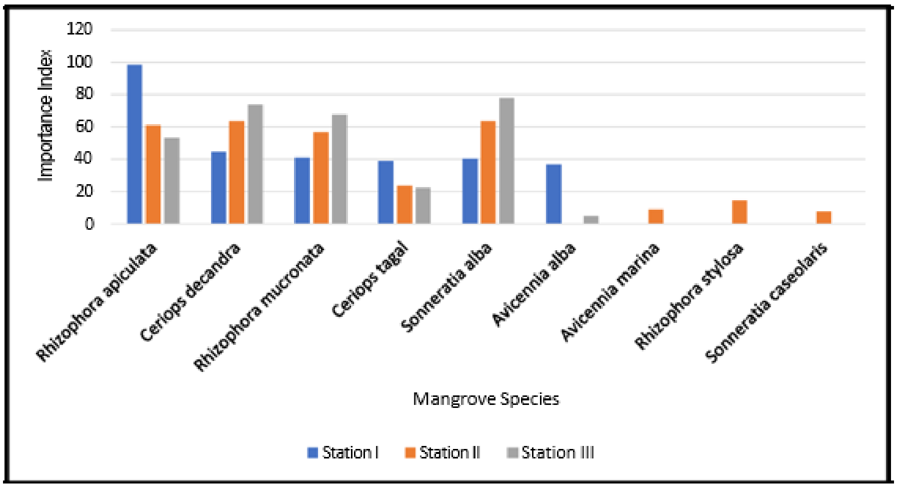

Figure 1. Comparation chart of stake level INP at three stations

3.3 Vegetation Structure and Importance Index, Value of Mangrove at Seedling Level

The structure of mangrove vegetation in East Pohuwato Marisa District at the seedling level at stations I and II is composed by Rhizophora apiculate species with the highest INP values of 80.2% and 70.45%, respectively. High INP illustrates that Rhizophora apiculate has a high level of density, dominance and frequency of occurrence in a mangrove vegetation area. Rhizophora apiculata has the highest INP value in the sapling category. INP is the sum of density, frequency and relative dominance so that it describes the overall structure of vegetation. The Vegetation types with high

INP such as Rhizophora apiculata are categorized as the main constituent of vegetation communities in an area. INP of vegetation species in a community is one of the parameters that show the role of the species in the community. The presence of a type of vegetation in an area shows the ability to adapt to habitat and great tolerance to environmental conditions.

Table 6. Mangrove Vegetation Structure and Important Value Index at the Seedling level Station I

No.	Species	F	FR (%)	K	KR (%)	D	DR (%)	INP (%)
1	Rhizophora apiculata	1	17,2	0,19	40,42	5273,87	40,94	80,23
2	Ceriops decandra	0,8	13,7	0,076	16,17	1868,99	14,51	36,46
3	Rhizophora mucronata	1	17,2	0,058	12,34	1471,7	11,42	53,43
4	Sonneratia alba	1	17,2	0,054	11,48	1504,35	11,67	36,98
5	Avicennia alba	1	17,2	0,042	8,93	1344,4	10,43	41,4
6	Ceriops tagal	1	17,2	0,05	10,63	1423,39	11,05	51,45

Table 7. Mangrove Vegetation Structure and Important Value Index at the Seedling level Station II

No.	Species	F	FR (%)	K	KR (%)	D	DR (%)	INP (%)
1	Soneratia alba	1	19,2	0,248	18,45	206,37	15,91	53,59
2	Rhizophora mucronate	1	19,2	0,288	21,42	285,41	22	62,65
3	Ceriops decandra	1	19,2	0,256	19,04	254,01	19,58	57,85
4	Ceriops tagal	0,8	15,3	0,152	11,30	188,45	14,53	41,21
5	Avicennia marina	0,2	3,8	0,008	0,59	17,91	1,38	5,81
6	Avicennia alba	0,2	3,8	0,032	2,38	17,34	1,33	7,55

Table 8. Mangrove Vegetation Structure and Important Value Index at the Seedling level Station III

No.	Species	F	FR (%)	K	KR (%)	D	DR (%)	INP (%)
1	Ceriops tagal	0,2	4,54	0,056	2,69	32,16	2,24	9,47
2	Sonneratia alba	1	22,72	0,536	25,76	352,87	24,64	73,12
3	Ceriops decandra	1	22,72	0,544	26,15	346,56	24,20	73,07
4	Rhizophora apiculate	1	22,72	0,336	16,15	242,80	16,95	55,82
5	Rhizophora mucronate	1	22,72	0,56	26,92	437,72	30,56	80,2
6	Avicennia alba	0,2	4,54	0,048	2,30	19,74	1,37	8,21

Table 8 shows the structure of mangrove vegetation at the sapling level at station III where Rhizophora mucronata species has the highest INP value of 80.2%, frequency 1, density 26.9 and dominance of 437.7. These results indicate that the structure of mangrove vegetation at the seedling level at station III consists mostly of Rhizophora mucronata species. Mangrove family Rhizophoraceae which dominates a mangrove area can be caused because the family is able to grow optimally in high salinity conditions of 8 - 18 ppt. Family Rhizophoraceae able to survive and grow well in suitable location conditions so that it can dominate an area or mangrove area [24]. Rhizophora sp has the highest mangrove density at the seedling level because the species has a mechanism of rapid seed dispersal to other places, then the seeds take root at the end and anchor themselves in the mud at low tide, then grow upright so that many species can live quickly. Seedlings also have a small diameter, allowing them to grow denser and dominate mangrove areas.

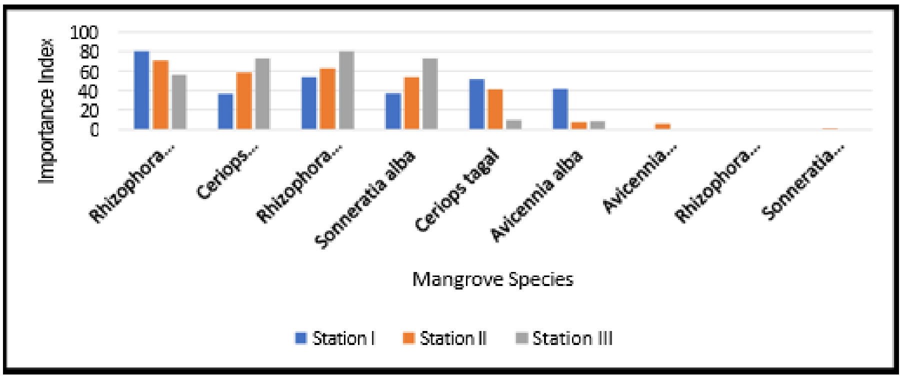

Figure 2. Comparation chart of seedling level INP at three stations

The results of the calculation of biomass, carbon content and carbon sequestration of mangrove vegetation stems and roots in East Pohuwato Marisa District can be seen in Figure 3.

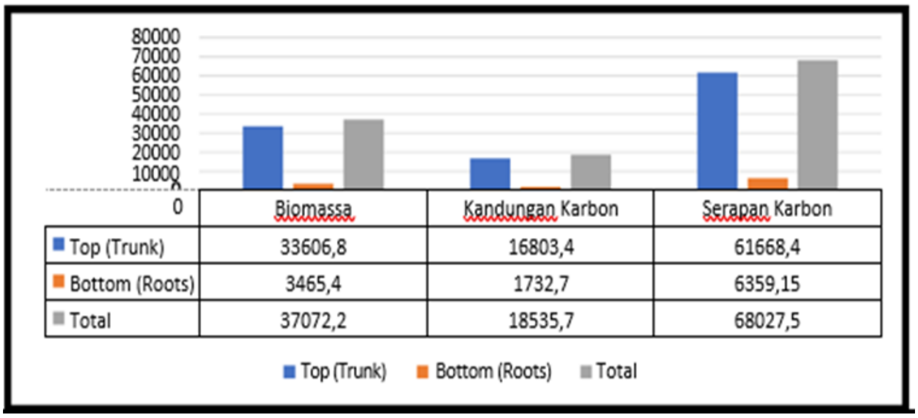

Figure 3. Biomass, carbon content and carbon sequestration

Figure 3 shows that mangroves in East Pohuwato have a total biomass, carbon content, and carbon uptake of 37,027.2 Kg/ha, 18,535.7 Kg C/ha, and 68027.5 Kg CO_2 /ha, respectively. The potential and carbon content of mangrove forests also showed that the total biomass, carbon content and carbon uptake in mangrove forests were 99,724.32 Kg/ha, 39,562.18 Kg C/ha, and 145,230.89 Kg CO_2 /ha. Biomass is the total weight or volume of organisms in an area or the total amount of living matter above the surface on a tree expressed in units of dry weight per unit area. Biomass indicates the potential amount of carbon dioxide released into the atmosphere when trees are felled or burned. Stand biomass is strongly related to mangrove density, diameter, height, weight. Diameter growth through division and regeneration of cambium cells continuously so that the diameter of the tree can determine the value of biomass in the plant.

Carbon content in mangroves is a carbon stock obtained from the process of carbon absorption (CO_2) from the air for the photosynthesis process which is stored in the form of. Biomass is directly proportional to carbon content, where the greater the biomass and the greater the mangrove carbon content. Potential carbon content can be seen from the biomass of existing stands. Along with the growth of a tree stand, it will produce a large value of biomass and stored carbon. Any increase in biomass content will be followed by the addition of carbon content due to the absorption of CO_2 from the atmosphere through the process of photosynthesis produces carbon stored in the form of biomass which is then allocated to all parts of the plant resulting in the addition of diameter and height of the plant. Biomass and carbon content are also related to the ability of plants to absorb carbon. The results showed that there were differences in biomass, carbon content, and carbon uptake in the roots and stems. This can occur due to differences in diameter, where the diameter of the roots is smaller than the tree so that the carbon storage area is also different. The amount of carbon uptake in mangrove species is influenced by the height and diameter of the tree, where the larger the tree, the tree absorbs carbon dioxide from the air through the leaves, twigs, stems, roots which are then carried out in the process of photosynthesis on the leaves, then converting it into organic carbon (carbohydrates) and then storing it in the form of biomass on the trunk, leaves, roots, branches, and twigs. The amount of potential biomass is influenced by the ability of plants to absorb carbon from the environment through photosynthesis, known as the sequestration process. The larger the diameter of the mangrove trunk, the biomass storage of CO_2 conversion results increases so that the more carbon that can be absorbed by mangroves and the amount of carbon content in the mangrove is greate (Maulida, 2016; Nedhisa & Tjahjaningrum, 2019).

4. CONCLUSION

There are 8 types of mangrove species found in the coastal area of East Pohuwato Regency, Marisa District with tree, sapling, and seedling categories, namely Soneratia alba, Rhizophora mucronata, Ceriops decandra, Ceriops tagal, Avicennia marina, Rhizophora stylosa, Sonneratia caseolaris, Rhizophora apiculata. The total amount of carbon biomass in the stems of all types of mangroves in the coastal area of East Pohuwato Regency, Marisa District is 33606.8 Kg/ha, while the total carbon content in all types of mangroves is 18,535.7 Kg C/ha, and the total carbon sequestration capacity of all types of mangroves reaches 68027.5 Kg CO_2 /ha

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