Potential of mangrove stands carbon deposits in the north part Pannikang islands, Barru Regency, South Sulawesi province

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Abstract. Global warming is one of the world's issues today. Global warming is a result of the greenhouse effect because it absorbs infrared light reflected by the earth from the sun. CO₂ gas contributes the most to the greenhouse effect. The solution to the problem of global warming is the presence of forests. One type of forest ecosystem is the mangrove forest ecosystem. This study aims to determine the carbon storage of mangrove stands found on Pannikang Island in the northern part of Barru Regency, South Sulawesi Province. Biomass measurement uses the allometric method performed on mangrove stems by measuring stem diameter in a circle-shaped sample plot of 12.62 m. The results showed that there were ten species found in the study locations: Avicennia alba, Avicennia marina, Bruguiera gymnorrhiza, Bruguiera sexangula, Ceriops decandra, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stilosa, Scyphiphora hydrophyllaceae, and Soneratia alba. The total value of the total stem carbon deposits in the mangrove stands on Pannikang Island in the northern part of Barru Regency reached a total carbon stem portion of 640,512 tons with a maximum range of 859,174 tons and a minimum of 421,871 tons.

1. Introduction
Global warming is one of the issues of the world today. Global warming occurs due to the greenhouse effect that absorbs infrared light reflected by the earth from the sun. This trapped heat then causes the Earth's temperature to increase. CO₂ gas contributes the most to the greenhouse effect. The CO₂ concentration in the atmosphere, coupled with its heating ability, CO₂ contributes around 55%. Other GHG components that fill the atmosphere are as much as 17% methane, 7% nitric oxide, and other gases, including chlorofluorocarbon (CFC) [1]. The solution for the global warming problem is the presence of forests presence.

One of forest ecosystem types is the mangrove forest ecosystem. Mangrove forests are forests that grow in the creek or tides. Mangrove plants are unique because they are a combination of characteristics of plants that live on land and in the sea [2]. Mangrove forest ecosystems can bind carbon much higher than terrestrial forests and tropical rainforests. Mangrove forest has functions and benefits of mangrove forests into three major groups. Physically, can maintain the stability of the...
coastline, accelerate land expansion, protect the coast from river cliffs, and process waste materials. Biologically, are places for spawning and enlarging the seeds of fish, shrimp and shellfish, nesting places and foraging for birds and natural habitats for most biota. Economically, it is one of the coastal areas suitable for fishponds, salt mills, recreation, and wood production [3].

Zainuddin and Gunawan stated that the area of mangrove forests in Indonesia is 25% of the total area of mangrove forests in the world. The area of Indonesian mangrove forests is between 2.5 and 4.5 million ha. Indonesia has the highest level of mangrove diversity in the world, with 202 species of mangroves [4]. Mangrove forests, as well as other forests, have a role as absorbers of carbon dioxide (CO₂) from the air. Absorption of carbon dioxide is closely related to tree biomass. Trees go through and convert them to organic carbon (carbohydrates) and store them in tree body biomass [5]. Based on this, research on the potential carbon storage of mangrove forests in Pannikiang Island needs to investigate. So that the amount of functional capacity of environmental services that can be played by mangrove forests in Pannikiang Island to reduce global warming.

2. Research Methodology

2.1. Time and place
This research was carried out from December 2018 to January 2019. Data collection and samples in Mangrove Forests on the Pannikiang northern island, Madello Village, Balusu District, Barru Regency and data processing conducted at the Faculty of Forestry, Hasanuddin University, Makassar.

2.2. Tools and materials
The tools used in this study were as follows GPS, Suunto Clinometer, roll meters, digital cameras, stationery, the book of mangrove identification.

2.3. Research procedure in the preparation and field observation phase
This initial stage research was carried out through literature studies and field observation activities. Observations will make by land and sea route. The land route by tracing the paths that exist in the mangrove forest area, while the sea route by using a boat, then gathering information from the local community about the mangrove forest area.

2.3.1. Plot making phase. The determination of the number of plots is done using the equation:

\[ \sum \text{Plot} = \text{Sampling Intensity} \times \frac{\text{Region area (ha)}}{\text{Plot Area (ha)}} \]

Where:
\[ \sum \text{Plot} \] = Number of plots
Sampling Intensity = Sampling intensity used 7%
Plot area = 0.05 ha
Region area = 21.40 ha

From the calculation results, showed that the plots to be made at the research location were 30 plots. After the location of the sampling plot is known, the plot placement is determined based on the length and width of the research location so that the laying of the plots can be systematically arranged.

2.3.2. Data collection phase. The measurement phase and data collection carried out in this study include measuring above ground biomass [6].

Preparation

Before making measurements in the field, the equipment that needs to be adequately prepared is:
Field Data Collection

a. Determine the main plot location (Center Plot) which will be used as the starting point of measurement.
b. Line making, 5 lines (Line 1 = 5 plot, Line 2 = 7 plot, Line 3 = 6 plot, Line 4 = 5 plot, Line 5 = 7 plot). The distance between lines is 150m, and the distance between plots in the lane is 50m (Appendix 4).
c. Make a circular plot with a radius of 12.62 m (Figure 1).
d. Then make the next circular plot to reach 30 plots (Figure 2).

Figure 1. Circular plot for tree biomass measuring

Figure 2. Pathways and plots for measuring the biomass of mangrove trees in the northern part of Pannikiang Island
e. Measure the circumference, total height, branch-free height, diameter, and write the name of the type of each tree contained in the plot. Research documentation can be seen in Appendix
f. Record the measurement results and the name of the tree type in the tally sheet provided.

2.3.3. Data analysis techniques.

*Tree biomass calculation*
Carbon storage research was carried out on plots that had been made for vegetation analysis. Carbon calculation is only done on the tree trunk. Data collection includes plant types and circumference measurements to obtain branch free diameter, total height, and height values. Calculation of carbon deposits and CO$_2$ uptake is based on the approach of aboveground biomass, namely by using allometric equations. Tree biomass can be estimated using the allometric equation, which is based on measurements of stem diameter and tree density.

According to Komiyama, et al (2008) allometric general equations for mangrove types are as follows:

$$B = 0.251 \rho D^{2.46}$$

Remarks:
- $B =$ Biomassa (kg)
- $\rho =$ BJ wood (g/cm$^3$);
- $D =$ Tree Diameter (cm).

| Scientific Name                  | Specific Gravity (g/cm$^3$) |
|----------------------------------|-----------------------------|
| *Bruguiera gymnorrhiza*          | 0.741                       |
| *Rhizophora apiculata*           | 1.050                       |
| *Rhizophora mangle*              | 0.830                       |
| *Sonneratia alba*                | 0.078                       |
| *germinans Avicennia*             | 0.661                       |
| *Laguncularia racemosa*           | 0.600                       |
| *Avicennia officinalis*           | 0.670                       |
| *Bruguiera gymnorrhiza*          | 0.860                       |
| *Ceriops decandra*               | 0.960                       |
| *Excoecaria agallocha*           | 0.450                       |
| *Fomes Herttiera*                | 1.074                       |
| *Sonneratia apetala*             | 0.559                       |
| *Xylocarpus granatum*            | 0.700                       |
| *Xylocarpus mekongensis*         | 0.725                       |
| **Average**                      | **0.752**                   |
Calculation of carbon from Biomass

The diameter of the tree influences the biomass amount. The larger the tree diameter shows the higher tree biomass. Increasing the size of the diameter indicates the more CO\textsubscript{2} absorbed by the tree. After obtaining the overall biomass of mangrove forests, the determination of stored carbon is done using conversion rates, which is 46\% of the total biomass. Total biomass is by the concentration of carbon in organic matter is usually 46\% so that carbon deposits can be calculated with total biomass x 0.46 [7].

\[
\text{Stored carbon} = \text{Total Biomass} \times 0.46
\]

3. Results and discussion

3.1. Tree biomass

The research results show that in this research, there were ten types of trees, stakes, and poles, which determined the amount of biomass in the mangrove forest in northern Pannikiang Island. The ten types of mangrove are \textit{Avicennia alba}, \textit{Avicennia marina}, \textit{Bruguiera gymnorrhiza}, \textit{Bruguiera sexangula}, \textit{Ceriops decandra}, \textit{Rhizophora apiculata}, \textit{Rhizophora mucronata}, \textit{Rhizophora stilosa}, \textit{Scyphiphora hydrophyllaceae}, and \textit{Soneratia alba}. Biomass can be divided into two categories, namely above-ground biomass (stems, branches, twigs, leaves, flowers, and fruit) and biomass in the soil (roots). In this study, the measurement of mangrove biomass was carried out on the above ground. Mangrove forest biomass is calculated using tree trunk diameter data. Results Analysis of tree biomass data can be seen in Table 2.

| No | Plot  | Biomass Total (kg/plot) | Biomass Total (ton/ha) |
|----|-------|-------------------------|------------------------|
| 1  | Plot 1| 15007,762               | 300,155                |
| 2  | Plot 2| 7338,096                | 146,762                |
| 3  | Plot 3| 5271,323                | 105,426                |
| 4  | Plot 4| 5205,891                | 104,118                |
| 5  | Plot 5| 6407,098                | 128,142                |
| 6  | Plot 6| 2128,897                | 42,578                 |
| 7  | Plot 7| 3151,488                | 63,030                 |
| 8  | Plot 8| 7527,647                | 150,553                |
| 9  | Plot 9| 1617,534                | 32,351                 |
| 10 | Plot 10| 1507,761               | 30,155                 |
| 11 | Plot 11| 1558,678               | 31,174                 |
| 12 | Plot 12| 952,134                 | 19,243                 |
| 13 | Plot 13| 956,254                 | 19,125                 |
| 14 | Plot 14| 641,428                 | 12,829                 |
| 15 | Plot 15| 1611,392               | 32,228                 |
| 16 | Plot 16| 980,344                 | 19,607                 |
| 17 | Plot 17| 964,171                 | 19,283                 |
| 18 | Plot 18| 5225,996                | 104,520                |
| 19 | Plot 19| 9143,26                 | 182,865                |
| 20 | Plot 20| 4729,668                | 94,593                 |
Based on Table 2., it can be seen that there were 1291 trees in the study location with average biomass of 69.845 tons/ha. So that the total biomass in the northern mangrove stands of Pannikiang Island was obtained at 1392.7093 tons. When compared with the research results on the biomass calculation in the Kemujan Island Mangrove Area Karimunjawa National Park shows that of the 977 fruit trees having biomass of 182.62 tons/ha. this biomass is much greater due to the different trees and tree diameters. The mangroves found in the research locations also differ in diameter in the Kemujaan Island Mangrove Zone. The difference number of mangrove species also influences the amount of biomass.

The research results conducted on plot 1 had the highest biomass content compared to other plots, which amounted to 300.55 tons/ha with 33 total trees and the lowest biomass content in plot 14 which was 12.829 tons/ha with 41 total trees. The high and low value of biomass produced by a mangrove ecosystem was caused by the level of soil fertility and tree density found in the region[8]. The tree biomass value varies in various ecosystems, depending on the diversity and density of existing plants, and how they are managed.

3.2. Carbon trees
After obtaining the overall biomass of mangrove forests, the determination of stored carbon by using conversion rates, which was 46% of total biomass [7]. So that the carbon deposits value was directly proportional to the biomass content. The higher the biomass content, the greater the carbon savings. Results Analysis of tree carbon data can show in Table 3.

| No. | Plot   | Total of carbon (kg/plot) | Total of carbon (ton/ha) |
|-----|--------|---------------------------|--------------------------|
| 1   | Plot 1 | 6903,570                  | 138.071                  |
| 2   | Plot 2 | 3375,524                  | 67.510                   |
| 3   | Plot 3 | 2424,809                  | 48.496                   |
| 4   | Plot 4 | 2394,710                  | 47.894                   |
| 5   | Plot 5 | 2947,265                  | 58.945                   |
| 6   | Plot 6 | 979,292                   | 19.586                   |
| 7   | Plot 7 | 1449,684                  | 28.994                   |
| 8   | Plot 8 | 3462,718                  | 69.254                   |
| 9   | Plot 9 | 744,066                   | 14.881                   |
| 10  | Plot 10| 693,570                   | 13.871                   |
| 11  | Plot 11| 716,992                   | 14.340                   |
| Plot | Plot Number | Carbon Storage (tons) | Carbon Storage (tons/ha) |
|------|-------------|-----------------------|-------------------------|
| 12   | Plot 12     | 437,982               | 8.760                   |
| 13   | Plot 13     | 439,877               | 8.798                   |
| 14   | Plot 14     | 295,057               | 5.901                   |
| 15   | Plot 15     | 741,240               | 14.825                  |
| 16   | Plot 16     | 450,958               | 9.019                   |
| 17   | Plot 17     | 438,919               | 8.778                   |
| 18   | Plot 18     | 2403,958              | 48.079                  |
| 19   | Plot 19     | 4205,899              | 84.118                  |
| 20   | Plot 20     | 2175,647              | 43.513                  |
| 21   | Plot 21     | 554,610               | 11.092                  |
| 22   | Plot 22     | 1105,175              | 22.104                  |
| 23   | Plot 23     | 1408,856              | 28.177                  |
| 24   | Plot 24     | 1106,642              | 22.133                  |
| 25   | Plot 25     | 731,092               | 14.622                  |
| 26   | Plot 26     | 687,919               | 13.758                  |
| 27   | Plot 27     | 668,321               | 13.366                  |
| 28   | Plot 28     | 2608,320              | 52.166                  |
| 29   | Plot 29     | 730,972               | 14.619                  |
| 30   | Plot 30     | 899,947               | 17.999                  |

**Average**

|          | 1606,120 | 1) 32,122 |

The carbon deposits research results in Table 3 show that the highest yield was found in plot one which was 138.071 tons/ha with 23 trees. The lowest results were in plot 14 which was 5.901 tons/ha with 41 trees. The results show that the number of trees the high did not always have high carbon stocks. Stored carbon stocks are determined by biomass that can be observed in the field, which is based on measurements of tree diameters. An observation plot that has trees larger than other plots can indicate that the biomass in the plot is large. So carbon deposits are also abundant as stated by [9] that CO$_2$ absorption has a relationship withstand biomass. An area can obtain the amount of biomass from production and density based on the estimation results of measurements of diameter, or plant height, specific gravity, and density of each tree species, and soil fertility. Another statement by [10] that, the high carbon content in the stem is caused by carbon elements which are organic materials that make up the walls of stem cells. The carbon content of the tree trunk is essential in estimating the carbon potential of stands and is closely related to the measurement of the diameter as one of the measurement indicators.

Based on this research, the total carbon stock in the northern part of Pannikiang Island was 640,512 tons with an average carbon deposit per hectare of 32,122 tons/ha. The carbon deposits on the northern part of Pannikiang Island were categorized as higher compared to the total value of biomass and carbon deposits in the mangrove community of Untia Village, Biringkanaya District, Makassar, with 700,332 tons/ha total biomass value and 350,158 tons/ha total carbon storage value. Based on Asdiron’s research [11].

The content carbon deposits research results were quite high in northern Pannikiang Island when compared with some research results. The carbon deposits size in vegetation depends on the biomass amount contained in the tree, soil fertility, and absorption of the vegetation. The tree trunks size affects biomass so that the amount of carbon also contained influences. The higher the tree stem diameter, the higher the biomass value and the stored carbon content. Basically, on tree trunks that have large diameters, the cellulose content and extractive substances and other polysaccharide
compounds stored in the stem are also getting more significant. The size of these constituents correlates with carbon content [12].

3.3. Average carbon value and estimated confidence interval value

It often appears in the environment in everyday life that cannot be avoided. The problem that often occurs is how these allegations can approach the truth. Hose estimation is the determination of the interval values, called the upper and lower limits. The boundaries are calculated based on the measurement of the sample, and the results have individual opportunities that contain the target parameters. The opportunity is called the level of trust. Hoses produced with a certain level of confidence are called confidence intervals. An estimate that is done is not closed, and an error will likely occur.

| Plot | Total of Carbon (ton/ha) |
|------|--------------------------|
| Plot 1 | 138.071 |
| Plot 2 | 67.510 |
| Plot 3 | 48.496 |
| Plot 4 | 47.894 |
| Plot 5 | 58.945 |
| Plot 6 | 19.586 |
| Plot 7 | 28.994 |
| Plot 8 | 69.254 |
| Plot 9 | 14.881 |
| Plot 10 | 13.871 |
| Plot 11 | 14.340 |
| Plot 12 | 8.760 |
| Plot 13 | 8.798 |
| Plot 14 | 5.901 |
| Plot 15 | 14.825 |
| Plot 16 | 9.019 |
| Plot 17 | 8.778 |
| Plot 18 | 48.079 |
| Plot 19 | 84.118 |
| Plot 20 | 43.513 |
| Plot 21 | 11.092 |
| Plot 22 | 22.104 |
| Plot 23 | 28.177 |
| Plot 24 | 22.133 |
| Plot 25 | 14.622 |
| Plot 26 | 13.758 |
| Plot 27 | 13.366 |
| Plot 28 | 52.166 |
| Plot 29 | 14.619 |
| Plot 30 | 17.999 |
| **Average** | **32.122** |
| **Lower Limit C1** | **21.157** |
Based on the results of the research in 30 research sample plots with 1921 trees, it was obtained that the average carbon value per plot was 32,122 tons/ha. Then a statistical calculation is performed by calculating the confidence interval of 95%. Based on the results, an upper limit value of 43,088 tons and a lower limit value of 21,157 tons was obtained for the research plot sample. So that the maximum total carbon value for the total mangrove stands in the northern part of Pannikiang Island was 859,174 tons and a minimum of 421,871 tons.

4. Conclusion

The composition of the mangrove stands in the northern part of Pannikiang Island consists of 10 species, namely Avicennia alba, Avicennia marina, Bruguiera gymnorrhiza, Bruguiera sexangula, Ceriops decandra, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stilos, Scyphiphora hydrophyllaceae, and Soneratia alba. The total value of the total stem carbon in the mangrove stands reached a total carbon stem portion of 640,512 tons with a maximum range of 859,174 tons and a minimum of 421,871 tons. When compared with carbon researches in other locations, the carbon content in the northern part of Pannikiang Island was high. The northern part of Pannikiang Island was used for fishing settlements. Part of the stand had been cut down which had caused the decline of carbon stocks throughout the northern part of the island.

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