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Estimation of biomass and carbon stock of *Aquilaria microcarpa* in Community Plantation Forest of Langkat Regency

Siti Latifah[1,2*], Nabila Ismi Mumlahanah Daulay[1], Grace Rama Novelyta Br Sembiring[1], Tatasari Cahaya Ningrum[1]

[1]*Faculty of Forestry, Universitas Sumatera Utara, Kampus 2 USU Bekala, Deli Serdang 20353, Indonesia*

[2]*PuskaTrop, Universitas Sumatera Utara, Medan, 20353, Indonesia*

[*]Corresponding Author: sitilatifah@usu.ac.id

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ABSTRACT

Agarwood is a type of non-timber forest product that is well known to communities around the forest and has high economic value. Agarwood plants are also important in absorbing carbon. However, there is still very little information and data regarding the biomass potential and carbon stocks of agarwood plants. This research aims to determine the amount of biomass per tree in Agarwood plants *Aquilaria microcarpa* type. Research conducted in Pekan Bahorok Village, Langkat Regency, North Sumatra Province. The method used is purposive sampling by selecting trees *Aquilaria microcarpa* whose body is normal. Biomass estimation uses allometric models from previous researchers, namely Chave, Ketterings, and Basuki. The tree parameters measured were trunk diameter, total height, and tree mass. The biomass estimation results for *A. microcarpa* aged 8, 10, and 13 years ranged from 3.7 to 25 kg/tree. Meanwhile, the carbon reserves of A. microcarpa range from 1.77 - 11.86 kg/tree.

Keyword: *Aquilaria microcarpa*, Biomass, Carbon, Community Forests

1. Introduction

Forests have a big role in increasing the absorption of carbon dioxide (CO_2), where vegetation containing chlorophyll can absorb carbon dioxide from the atmosphere through the process of photosynthesis with the help of sunlight and water in the soil [1]. With sustainable forests, the amount of carbon (C) stored will increase [2]. Biomass is a carbon storage container or carbon sink. Most biomass consists of carbon (C). The carbon content of plants shows how much carbon dioxide the plants can absorb from the air. The carbon stored in a tree can be determined by first calculating the tree's biomass content. Carbon is an important component of plant biomass from the process of photosynthesis [3].

Agarwood is an important species that is one of the trees that produce Agarwood sapwood and is classified in the group of Non-Timber Forest Products (NTFPs) which have high economic value. Agarwood products have many uses, including as a basic ingredient for the perfume industry, cosmetics, medicines, and religious rituals [4]. The type of gaharu found in Bhorok Village, Langkat Regency which is the focus of this research is Aquilaria microcarpa. Based on the statement [5]. That *Aquilaria microcarpa* Baill. is a genus of plants from the Thymelaeaceae family that can produce aloes. Conventional propagation of Aquilaria plants can be done vegetatively and generatively. Large numbers of uniform Aquilaria plant seeds are difficult to obtain through generative propagation, while seeds obtained vegetatively are quite difficult to adapt to new environments.

Estimating forest biomass is very useful for assessing forest structure and condition and forest productivity [6]. Information regarding the value of biomass reserves is still needed to determine the biomass and carbon stocks of each Agarwood tree found. This is the background for the author's interest in conducting research on Biomass Reserve Estimation *Aquilaria microcarpa* aged 8, 10, and 13 years in Bohorok District, Langkat Regency. This research aims to determine the amount of biomass and carbon per tree of *Aquilaria microcarpa*.

2. Method

2.1. Time and place

The research was carried out in the Community Plantation Forest, Pekan Bahorok Village, Langkat Regency, North Sumatra Province. Geographically, it is located at 03°20'30" - 03°36'51" North Latitude, 88 °36'15" - 98°58'06" East Longitude, and an altitude of 105 meters above sea level. A map of the research location can be seen in Figure 1. The tools used in this research are digital cameras for research documentation, laptops, writing tools, ArcGIS applications to create research location maps, Microsoft Excel software to process data, and SPSS software to carry out data analysis.

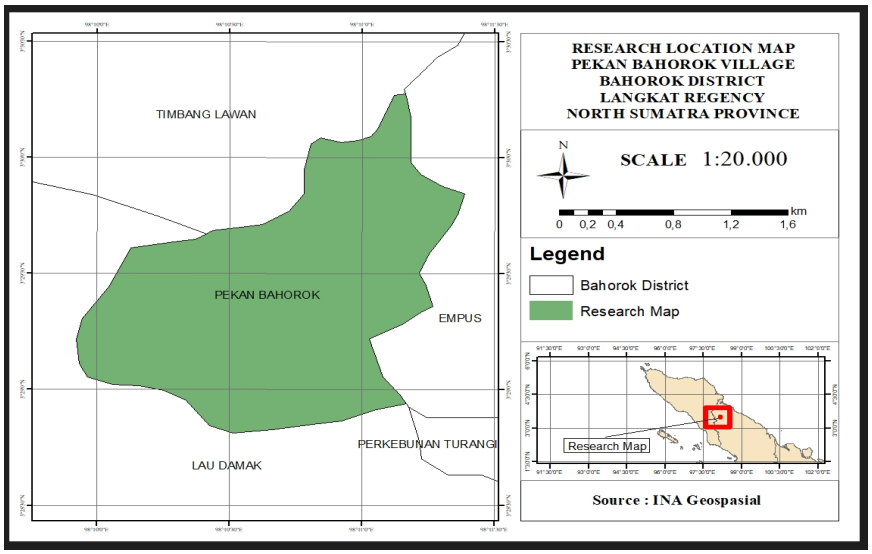

Figure 1. Research location map

2.2. Research procedure

This research was carried out by establishing Agarwood plants *Aquilaria microcarpa* aged 8, 10, and 13 years. Agarwood is planted at a distance of 3 m x 3 m. The method used is purposive sampling, namely deliberately selecting trees with normal growth (not stunted, not burned, not broken/not fallen). Each tree found was measured for its diameter, height, and number.

2.3. Data analysis

Biomass measurements are carried out without destroying vegetation in the research location, which is called the non-destructive sampling method [7]. In this case, biomass estimation uses an allometric equation which is based on the relationship between the diameter and height of the tree and the amount of biomass [8]. Biomass estimation based on global allometric equations is a popular non-destructive method for estimating biomass and sequestered carbon [9]. Calculation of tree biomass uses three allometric equations, namely:

$$B = 0.0673 \text{ x } (\rho D2H)0.976 \quad [12] \tag{1}$$

$$B = 0.11 \text{ x } (\rho D)\ 2.62 \quad [13] \tag{2}$$

$$B = -1.201 + 2.196 \text{ x } (D) \quad [14] \tag{3}$$

Where:
B : tree biomass (kg)
DBH : Diameter at chest height (cm)

ρ : Density of wood (gr/cm^3) = 0.34 gr/cm^3
H : Total height of Tree (m)

The calculation of the average biomass per Agarwood tree is as follows:

$$X = \frac{N}{n} \quad (4)$$

Information:
X : Average biomass per tree
N : Total biomass (Kg)
n : Number of tree samples

2.4. Calculation of Carbon Content

Carbon constitutes 47% of the total biomass in forest vegetation. Calculation of carbon content is calculated using the following formula [15]:

$$Cb = B\ x\ \%\ C - Organic \quad (5)$$

Information:
Cb : Carbon content of biomass (kg/tree)
B : Total biomass (kg/tree)
% C-organic : Carbon percent value (0.47)

3. Results and Discussion

3.1. Soil characteristics at the research location

The results of observations of soil properties at the research location showed that the texture of the soil was dusty clay, the soil structure at a depth of 0-20 cm was granular, while at a depth of > 20 cm, it was lumpy. Based on research [16], the chemical properties of soil in the Bohorok sub-district show that the soil pH is around 5.8 Am; Soil C-organic (%) 0.84 Sr. Aquilaria species have adapted to live in various habitats such as rocky, sandy or chalky habitats, dry slopes, mountains and land near swamps. This species usually grows at an altitude of 0-850 meters with an average daily temperature of 20-22 ºC.

3.2. Height and diameter of Aquilaria microcarpa

Tree height is defined as the shortest distance between a point at the top of the tree or another point on the tree and its projection point on a flat plane on the ground surface [9]. Tree height and diameter are variables for estimating stand biomass. The average height of *Aquilaria microcarpa* aged 8, 10, and 13 years was 9.0 m, 9.2 m and 9.9 m, respectively (Figure 2). Tree diameter is the diameter of the tree trunk measured at a height of 1.3 meters above ground level. Apart from being used to estimate tree biomass, Tree diameter is also used to calculate the basal area value of a stand and tree volume [10]. The average diameter of trees aged 8, 10, and 13 years respectively is 10.60 cm, 10.81 cm, and 11 cm (Figure 3). This is by the age range between trees, the greater the age, the greater the height and diameter of the tree.

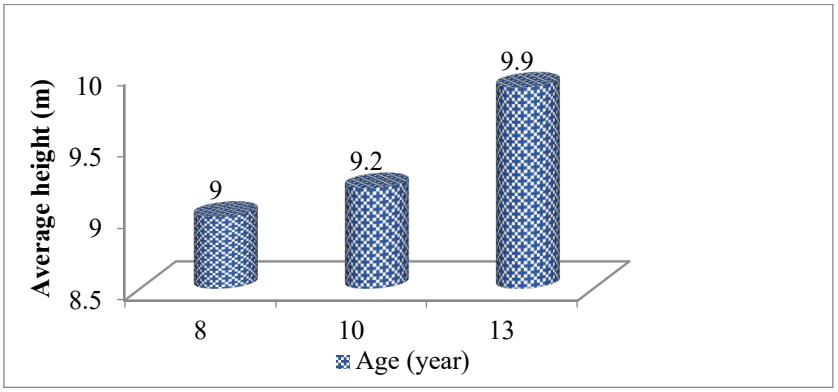

Figure 2. The average height of gaharu trees *Aquilaria microcarpa*

In the *Aquilaria microcarpa* land area, gaharu has different heights even though it lasts this is due to the topographic conditions of the land and the different levels of soil fertility in the area. Some of it is burnt land and some of it is land with lots of undergrowth. This causes trees that live on land with lots of undergrowth to contain lots of nutrients so that the tree growth is higher than trees that live on burnt land. The availability of nutrients in soil that has a lot of undergrowth will stimulate growth in diameter and height in trees [11].

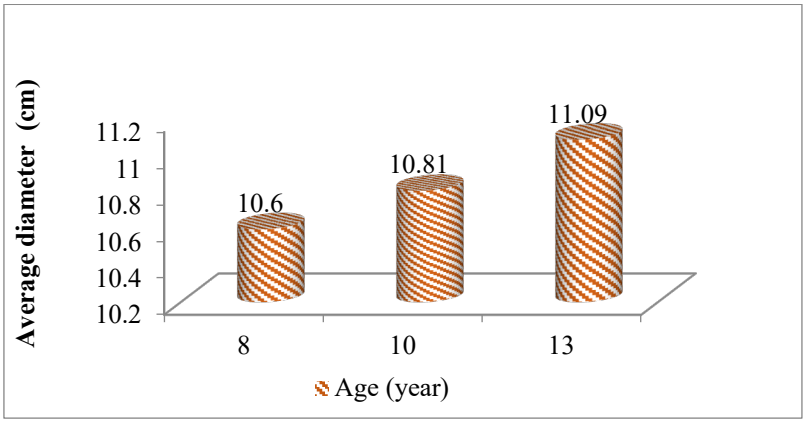

Figure 3. The average diameter of gaharu trees *Aquilaria microcarpa*

3.3. Biomass and Carbon Stocks of Aquilaria microcarpa

Biomass estimation *Aquilaria microcarpa* in community plantation forests was obtained using the allometric equation of previous researchers. Biomass and carbon estimation results in Aquilaria microcarpa have varying values from each of the Allometric equations can be seen in Table 1.

The equation of Ketterings [13] uses two parameters, namely trunk diameter and wood density, while the equation of Basuki [12] only uses one parameter, namely trunk diameter, while the Chave [12] equation already involves 3 parameters, namely trunk diameter, wood density, and tree height so that the accuracy of the Chave equation in biomass estimation is better. Estimation of biomass content from the allometric equation [12] using the diameter and height of the tree, and the wood density based on the Chave formula respectively obtained 21.43 kg/tree; 26.57 kg/tree, and 27.70 kg/tree (Table 1).

Table 1. Biomass and Carbon stocks (*Aquilaria microcarpa*)

Year	Number of plants	Average height (m)	Average diameter (cm)	Biomass (kg/tree)			Carbon (kg/tree)		
				Chave [12]	Ketterings [13]	Basuki [14]	Chave [12]	Ketterings [13]	Basuki [14]
8	49	9	10.6	21.43	3.40	22.08	10.07	1.60	10.38
10	22	9.2	10.81	26.57	3.78	22.55	12.49	1.78	10.60
13	12	9.9	11.09	27.70	4.12	23.16	13.02	1.94	10.89
Average				25.23	3.77	22.60	11.86	1.77	10.62

Biomass estimation uses allometric equations that have been developed by [13] as necessary parameters of the diameter and density of wood. Biomass estimation *Aquilaria microcarpa* for ages 8, 10, and years based on the Kettering formula are 3.4 kg/tree; 3.78 kg/tree, and 4.12 kg/tree respectively. Meanwhile, according to [14] the parameter needed to estimate tree biomass is only tree diameter. Biomass estimation *Aquilaria microcarpa* s for ages 8, 10, and 13 years based on the formula [14] obtained respectively 22.08 kg/tree; 22.55 kg/tree, and 23.16 kg/tree. Biomass estimation *Aquilaria microcarpa* for ages 8, 10, and 13 years based on the Basuki formula respectively amounting to 22.08 kg/tree; 22.55 kg/tree, and 23.16 kg/tree. The increase in biomass of *Aquilaria microcarpa* from 8 to 13 years old based on the Chave, Ketterings, and Basuki formulas were respectively 6.7 kg/tree; 0.72kg/tree, and 1.08 kg/tree.

Furthermore, an estimate of the carbon reserves of *Aquilaria microcarpa* aged 8, 10, and 13 years using the Chafe, Kettering, and Basuki allometric model can be seen in Table 1. To calculate carbon stocks by estimating that the biomass of a stand contains 0.47% carbon [15]. The research results show that the average carbon stocks of *Aquilaria microcarpa* at all allometric ages of Chave, Kettering, and Basuki respectively

11.86 kg/tree, 1.77 kg/tree, and 10.62 kg/tree. The increase in carbon stocks of Aquilaria microcarpa from the age of 8 to 13 years based on the Chave, Ketterings, and Basuki formulas respectively amounted to 2.95 kg/tree; 0.34kg/tree, and 0.51 kg/tree.

Results of biomass and carbon calculations *Aquilaria microcarpa* from the Chave and Basuki allometric models show almost the same values, while the estimation results from the Kettering allometric model show that the values tend to be lower. The amount of biomass content or carbon reserves of stand *Aquilaria microcarpa* is greatly influenced by the size of the stand diameter. This is in accordance with the statement by [16] that the biomass contained and the amount of carbon absorbed or stored in a stand are influenced by the diameter factor. The amount of carbon that can be absorbed by a stand is determined by the increase in the diameter of a stem dimension [19]. According to [20] the value of carbon stocks in the form of biomass shows the amount of carbon that can be absorbed by plants. The increase in the amount of carbon stocks must be balanced with the amount of plant carbon uptake to overcome global warming.

4. Conclusion

The community plantation forest in Pekan Bahorok, Langkat Regency is a forest dominated by agarwood-producing trees. Biomass accumulation uses three allometric equations based on the Chave, Ketterings, and Basuki formulas on *Aquilaria microcarpa* trees. The fewer parameters used indicate a reduction in tree biomass. The average increase in *Aquilaria microcarpa* biomass from 8 to 13 years of age was 2.69 kg/tree, while the increase in carbon stocks was 1.27 kg/tree. Tree biomass and carbon stocks *Aquilaria microcarpa* increase in size with increasing stand age. *Aquilaria microcarpa* trees help store up to half of forest surface biomass, thereby impacting forest governance and climate change mitigation.

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