Potential of carbon stock on red jabon stand (*Anthocephalus macrophyllus* (Roxb.) Havil) in Tampinna Village, Angkona District, Luwu Timur Regency

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Abstract. In addition to producing wood as a raw material for construction, pulp and firewood, forests also serve as carbon sinks so they have an important role in the global carbon cycle. Red jabon is a fast-growing plant species, so it is suspected to have high carbon absorption. The purpose of this study is to know the potential of carbon content and increased uptake of carbon above the soil surface for species of red jabon (*Anthocephalus macrophyllus* (Roxb.) Havil) in the forest Tampinna village community. Methods of data collection in the field is done by census, that is data retrieval as a whole. In the sample tree, the diameter measured at breast height (dbh) and tree height (TBC). Furthermore, the resulting data was processed to determine the biomass produced by using allometric equations. Samples of 302 red jabon trees were obtained from six sites with four different age levels, which were three to six years old. Based on the result of paired observation test of red jabon biomass prediction by using volume formula gives bigger result than allometric equation. The average potential of total carbon uptake in red jabon stands is 19.57125 ton/ha. In general, there is a tendency that the older age of the tree stands to produce a large carbon content as well. Equation of relationship between age with carbon content in the form of quadratic.

1. Introduction

Global warming and climate change are two issues that are often the subject of a public talk in different countries. The causative factors of global warming and climate change are forest damage [1]. Forests have considered being one of the components in carbon emission reduction mechanisms if carried out sustainably because forests as a dynamic system have a huge role to play in the environment [2]. Forests continued to experience a reduction in area (deforestation) of about 420 million hectares worldwide in the period 1990 - 2020 [3]. Forest area also decreases from year to year due to illegal logging, forest fires and encroachment of forest areas due to the conversion of forest land into residential areas, plantations and agriculture [4].

The countermeasures made for the problem are forest rehabilitation programs. Forest rehabilitation can restore, maintain and improve the functioning of forests and land so that their support, productivity, and role in supporting life support systems have to sustain, including through increasing forest capacity in absorbing and storing carbon [5]. Many of the rehabilitation programs carried out were unsuccessful, one of which was the forest rehabilitation carried out in Angkona Subdistrict, East...
Luwu, South Sulawesi Province. The rehabilitation was carried out in 2011 independently by the community by planting red jabon.

Red jabon (*Anthocephalus macrophyllus*) is a type of local plant that has been developed by the community. This type of plant has very fast growth and can thrive in tropical forests and endemic Sulawesi [6,7]. In addition, it is classified as a pioneer plant that can grow in various soil conditions [8]. Red jabon is a type of fast-growing species that should think to have high carbon absorption [9].

Apart from the ecological conditions, the red Jabon plant has been cultivated as a trading commodity on a wide scale, starting from the provision of seeds, nurseries, to processed products. In terms of utilization, Jabon plants are ready to be harvested at the age of 5-6 years. Stems are fairly straight, and relatively more resistant to pests and diseases [10]. Red Jabon belongs to strong class I to II, and its durability is classified as class IV, so that it becomes industrial raw materials, such as pulp and paper, veneer, plywood, furniture industry, and matches [9]. Even the selling price of red Jabon is higher than other fast-growing wood types [11].

One of the developments in Jabon Merah is through community-based programs such as Community Forests (HR) and Community Plantation Forests (HTR). Government Regulation No. 6 of 2007 concerning Forest Management and Formulation of Forest Management and Forest Utilization Plans. This gives hope as an effort to revitalize the forestry sector, reduce poverty and unemployment and increase the contribution of forestry to national economic growth. The development of HTR in the form of an agroforestry pattern with red Jabon as the main crop provides sustainable financial results [11]. Various considerations, the development of red Jabon plants must be carried out in a sustainable manner to be able to meet the ecological needs and economic needs of the community [8]. Therefore, an analysis of the potential reserves and carbon uptake is needed to know the value of the benefits of the community's red jabon.

The research aims to find out the potential for carbon uptake and increased carbon reserves at various ages. The increase in plant diameter is very influential to carbon reserves, the largest diameter greater carbon reserve [12]. Carbon reserves have different quantities in each type of land use [13]. It is influenced by several factors: (a) vegetation factors, including the type, number, density of trees, and (b) environmental factors, which affect the process of photosynthesis and growth, namely water content, fertility, temperature, and sun exposure. This research was conducted in Tampinna village of Angkona Sub-District of East Luwu Regency and expected to be useful as an information material underpinning effort to develop and manage red jabon plants in the future.

2. Material and method

2.1. Research site

This research was conducted in Tampinna Village, Angkona District, East Luwu Regency. The selection of research sites was conducted based on data that one of forest rehabilitation programs that the community successfully conducted was in the angkona sub-district in 2011. Angkona District, Luwu Timur Regency is geographically located between 2° 21' 00" - 2° 40' 22" South Latitude and 120° 52' 02" - 121° 01' 35" East Longitude/ East Longitude. The location of the Angkona District, East Luwu Regency can be seen in Figure 1.
2.2. Methods
This research has been conducting at several community garden locations that have jabon trees in Tamppinna Village. The method of data collection in the field by the census, namely overall data retrieval. Data retrieval with this method due to the area of red jabon stand in Tampinna village is relatively limited, which is approximately 0.25 ha per tile. Tree sample has measured the diameter of the chest (dbh) and the height of the tree (Tuberculosis). Furthermore, the resulting data is processed to determine the biomass produced using allometric equations.

\[Y = 0.010 \times D^{2.999}\]
\[Y = 0.001 \times D^{3.082}\]
\[Y = 0.011 \times D^{2.135}\]
\[Y = 0.014 \times D^{2.958}\]

**Description:**
- **Y**: Above-ground Biomass (kg)
- **D**: Diameter of the chest (cm)

The calculation or the presumption of biomass has calculated using allometric equations, also calculated red jabon biomass using tree volume formula, then conducted a paired observation test to compare the results of two-equation.

\[Y = \text{Weight type } \times V\]
\[V = \frac{1}{4} \times \pi \times (D/100)^{2} \times H \times f\]

**Description:**
- **Y**: Biomassa (ton)
- **Weight Type**: 0.48 (gr/cm³)
- **V**: Volume (m³)
- **π**: 3.14
- **D**: diameter (cm)
- **H**: Tinggi (m)
- **f**: 0.6 (shape factor)
The calculation of carbon from biomass can be done by formula [14]:

\[ C_b = B \times \% \text{C organic} \]

Description:
\( C_b \): Carbon content of biomass, expressed in kilograms (tons);
\( B \): Total biomass, expressed in (tons);
\( \% \text{C organic} \): is the percentage value of carbon content, amounting to 0.47 or using the percent value of carbon obtained from the measurement results in the laboratory.

Calculation of carbon reserve per hectare for above-ground biomass can use the following equations:

\[ \bar{C} = \frac{\sum_{i=1}^{n} C_i}{\sum l_i} \]

Description:
\( \bar{C} \): Average carbon (tons/ha)
\( C_i \): carbon content in the i-th measuring plot (kg)
\( l_i \): the area of the i-th square (ha)

3. Result and discussion

3.1. Description of red jabon

Based on the image above, there are six data capture locations with different ages of three to six years. The maximum lifespan of the red jabon plant in the 2011 rehabilitation program in Tamppina Village is six years. The entire area of the research area at the Red Jabon stand site is 0.54 ha.

Based on the results of community interviews, the red jabon stand when planted has different planting distances such as 4 x 4 m and 3 x 4 m. Based on the table, the red jabon stand has a density ranging from 480 to 657 trees/ha, so it can be concluding that the red jabon stand has not carried out looting.

| Age | Location | Number of Tree | Area (ha) | Average Diameter (cm) | Density (\( \sum \text{Tree/ha} \)) |
|-----|----------|----------------|-----------|-----------------------|-----------------------------------|
| 3   | 2        | 49             | 0.09      | 17.03                 | 544                               |
|     |          | 46             | 0.07      | 17.27                 | 657                               |
| 4   | 1        | 36             | 0.06      | 15.63                 | 600                               |
| 5   | 2        | 66             | 0.13      | 17.71                 | 508                               |
|     |          | 57             | 0.09      | 17.45                 | 633                               |
| 6   | 1        | 48             | 0.1       | 19.52                 | 480                               |

| Total |          | 302           | 0.58      |                       |                                   |

3.2. Biomass potential

Forest biomass has been used to suspect the potential for carbon uptake stored in forest vegetation because 50% of biomass is composed of carbon [15]. Biomass has divided into two categories, namely above-ground and sub-ground biomass. In this study, the measurement has on the above-ground biomass of the red jabon plant. The biomass content of trees is the sum of the biomass content of each tree organ is a total picture of organic material resulting from photosynthesis [16]. Through the
process of photosynthesis, CO in the air is absorbed by plants with the help of sunlight have converted into carbohydrates, then distributed throughout the body of the plant, and stockpiled in the form of leaves, stems, branches, fruits, and flowers [2]. The following data showing the biomass content in each part of the tree has displayed in Table 2.

| Part of Tree       | Age 3 | Age 4 | Age 5 | Age 6 |
|--------------------|-------|-------|-------|-------|
| Stem               | 80.47%| 80.54%| 80.54%| 80.86%|
| Branch             | 10.25%| 10.27%| 10.27%| 10.39%|
| Twigs and Leaves   | 7.27% | 7.15% | 7.12% | 6.56% |
| Total              | 100%  | 100%  | 100%  | 100%  |

The amount of biomass on the Red Jabon tree has a varied size of the tree diameter, which is due to the difference in the value of water content in the sample tree. The smaller amount of water content will affect the amount of biomass. The value of water content is inversely proportional to biomass the highest moisture content will be smaller than the biomass [17].

Biomass in stems has the most general contribution than biomass in other parts. This stem saving most of the reserves of photosynthesis for plant growth [18]. Modeling using a regression between diameter and biomass, as the contribution of the stem part to the total composition of the total biomass is greater than the rest, and also the part of the stem tends to enlarge the percentage.

The sample tree observed is a red jabon tree located in Tampinna village whose access is easy to reach and close to the road. Measurements are carried out thoroughly on the red jabon stand by measuring the height of the tree and the circumference of the tree. After the results from the high value and round of the tree, then calculate the biomass on each sample. Calculation of biomass can be done directly (destructively) and indirectly (non-destructive) using allometric equations. In this study, allometric methods and tree volume equations have been using to perform paired observation tests on both equations. The result of both of the equations in Table 3.

| Age | Plot | Number of Tree | Area (ha) | Stem Biomass (ton/ha) |
|-----|------|----------------|-----------|-----------------------|
|     |      |                |           |                       |
| 3   | 1    | 49             | 0.09      | 33.56                 | 31.67 |
| 4   | 2    | 46             | 0.07      | 41.29                 | 28.43 |
| 5   | 1    | 66             | 0.13      | 43.77                 | 30.69 |
| 6   | 2    | 57             | 0.09      | 43.11                 | 35.33 |
|     | 1    | 48             | 0.1       | 45.1                  | 38.2  |

Description:
1. Total biomass with the branch-free volume equation
2. Total biomass with allometric equations.

Based on the paired observation, the estimated biomass of branch-free trunks is the number of trees as many as 302 red jabon trunks. In general, the equations used that the volume of branch-free bars provides relatively higher biomass results than allometric equations for rods. The results influence by the factor density grows, and the diameter of two different locations.
The other result has been obtained that the higher the value of biomass on rods with a large diameter thought in the value factor density (weight type) of wood. The higher density of wood, the greater the value of biomass in the same volume. Trees with large diameters with older age have a higher density than young trees, so the portion of juvenile wood is higher with characteristics of lower wood density [19].

3.3. Carbon stock
The carbon content of the Red Jabon is obtained based on a defined equation by first calculating the biomass of the plant. The amount of biomass is calculated based on allometric equations. In general, there is a tendency that the older the age of a tree or plant, the carbon content. The relationship between age and quadratic carbon content is expressed in the regression equation \( Y = 18.77 - 1.17x + 0.28x^2 \), where \( Y \) is carbon content, \( x \) is the age of the tree. A graph of the equation has seen in Figure 2.

![Figure 2](image-url)

**Figure 2.** The relationship between age and carbon content in Red Jabon stands.

In addition to density factor and dbh that is the cause of the low carbon content of trees, the location of the place of growth is also influential. According to Mansur and Tuheteru (2010), the environmental conditions in which jabon sprouts are clay soil, Brown Podsollic, and moist Alluvial usually met in riverfront areas, transitional areas between swamplands, and dry land that sometimes inundated with water [20]. Trees that have a large diameter do not always produce large biomass because a watery growing place will produce water content in the tree is also large. Darussalam (2011), which is states that the value of water content is inversely proportional to biomass, the greater moisture content will be smaller biomass [17]. The smaller the biomass of the tree smaller the carbon content.

4. Conclusion
Calculation of Red Jabon biomass using volume formulas provides results than allometric equations. The average total carbon absorption potential in Red Jabon is 19.57125 tons/ha. In general, there is a tendency that the older the tree produces a large carbon content also by using quadratic-shaped equations.

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