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Estimation of Aboveground Carbon Stock in The Pertamina Hulu Rokan (PHR) Forest in Pinggir District, Bengkalis Regency, Riau Province

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Abstract

Extreme climate change affects human life. One of the causes of climate change is the increase of CO_2 gas in the air. Forests can absorb CO_2 from the air and store it in the form of tree biomass through the process of photosynthesis. One of the forests that can absorb and store carbon is Pertamina Hulu Rokan (PHR) forest, therefore it is necessary to conduct research on estimating the carbon content of PHR Forest area. The methods to be used in this research are non-destructive sampling and destructive sampling methods. The method with harvesting is only for seedlings, undergrowth and litter, while for saplings, poles, trees and necromass with the method without harvesting. Aboveground carbon stock in PHR forest was found to be 95.37 tonnes/ha. The largest carbon stocks were from trees (68.96 tonnes/ha), poles (13.06 tonnes/ha), necromas (5.70 tonnes/ha), litter (3.72 tonnes/ha), saplings (3.54 tonnes/ha) and the smallest carbon stocks were seedlings and understorey (0.39 tonnes/ha)

Keywords: *Biomass, Carbon, Forest, Pertamina Hulu Rokan (PHR)*

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INTRODUCTION

Extreme climate change affects human life. Impacts that occur in Indonesia such as floods, landslides and irregular rainfall are often found in every region. Climate change results in global warming. This event occurs due to increased levels of greenhouse gases, especially carbon dioxide (CO_2) and methane (Manuri et al., 2014). In 1750, the CO_2 concentration increased by about 277 parts per million (ppm) (Joos & Spahni, 2008). The beginning of the industrial era in 2018 was 407.35 ppm (Oktian et al., 2021). The 2.58 ppm increase during 2021 is one of the largest increases monitored by NOAA (National Oceanic and Atmospheric Administration) (NOAA, 2022).

Deforestation and other land uses cause an increase in atmospheric CO_2 due to carbon release (Sabine et al., 2013). CO_2 in the atmosphere can be reduced by using the carbon sequestration method, which absorbs carbon in the atmosphere and stores it in vegetation (Husna, 2019). Vegetation has an important role in maintaining climate stability, both terrestrial and marine vegetation by carrying out the process of photosynthesis to storecarbon into biomass (Patil et al., 2014).

Various efforts have been made to reduce carbon emissions. One of the efforts made is by implementing the FOLU Net Sink 2030 (Forestry Other Land Use) scheme. FOLU Net-Sink 2030 is a condition where the carbon sequestration level of the forestry and other land use sectors is balanced or even higher than the level of GHG emissions produced by the sector in 2030 (KLHK, 2022). The Indonesian government's commitment needs to be supported and the amount of potential carbon sequestered and stored in various places such as forests should be calculated (Mawardi et al., 2022.).

Estimating carbon stocks in standing vegetation, especially in forests, has become an urgent issue in efforts to calculate, monitor, manage and evaluate carbon stocks (Dewanto & Jatmiko, 2021). One of the forest areas that is a major store of carbon is the Pertamina Hulu Rokan (PHR) Forest. PHR forest is one of the areas that store and absorb CO_2. The PHR forest is located in the Duri area, Bengkalis Regency, Riau Province. Carbon trading is currently being intensively discussed by the world community. Various studies have been conducted in estimating carbon content through allometric formulation, so that the potential of carbon reserves in a forest area can be known. This is one of the opportunities for PHR forests that have the potential to take part, but for now PHR forests have not known the overall carbon potential stored in them. Therefore, it is necessary to conduct research on estimating the carbon content of the PHR Forest area.

METHOD

Time and Location of Research

The research was conducted in the PHR forest located in Pinggir District, Bengkalis Regency, Riau Province. The research location can be seen in Figure 1. The research was conducted in 2022. This research was carried out in two stages, namely sampling and data collection in the field and curing litter and understorey samples at the Forestry Laboratory, Faculty of Agriculture, Riau University.

Tools and Materials

The equipment and materials needed are: Map, Phi band, GPS (Global Positioning System), stationery, tally sheet, Meter, 1.3 m wooden stick, raffia rope, envelope, scissors, plastic bags, scales and oven, while the research material is PHR forest.

Research Implementation

The methods to be used in this study are non-destructive sampling and destructive sampling. The method with harvesting is only done for seedlings, lower plants and litter, while for saplings, poles, trees and necromas with a method without harvesting.

The types and techniques of data collection in this study were carried out by:

a. Primary Data: direct measurement to the field, namely measuring the diameter, sampling of undergrowth, litter, seedlings and determining the type of tree.
b. Secondary Data: Literature study on the specific gravity of trees and the general condition of the research location.

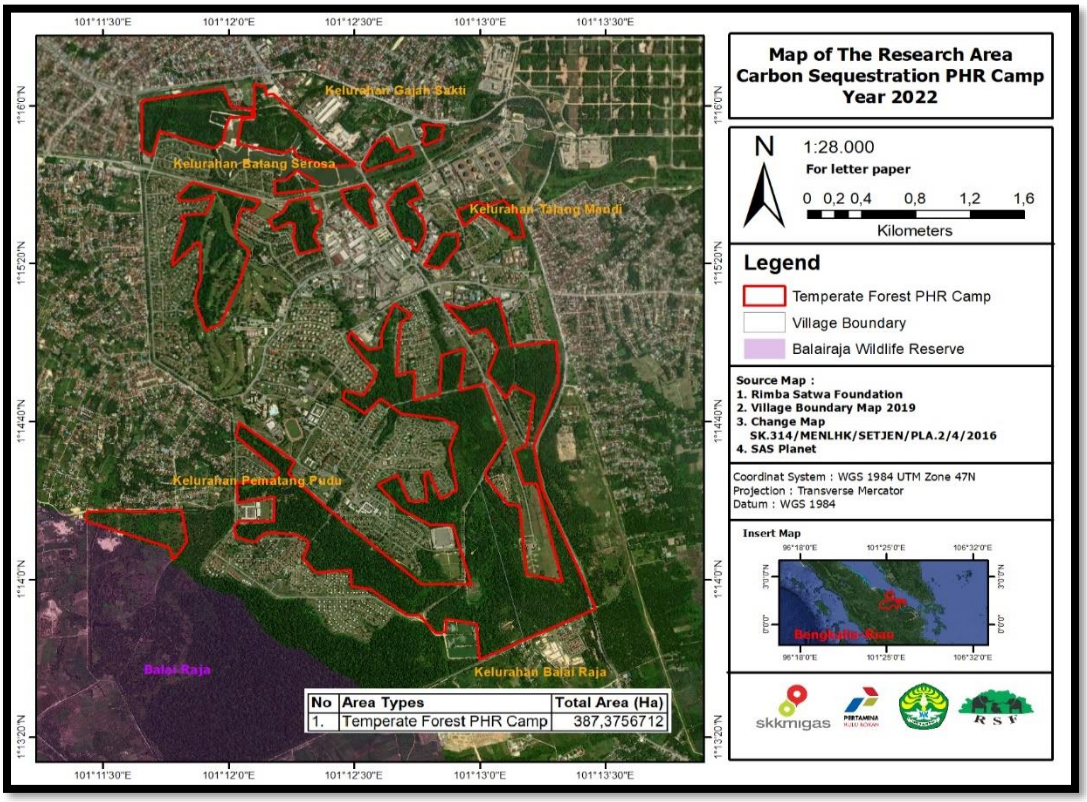

Figure 1. Research location of PHR forest carbon measurement.

The sampling location was determined by purposive sampling method, namely data collection by taking into account the conditions around the research area by considering the accessibility and diversity of species (Husna, 2019). Parameters measured in the field are measurements of tree trunk diameter (diameter at breast height) and species determination. This study used a square plot of 20 m x 20 m, with subplots of the following levels of maturity: Seedlings, understorey and litter with a size of 2 x 2 m, saplings with a size of 5 x 5 m, poles with a size of 10 x 10 m, trees with a size of 20 x 20 m. The shape and size of the plot is adjusted to the size of the plot. The shape and size of the plot is adjusted to the size of the plot in accordance with SNI 7724 for each level of vegetation growth (BSN, 2019). The creation of this plot refers to the modified results of the survey plot according to (Suardana et al., 2023)

Stages of Biomass Measurement

Stake, pole and tree level vegetation were measured for diameter. Measurement of diameter at breast height (DBH) was conducted 1.3 metres above ground level. Suprihatno & Hamidy, (2012) stated that to evaluate allometric biomass and carbon

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stocks, DBH is used against plant height, because there is a correlation between DBH and plant height. The results of diameter measurements were recorded in a tallysheet. The data obtained in the form of diameter and specific gravity were tabulated, then analysed using Microsoft Office Excel software. Primary data obtained in the field in the form of DBH and tree species names will be used to estimate biomass content using the equation of (Ketterings et al., 2001) which is $W = 0.11\ \rho\ D^{2.62}$ where W = Biomass (kg), D = Diameter (cm), ρ = wood density.

Seedlings, understorey and litter were weighed wet in the field and 300 gram samples were taken to be baked at 105^0C for 48 hours. The calculation of organic matter of seedlings, understorey, and litter uses the following formula (BSN, 2019):

$$Bo = \frac{Bks\ x\ Bbt}{Bbs}$$

Description:
Bo is the weight of organic matter, expressed in kilograms (kg);
Bks is the dry weight of the sample, expressed in kilograms (kg);
Bbt is the total wet weight, expressed in kilograms (kg);
Bbs is the wet weight of the sample, expressed in (kg)

The stages of measuring dead tree biomass are carried out by measuring the dbh of standing dead trees and or dead trees that have fallen down. After that, determine the level of integrity of the dead tree and calculate the dead tree biomass with the allometric equation multiplied by the correction factor of the level of integrity of the dead tree.

Carbon content analysis

Carbon reserves or content (C, in kg) were estimated by multiplying biomass by the conversion factor proposed by (Murdiyarso, 2002) as follows:

$$C = 0.50 \times B$$

Where:
C = Carbon content (kg)
B = Biomass (kg) (Half of the biomass is carbon content)

RESULTS AND DISCUSSION

General Situation of the Research Site

PHR forest is located in Mandau sub-district, Bengkalis Regency, Riau Province. The distance between PHR forest and Pekanbaru city is about 130 km. The PHR forest area is classified as a tropical climate with not too high rainfall. Average humidity ranges from 79% - 83%. The average maximum temperature is 32.9°C and the average minimum temperature is 21.3°C. The research location is at an altitude with a range of 25 - 75 m above sea level (mdpl). The topography of the research location is relatively flat to undulating with a slope in the range of 0-15%.

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Carbon Stock at Saplings, Poles and Trees Levels

Trees are the main constituent component of forests that have a role in storing carbon above the soil surface. The larger the diameter of the tree, the more carbon is stored in the forest. However, the larger the diameter of the tree, the fewer the individuals in the natural forest (Pebriandi, 2017; Pebriandi et al., 2017). This occurs naturally due to competition for growing space. The growth level of saplings and poles is an active growth level in growth, so that the ability to absorb carbondioxide from the air through the process of photosynthesis takes place more quickly. Carbon stock at the sapling, pole and tree levels in the PHR forest can be seen in Table 1.

Table 1. Carbon stock in PHR forest at tree, pole and sapling level

No	Carbon Stock	Amount (Tonnes/ha)
1	Trees	68.96
2	Poles	13.06
3	Sapling	3.54

Based on the results in Table 1, it can be seen that tree carbon has the highest amount of carbon stock when compared to carbon stock in other carbon stock sources. Carbon stock in trees is 68.96 tonnes/ha or 72.37% of the total carbon stock. Trees in tropical rainforest are effective carbon sinks and can inhibit the effects of CO_2 in the atmosphere (Ekoungoulou et al., 2014). The larger the diameter of the tree, the greater the biomass contained in the tree, and the more CO_2 the tree absorbs (Dharmawan & Siregar, 2008).

Carbon Stock in seedlings, understoreys and litters

The results showed that the level of seedlings and lower plants is the lowest carbon stock when compared to other carbon stores. This is in line with the results of (Golden Agri-Resources & SMART, 2012) who stated that seedlings and lower plants are not significant enough to increase carbon stock in the forest. However, seedlings and understorey plants are very important components of the forest. Measurement of carbon stock in seedlings and understorey plants requires destructive sampling method, where researchers must harvest, weigh the wet weight and do the oven to get the dry weight. The results of carbon biomass measurements in PHR forests in seedlings, understorey and litter can be seen in Table 2.

Table 2. Carbon stock in PHR forests at the seedling, understorey and litter levels

No	Carbon Stock	Amount (Tonnes/ha)
1	Seedlings and understoreys	0.39
2	Litters	3.72

The amount of litter carbon is high when compared to other research locations. The amount of litter carbon is high because at the research site there are stands dominated by Acacia (*Acacia mangium*). Acacia litter is very difficult to decompose due to the high lignin content in its leaves. This results in the accumulation of litter on the forest floor.

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Litter in high quantities is a potential fuel, so it is hoped that the management can eradicate Acacia stands in PHR forests. Research results in PHR forests show that understorey and seedlings contribute 0.40% of the total aboveground carbon. the results of research by (Mali et al., 2021) show that the decomposition rate of acacia litter average amount of litter by 8.17% gr/month or 98.1 x10^{-6} %. The low decomposition of acacia litter is due to its high lignin composition.

Carbon Stock in Necromas

Necromas are masses of dead tree parts, both those that are still upright (dead trees) and those that have fallen to the ground (dead wood) (BSN, 2019). Necromass is an important source of carbon as a nutrient provider for plants. The results of necromass measurements in PHR forests were found to be 5.70 tonnes/ha. The amount of necromass carbon in the PHR forest is greater when compared to necromass in the Dramaga research forest. The results of (Hendrawan et al., 2014) research in the mineral soil natural forest area found that the amount of necromass in the Dramaga research forest was 0.19 tonnes/ha. The large number of necromasses found in the PHR forest is because part of the PHR forest area is dominated by Akasia stands. Acacia trees with large diameters are found in standing and lying dead.

Acacia is a plant that has invasive properties and releases allelophaty substances, so it can dominate an area. This will have an impact on the elimination of local native plants. This needs to get special attention in handling these conditions. One of the efforts that can be made in overcoming this is to kill Acacia stands and carry out planting activities by selecting species that are resistant to allelophaty substances and are able to compete with these Acacia plants. Forest area managers will generally seek to eradicate Acacia plant species, such as those carried out by the National Park management.

Total Carbon Stock in PHR Forest

Total aboveground carbon stock in the PHR forest is the sum of carbon stock in the vegetation of trees, poles and saplings, seedlings and understorey, litter and necromass. The total carbon stock can be seen in Table 3.

Table 3. Total aboveground carbon stock in PHR forest

No	Carbon Stock	Amount (Tones/ha)	Percentage (%)
1	Trees	68.96	72.31
2	Poles	13.06	13.69
3	Saplings	3.54	3.72
4	Seedlings and understoreys	0.39	0.40
5	Litters	3.72	3.90
6	Necromas	5.70	5.97
	Total	**95.37**	**100.00**

The total aboveground carbon stock in the PHR forest was found to be 95.37 tonnes/ha. The value of carbon contained in PHR forest is higher when compared to secondary forests in Pelalawan with carbon content of 83.49 tonnes/ha

(Rochmayanto et al., 2010). PHR forest has a lower content when compared to the results of research by (Pebriandi et al., 2013) which showed the potential amount of aboveground carbon in Sentajo Protection Forest of 223.17 tonnes/ha. Sentajo Protection Forest and PHR forest are representative of lowland tropical forest ecosystems found in Riau Province. The difference in carbon content in each forest area is due to differences in stand composition and tree diameter in the forest area. The carbon absorption and stock capacity of plants is influenced by their diameter and specific gravity. The larger the diameter of the plant, the greater the carbon content, as well as the specific gravity of the tree, the greater the specific gravity, the greater the carbon content.

CONCLUSION

Aboveground carbon stock in PHR forest was found to be 95.37 tonnes/ha. The largest carbon stocks were from trees (68.96 tonnes/ha), poles (13.06 tonnes/ha), necromass (5.70 tonnes/ha), litter (3.72 tonnes/ha), saplings (3.54 tonnes/ha) and the smallest carbon stocks were seedlings and understorey (0.39 tonnes/ha).

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