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Preliminary Study of Aboveground and Belowground Biomass Estimation in Som Forest Reserve, Jerantut, Pahang

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ABSTRACT

The biomass of trees is a by-product of photosynthesis and carbon sequestration by trees. The study of biomass estimation is the assessment of a forest's carbon stock to determine the ecosystem's carbon accumulation and yield. In the Kyoto Protocol, tree biomass assessment was recognized as an important method to quantify the carbon stock of the forest accurately. Many researchers in Malaysia have conducted extensive research on forest biomass assessment. However, the biomass data in the Som Forest Reserve of Pahang, which is located in the protected forest area in the Jerantut district, has yet to be investigated. Thus, this study aimed to determine the biomass of trees in a Malaysian lowland dipterocarp forest at an altitude of 118-129 meters above sea level. Seven plots with a diameter of 20 m × 50 m were established, and trees with a diameter at breast height (DBH) greater than 5 cm were tagged, and the DBH was recorded. The study was conducted in February 2023. Aboveground and belowground biomass was determined using a non-destructive method, and biomass analysis was performed using the allometric equation. The study plots contained 669 trees with a more than 5 cm DBH. The diameter at breast height (DBH) of the trees in the study area ranged from 5.0 to 116.0 cm. The total basal area in the Som Forest Reserve was 36.82 m^2/ha. The aboveground biomass is 617.06 t/ha, and the total belowground biomass is 81.11 t/ha. Therefore, it is assumed that the total biomass assessed in this study achieves a similar result to other biomass estimation studies conducted in the lowland dipterocarp forest in Malaysia.

INTRODUCTION

Global warming is a long-term increase in the average Earth's surface temperature caused by the accumulation of greenhouse gases (GHG) in the atmosphere. According to the study by the Intergovernmental Panel on Climate Change (IPCC) [1], the sheer intensity of the climate problem and the increasingly severe climatic consequences for humans and ecosystems. The effects of global warming will have a negative impact not only on land ecosystems but also on fresh and salt water. Most of the world's animal populations are threatened by natural disasters such as droughts, floods, fires, habitat

destruction, shifts in the water cycle, and the effects of extreme temperatures. If nothing is done to solve the problem on a global scale, humans will suffer the consequences of competition for resources.

Malaysia has an equatorial climate with constant daily temperature variations throughout the year. The average daily temperature ranges between 26°C and 28°C [2]. There has been a clear upward trend in temperatures over the last half-century. The average surface temperature increases by 0.13°C to 0.24°C per decade [2]. Malaysia is facing a problem that will lead to an average temperature increase of 1.5 °C per month by 2050 [3]. This will result in Malaysia's climate becoming more extreme, with the rainy season becoming more intense and the dry season becoming more severe. This demonstrates that Malaysia needs to take urgent action to mitigate the effects of climate change.

As a developing country, Malaysia has made remarkable progress in utilizing the potential of biomass as a renewable energy source. However, to maximize the benefits of biomass, a complete and accurate estimation of the biomass available in Malaysia needs to be carried out. Tree biomass, in other words, is organic material produced by living or dead plants through photosynthesis. The carbon in the atmosphere is recycled and stored in the trees as biomass. The woody biomass contains about 50% carbon. Carbon dioxide (CO_2) is released into the atmosphere when biomass is burnt. Each nation must report its national GHG inventories, which include estimating GHG emissions and removals from the atmosphere to the United Nations Framework Conventions on Climate Change (UNFCCC) [1]. This also applies to the Kyoto Protocol and the Paris Agreement governments. National GHG inventories are a tool to estimate the global emissions and removals of specific gases from specific sources in specific regions and at a specific time. Biomass is directly linked to GHG, as carbon dioxide is released when biomass is burned. These released gasses contribute to the GHG effect and climate change.

The lowland dipterocarp forest in Malaysia has been well-documented in recent years. However, researchers have not noticed the Som Forest Reserve in Jerantut as there was no report on biomass estimation in this forest. The lack of research in this forest reserve is noteworthy. The preliminary research on biomass assessment in this forest can provide basic data on carbon stocks in the studied region. This research will be very helpful in complementing the data from the total biomass estimation study. This study aims to calculate the biomass accumulation and carbon stocks in the Som Forest Reserve.

EXPERIMENTAL

The Study Area

The research was carried out in Som Forest Reserve, Jerantut, Pahang. Jerantut is a district located 196 kilometers from Kuantan, the capital of Pahang. Jerantut is the largest district in Pahang and is home to the Kuala Keniam National Park. The Som Forest Reserve is a lowland dipterocarp forest. The elevation of the study area ranges from 118 m to 129 m in this study. Som Forest Reserve area has an eco-park with camping, hiking, and bird-watching activities. Som Forest Reserve is home to 26 mammal species protected under Malaysian law. These species include sun bears (*Helarctos malayanus*), Asian elephants (*Elephas maximus*), Malayan tigers (*Panthera tigris jacksoni*), and Malayan tapirs (*Acrocodia inica*). In 2019, the state authority has degazetted an area of 60.75 hectares. This will lead to environmental disturbance as there is a threat of biodiversity loss, and the wildlife will no longer have a place to live, disturbing the area's local population. Figure 1 shows the map of the Som Forest Reserve location.

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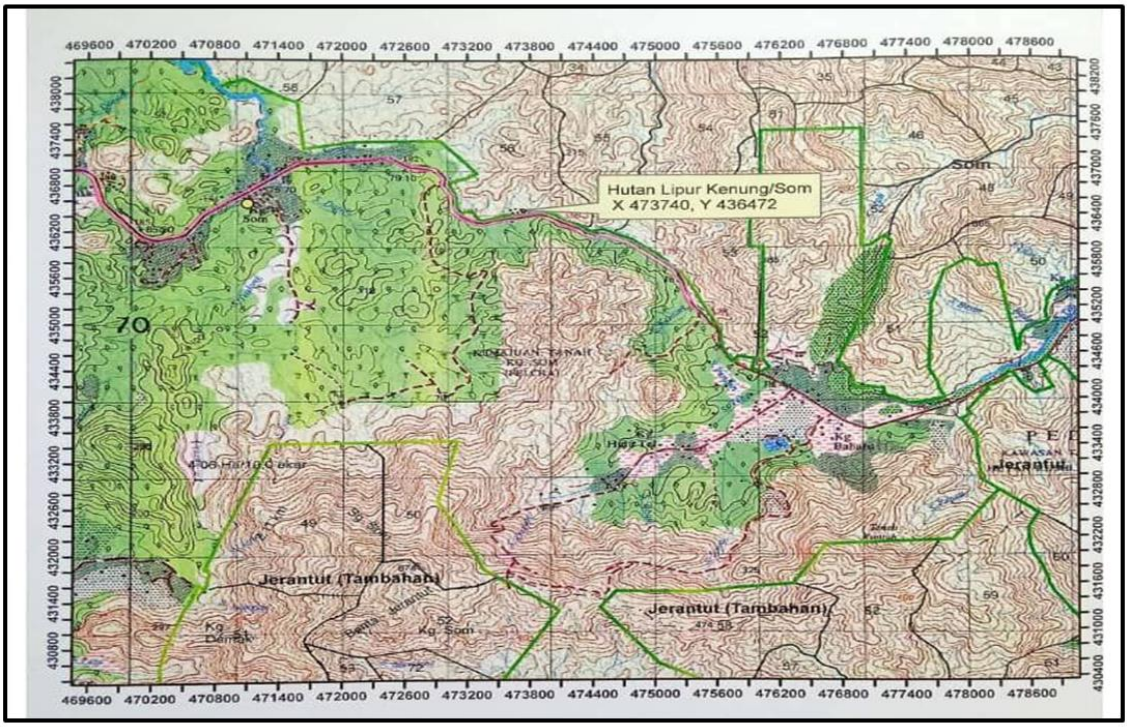

Figure 1. Map of Som Forest Reserve in Jerantut Pahang

Seven plots measuring 20 m × 50 m were laid out with the help of the staff of the Malaysia Forestry Department. The plots were marked with a compass, and the boundaries were marked with tape and a polyvinyl chloride (PVC) tube. The coordinates of the plots were recorded using the Garmin GPSMAP 65s Global Positioning System (GPS). Table 1 shows the plots' coordinates and the plots' elevation in this study.

Table 1: The coordinate and the elevation of the study area

Plots Number	Coordinates	Elevation
Plot 1	N3.946741° E102.259437°	129 m
Plot 2	N3.946916° E102.259731°	121 m
Plot 3	N3.947055° E102.259315°	124 m
Plot 4	N3.946766° E102.254315°	118 m
Plot 5	N3.947174° E102.254564°	119 m
Plot 6	N3.947855° E102.254048°	128 m
Plot 7	N3.947563° E102.253916°	123 m

Data Collection

The trees with a diameter at breast height (DBH) of more than 5 cm and above were counted. The DBH was measured with a DBH meter. The DBH is measured about 1.3 m above the forest floor [4]. After the DBH was measured, the tree was tagged and labeled. The tree was labeled to avoid sampling errors. The tree samples, such as leaves, flowers, or fruits, are collected and taken to the herbarium laboratory for further species identification. The data collection was completed in February 2023.

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Data Analysis

The DBH data measured in the study is presented in a graph, and the frequency of the DBH classes is determined. The DBH is one of the most acceptable parameters for determining the biomass of trees using the non-destructive method. The DBH measurement shows a significant relationship with biomass compared to other variables and is easy to measure [5] accurately. The basal area (BA) of all standing trees in the 0.7 ha area of the study site was determined using the DBH parameter and included in the calculation. The basal area is the cross-sectional area of all standing trees in the study area. The cross-sectional area of the tree is measured at breast height. The assessment of the BA contributes to the information on biomass and also provides important data on the stand structure of the forest. As the tree grows, the BA increases, increasing the total biomass accumulated for the aboveground biomass [6]. The following equation shows the calculation to determine the basal area.

$$\mathrm{BA} = 0.7854 \times (D)^2 \qquad \text{Equation 1}$$

Where BA and D are the basal area and the DBH of the tree respectively.

The aboveground biomass (AGB) consists of tree components such as tree trunks, twigs, and leaves. The belowground biomass (BGB), on the other hand, is the dry mass of the tree roots. The AGB and BGB accumulated in the Som Forest Reserve are determined using a non-destructive method. Kato's allometric equation is used to estimate AGB, while Niiyama's is used to determine BGB. The following equations (2) to (5) show the calculation [7], while equation (6) is the allometric equation [8].

$$\mathrm{Ws} = 0.313(D^2H)^{0.9733} \qquad \text{Equation 2}$$

$$\mathrm{Wb} = 0.316(\mathrm{Ws})^{1.070} \qquad \text{Equation 3}$$

$$\mathrm{Wl} = \frac{(125 \times 0.124 \times \mathrm{Ws}^{0.794})}{(0.124 \times \mathrm{Ws}^{0.794} + 125)} \qquad \text{Equation 4}$$

$$\text{Total above ground biomass} = \mathrm{Ws} + \mathrm{Wb} + \mathrm{Wl} \qquad \text{Equation 5}$$

$$\text{Root biomass} = 0.0262 \times D^{2.497} \qquad \text{Equation 6}$$

Where Ws, Wb, and Wl are the weights of the stem, branch, and leaves, respectively. D and H in the equation indicate the DBH value and the height of the individual trees. The total AGB is determined by the sum of Ws, Wb, and Wl and then divided by 1000 to convert to the unit of t/ha.

The carbon stock of the study site in the Som Forest Reserve is evaluated using the conversion factor of the Intergovernmental Panel on Climate Change (IPCC) [1]. The carbon in the forest is mainly stored in the form of living biomass, and in the soil, only a part is in coarse wood. The following equation (7) is the conversion factor used to determine the carbon stock above and below ground in the forest [1].

$$\text{Carbon stock} = \text{Total biomass estimated} \times 0.47 \qquad \text{Equation 7}$$

RESULTS AND DISCUSSION

The distribution of the DBH

There were 669 trees with a DBH of more than 5 cm. The DBH of the trees in the study site ranged from 5.0 cm to 116.0 cm. The DBH is divided into 12 DBH classes with an interval of 10 cm. The classes consist of Class 1: 5.0 cm to 14.9 cm; Class 2: 15.0 cm to 24.9 cm; Class 3: 25.0 cm to 34.9 cm; Class 4: 35.0 cm to 44.9 cm; Class 5: 45.0 cm to 54.9 cm; Class 6: 55.0 cm to 64.9 cm; Class 7: 65.0 cm to 74.9

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cm; Class 8: 75.0 cm to 84.9 cm; Class 9: 85.0 cm to 94.9 cm; Class 10: 95.0 cm to 104.9 cm; Class 11: 105.0 cm to 114.9 cm and Class 12: > 115.0 cm.

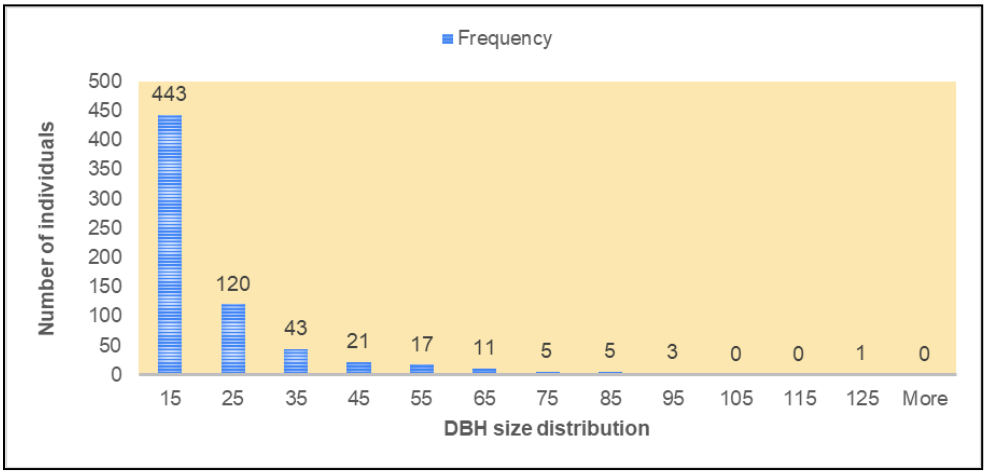

Figure 2. DBH distribution of the stand structure in the Som Forest Reserve.

Figure 2 shows the distribution of stand structure based on DBH in Som Forest Reserve. There were 443 individual trees belonging to Class 1: 5.0 cm to 14.9 cm, followed by 120 individual trees belonging to Class 2: 15.0 cm - 24.9 cm DBH. There was only one tree with a DBH of more than 100.0 cm. *Shorea ovalis* was the largest tree in the study plots, with a DBH of 116.0 cm. The distribution of DBH class versus the number of individual trees in Figure 2 shows an "inverted J-shape," which is common for lowland dipterocarp structures [9,10]. The number of trees decreases as the DBH class increases. This condition also applies to other forest types, for example, hill dipterocarp stands [11] and island forests [12]. This trend is common for tropical rainforests in the regeneration or climax forest in Peninsular Malaysia [13], where the number of seedlings and saplings dominates the small DBH class [14].

Basal Area

The total basal area of all trees in the study area was 36.83 m^2/ha. In comparison, other studies conducted in lowland dipterocarp forest reported 30.53 m^2/ha in Hulu Langat Forest Reserve [15], and 32.05 m^2/ha were recorded in Sungai Lalang Forest Reserve [16]. The basal area of a mature tropical rainforest is between 36 and 46 m^2/ha, while unmanaged forests in Peninsular Malaysia usually have a basal area of 32.00 m^2/ha, as claimed by Ramos [17]. The basal area differs from one habitat to another due to differences in altitude [18], species composition [19], and the developmental stage of the tree in the study area [20]. According to a study by Nor Farika [21], a high value of tree basal area in a study area indicates a more stable community.

Biomass Estimation and Carbon Stocks

The estimated biomass in Som Forest Reserve was 698.17 t/ha. The total estimated AGB in the study area was 617.06 t/ha, representing 88.38 % of the total biomass, while the BGB accumulated in the study area was 81.11 t/ha. The estimated total biomass of trees in the Som Forest Reserve is higher than the biomass estimates of several biomasses in Malaysia. For instance, in a study conducted in hill dipterocarp forest in Bukit Lagong Forest Reserve and a twice-cleared forest in Perak, the total biomass was found to be 525.20 t/ha [11] and 279.20 t/ha [22], respectively. Natasha [16] conducted in the

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lowland dipterocarp of Sungai Lalang Forest Reserve found a slightly higher value than this study, with an estimated total biomass of 768.98 t/ha. According to [23], in India's tropical semi-evergreen forests, the larger trees account for 49% of AGB in natural forests, while smaller trees account for 76% of AGB in plantation forests. A study conducted by [4] found that smaller trees can contribute up to 300 Mg ha^{-1} of AGB. On the other hand, another contributing factor to forest biomass is the age and density of the forest [5]. As mentioned earlier, the different composition of tree species leads to differences in stand structure, resulting in variations in the total amount of forest biomass [24].

The total amount of carbon stocks in the study area was calculated to be 328.14 t/ha, divided as follows: 290.02 t/ha were accounted for by aboveground carbon and 38.12 t/ha by belowground carbon. This study found a lower carbon stock than lowland dipterocarp in Kuala Keniam, Taman Negara, and Pahang, where the carbon stock in the study area was estimated to be 448.68 t/ha [25]. Previous studies in dipterocarp lowland forests, hill dipterocarp forests, and riparian forests in Taman Negara, Pahang, revealed lower carbon stock compared to total carbon in Som Forest Reserve, where total carbon was estimated to be 207.88 t/ha, 161.67 t/ha, and 289.52 t/ha, respectively [26]. Conducting well-characterized biomass estimates is important as it contributes to the efficient conservation and sustainable management of forests [27].

CONCLUSION

This study shows that the Som Forest Reserve is a lowland dipterocarp forest in which a large amount of biomass has accumulated. The total biomass estimated in this study is comparable to other biomass estimation studies conducted in lowland dipterocarp forests in Malaysia. To assess the total carbon pools in Som Forest Reserve, soil carbon and dead organic matter in the study areas must be estimated. In addition, soil analysis needs to be conducted to determine the influence of edaphic factors on total biomass and carbon stocks in Som Forest Reserve.

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CONFLICT OF INTEREST STATEMENT

The authors agree that this research was conducted without any self-benefits or commercial or financial conflicts and declare the absence of conflicting interests with the funders.

AUTHORS' CONTRIBUTIONS

Nur Yasmin carried out the research and wrote and revised the article. Nurun Nadhirah and Liliwirianis supervised the research progress, anchored the review and revisions, and approved the article submission.

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