

# Stand structure and carbon storage of Bukit Lawang's tropical rain forest of Gunung Leuser National Park

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**Abstract.** Deforestation and forest degradation are the main contributors to climate change. Changes in the structure and composition of forests affect the value of biomass and carbon storages. Bukit Lawang's tropical rainforest of Gunung Leuser National Park which has great potential is not only a habitat for key species, namely the Sumatran orangutan (*Pongo abelii*) but also has other biodiversity values. This study aimed to determine the vegetation structure and to estimate the value of standing carbon storage of the forest. The vegetation structure was analyzed by the line transect method and the estimation of biomass and carbon storage values was carried out using an allometric model. Distribution of diameter classes is dominated by trees in the 30-50 cm diameter class, with B strata dominated by *Aglaia tomentosa* tree species. The value of standing biomass is 523.2-562.2 t/ha, carbon storage is 261.6-281.1 t C/ha and the amount of CO<sub>2</sub> gas absorbed is 960.0-1,031.6 t CO<sub>2</sub>/ha. The results indicate that it is necessary to do better forest management ecosystems in Bukit Lawang to improve and maintain the ecological and economic functions of these ecosystems in order to support the implementation of REDD + in efforts to mitigate climate change in Indonesia.

## 1. Introduction

Gunung Leuser National Park (GLNP) gained international recognition as a Biosphere Reserve in 1981 and as a world heritage in 2004 designated by UNESCO through the Man and Biosphere (MAB) program and the World Heritage Committee [1, 2]. The recognition shows that GLNP has important values in various ways, especially for science, and humanity in a broad sense. Tropical rain forest of Bukit Lawang which is part of GLNP has great potential, not only as a habitat for key species of Sumatran orangutan (*Pongo abelii*) [1, 2] but also has other biodiversity values.

Tropical rain forest is rich in carbon storage [3], has high species diversity [4] and abundant litter [5]. Deforestation and forest degradation are the main contributors to climate change. The GLNP area has experienced deforestation of 18,089 ha, and degradation of 142,087 ha [6]. Changes in the structure and composition of forest stands affect the value of biomass and carbon stocks. Until 2006, attention to the value of forest carbon in CO<sub>2</sub> mitigation has focused on planting activities in the form of afforestation and reforestation (AR) which is a clean development mechanism (CDM) sourced from the Kyoto protocol [7]. Then, it extend into reducing emission from deforestation and forest degradation (REDD) and subsequently, REDD and forest conservation (REDD+).



In order to support and implement REDD + requires a strong scientific basis as an effort to mitigate climate change in Indonesia. This can be done through identification of carbon deposits in the forest. However, carbon storage and biomass values in natural forests are not well known, including the forests in Bukit Lawang. Therefore, this research aimed to determine the structure of vegetation and estimate the value of carbon stock in the Bukit Lawang forest using an existing estimator model.

## 2. Materials and Methods

### 2.1. Study site and period

This research was conducted in Bukit Lawang forest as part of Gunung Leuser National Park (Figure 1) in North Sumatra from November 2017 to April 2018. Bukit Lawang Forest is the first orangutan rehabilitation station in Indonesia that was established in 1979 [1, 2].



**Figure 1.** Study area of Bukit Lawang Forest of Gunung Leuser National Park

### 2.2. Data collection and analysis

Vegetation data collection in the study area was carried out using the plot line method with a plot size of 20 m x 20 m [1, 7, 8]. The length of the line transect in data collection was 1000 meters as many as 4 line transects. The diameter of the tree measured was diameter at breast height (DBH), which is at height of 1.3 m from the ground surface (non-buttressed trees) and 20 cm above buttresses (buttressed trees).

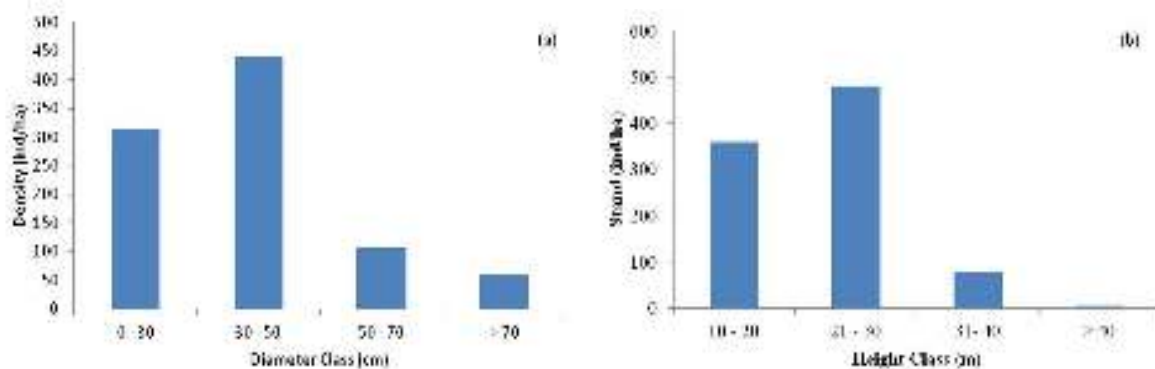
Estimation of the value of biomass was carried out using allometric models that already exist and are suitable for tropical forests. The allometric model used was  $W = 0.118D^{2.53}$  according to Brown equation [9] and  $W = 0.071(D)^{2.667}$  as equation of Manuri et al. [10], where  $W$  is the tree biomass (kg), and  $D$  is the DBH value (cm). The value of carbon content ( $C$ ) of tree biomass is calculated using

the formula  $C = 50\%$  of tree biomass [11]. The carbon value obtained is then calculated the amount of  $\text{CO}_2$  absorbed using the formula  $\text{CO}_2 = C \times 3.67$  [12].

### 3. Results and Discussions

#### 3.1. Vegetation structure

Standing trees in the Bukit Lawang forest consisted of a mixture of all diameter classes (Figure 2). The distribution of diameter class was dominated by trees in the diameter class of 30-50 cm and its density continues to decrease for the diameter class of  $> 50$  cm. Trees in the diameter class of 30-50 cm consisted of 144 species and were dominated by *Aglaiia tomentosa* species of 181 species of trees found in four 3.8 ha all sampling plot. Distribution of tree diameter 50-70 cm was dominated by *Shorea parvifolia* species.



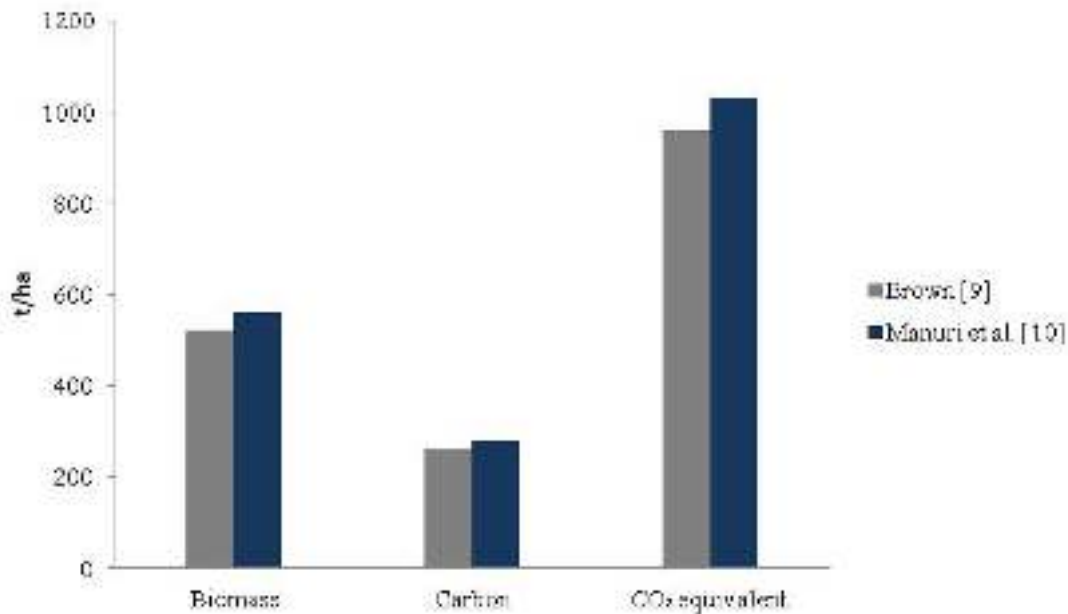
**Figure 2.** Distribution of tree diameter class (a), and tree height class (b) at Bukit Lawang Forest.

Based on high class (Figure 2b), Bukit Lawang forest is dominated by trees with a high class of 21-30 m. The maximum tree height found in the Bukit Lawang forest is 46 m at the trees of *Ficus fistulosa* (Moraceae). The minimum tree height is found in 2 tree species, namely *Alseodaphne bancana* and *Baccaurea sumatrana* with a height of 10 m. Based on diameter class, Bukit Lawang forest is dominated by 30-50 cm diameter class (Figure 2a) and then its density decreases with increasing diameter class. This gives an illustration that conditions in the forest are experiencing disruption which causes the loss and reduction of trees that have large diameters. Besides having an impact on the loss of carbon storage, it also has an impact on the loss of biodiversity and disturbance to animal habitats.

Trees in the Bukit Lawang forest (Figure 1b) are mostly included in strata B, which is the second canopy layer from the top formed by trees 20-30 m high. The shape of the B stratum crown is rounded, elongated but not wide. Canopy stratification in the Bukit Lawang forest starts from stratum A to stratum C only. Canopy layer has a significant role in preserving the balance of the forest ecosystem, especially as erosion control.

#### 3.2. Forest biomass and carbon storage

The results of forest biomass estimation using 2 allometric models namely Brown [9] and Manuri et.al [10], showed almost similar results, but there was a tendency that the estimation with the Manuri et.al [10] model had higher results. Standing trees in Bukit Lawang forest have aboveground biomass of 523.2-562.2 t/ha, then aboveground carbon storage of 261.6-281.1 t C/ha and  $\text{CO}_2$  equivalent at 960.0-1,031.6 t  $\text{CO}_2$ /ha (Figure 3, Table 1 and 2).



**Figure 3.** Aboveground biomass, carbon storage and CO<sub>2</sub> equivalent of standing trees of Bukit Lawang Forest

**Table 1.** Aboveground biomass and its distribution of standing trees of Bukit Lawang Forest

Diameter class (cm)	Aboveground Biomass			
	Brown model [9]		Manuri et al. model [10]	
	(t/ha)	(%)	(t/ha)	(%)
0-30 cm	9.9	1.9	9.7	1.7
30-50 cm	358.4	68.5	378.8	67.4
50-70 cm	142.0	27.1	159.4	28.3
>70 cm	12.8	2.4	14.3	2.5
Total	523.2	100.0	562.2	100.0

**Table 2.** Aboveground carbon storage (ACS) and CO<sub>2</sub> equivalent (CO<sub>2</sub>e) based on diameter class of Bukit Lawang Forest

Diameter class (cm)	Brown model [9]		Manuri et al. model [10]	
	ACS (t C/ha)	CO <sub>2</sub> e (t CO <sub>2</sub> /ha)	ACS (t C/ha)	CO <sub>2</sub> e (t CO <sub>2</sub> /ha)
0-30 cm	6.4	23.5	7.1	26.2
30-50 cm	5.0	18.3	4.9	17.8
50-70 cm	179.2	657.6	189.4	695.1
>70 cm	71.0	260.6	79.7	292.5
Total	261.6	960.0	281.1	1031.6

Stand biomass is very dependent on the tree diameters that compose it, where if tree diameter increases the stand biomass will increase along with equivalent carbon and CO<sub>2</sub> deposits (Tables 1 and 2). Tree biomass with a large diameter also produces low necromass. Palace [13] states that as biomass increases in high density forests, the proportion of necromass will decrease.

The average of aboveground biomass in primary rainforest in Indonesia by Brown [9] is 533 t/ha. According to aboveground biomass calculation of the Bukit Lawang forest that estimated by Brown equation [9] shows the Bukit Lawang forest is experiencing disturbances. Forest degradation causes loss of tree composition and disruption of forest structure. Forest disturbance results in the loss of trees, especially trees with large diameters, which means the loss of carbon storage from forest stands. However, if using biomass estimation by Manuri et al. [10] the aboveground biomass of Bukit Lawang

forest is much higher than the Amazon forest area [13, 14] and the JICA [15] stated that ranges from 356.2-376.6 t/ha, carbon storage in tropical forests in Asia varies between 40-250 t C/ha for vegetation and 50-120 t C/ha for soil.

#### 4. Conclusions and Recommendations

The results of this study indicated that the Bukit Lawang forest has a high carbon stock, which this forest is important in mitigating climate change. Therefore, it is necessary to make better management of forest ecosystems in Bukit Lawang to improve and maintain the ecological and economic functions of these ecosystems in order to support the implementation of REDD + in efforts to mitigate climate change in Indonesia.

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