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Estimation of Carbon Stock in the Ecotourism Ecosystem of Proboscis Monkeys Conservation Area Pt Antang Gunung Meratus

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Abstract: Peatland ecosystems provide a range of environmental services and biodiversity through their ability to store and sequester carbon. One of them is an ecotourism area for probosci's monkeys with the aim of protecting endemic Bornean animals. Fires and increased land clearing, realised or not, have a negative impact on the local environment in the form of land degradation and a wider (global) impact in the form of loss of carbon stocks and increased GHG emissions that can trigger global warming. This study aims to identify carbon distribution in the PT AGM proboscis monkey ecotourism area. The research was conducted in the PT AGM conservation area which had a fire in 2015. The results showed an increase in C-Stock and a change in succession towards secondary forest. The amount of carbon stock available is 12.35 tonnes/ha.

Keywords: Carbon stock, ecotourism ecosystem, proboscis monkeys, conservation area, pt antang gunung meratus

I. INTRODUCTION

Tropical peatlands are an integral part of the Earth's terrestrial biosphere and have been an important part of the global carbon cycle since the Middle Paleozoic, as evidenced by continental coal deposits [1;2]. Peat bogs are comprehensive wholes with a variety of functions that interact in shaping balance, stability, and productivity [3].

Peat swamp forest is one of the important natural ecosystems. [4] stated that peat swamp forests have climate control functions through their ability to absorb and store carbon. Peat swamp forests are carbon-rich both above ground and below ground. Indonesia's peatland area of approximately 14.91 million ha is the largest peatland in the tropics [5]. It is mainly distributed in Sumatra (6.4 million hectares), Kalimantan (4.8 million hectares) and Papua (3.7 million hectares).

Over the past three decades, peatlands have been extensively developed for oil palm plantations, making Indonesia one of the world's largest producers of palm oil and causing deforestation. Despite being a global palm oil producer, this has implications for large-scale land use change from peat swamp forest to other forms of agriculture and non-agriculture.

Indonesia's peat swamps are forested and offer many benefits, including water supply, protection of endangered endemic species such as orangutans, tigers and elephants, protection of fish for local livelihoods, and twice the carbon storage capacity of forests. of ecosystem services. This makes peat bogs a rare but important ecosystem [6-8] [1-3]. Among the ecosystem services of peatlands, climate regulation is the most important due to their high carbon stocks per unit area, with total carbon stocks estimated at over 75 billion tons [9,10][4, Five]. Other studies have shown that peat bogs and their soil organic carbon account for approximately 30% of global soil organic carbon [11,12][6,7]. Another study estimates that primary peat swamp forests on mineral soils in Asia store on average 12 times more carbon, with an average peat depth of 5.5 m [13] [8]. About half of the world's tropical peatlands are estimated to be in Southeast Asia, with 14.9 million hectares in Indonesia alone and a carbon reserve of about 13.6-40.5 billion tons [14][9].

The probosci's monkey ecotourism area is located in the gelam swamp forest of Tapin Regency on the side of the Muning River Canal. This canal is managed by PT Antang Gunung Meratus (AGM) which is engaged in the business of exploiting coal from Mount Meratus. The area of the Proboscis Monkey Ecotourism in Lawahan village was initially only 11 ha, then continued to be expanded until now it has reached 74.4 ha from the target area of 90 ha (based on the Decree of the Tapin Regent in 2014). In 2015 the area caught fire which caused a lot of loss of vegetation above it and in 2016 the area was restored.

Estimating peat swamplands' biomass and carbon stock still needs to be done, especially on burnt areas, as biomass plays a very important role in carbon sequestration. In addition, the protection and maintenance of peatland reduce CO2 levels [15; 16; 17] (Heriyanto and Subiandono 2012; Onrizal and Kusmana 2009; Subiandono et al. 2013). Developed countries must reduce carbon dioxide (CO2) emissions as part of the Clean Development Mechanism. In contrast, developing countries, most of which are located in tropical regions, must prevent deforestation to reduce global warming (Astiani et al. 2017; Lugina et al. 2011). The purpose of this study was to obtain information about the carbon content of the probosci's monkey ecotourism area in the PT Antang Gunung Meratus conservation area.

II. METODE

The research was conducted in February - March 2023 in the gelam swamp forest proboscis monkey ecotourism area located along the PT Antang Gunung Meratus (AGM) Canal, Tapin Regency, South Kalimantan (Figure 1). The sampling in this study used Non-Destructiv sampling or without logging. This method includes measuring the diameter of trees as high as 1.3 m from the ground and using the appropriate allometric equation to estimate biomass. Sample plots in this study were divided based on density, namely low, medium, and high density. Each density consists of 3 observation plots with a size of 20m x 100m. The total area of the observation sample is 1.8 ha with a total of 45 observation plots. Each measuring plot is made a subplot size of 10m x 10m used to collect pole data, a subplot size of 20m x 20m used to collect data on trees with diameter at breast height (DSD) ≥ 10 cm, while the size of 1mx1m to take samples of litter. Sample plots with systematic sampling are placed based on the density shown in Figure 2.

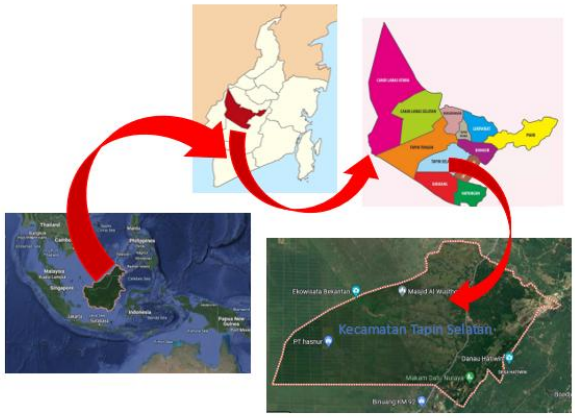

Figure 1: Research location

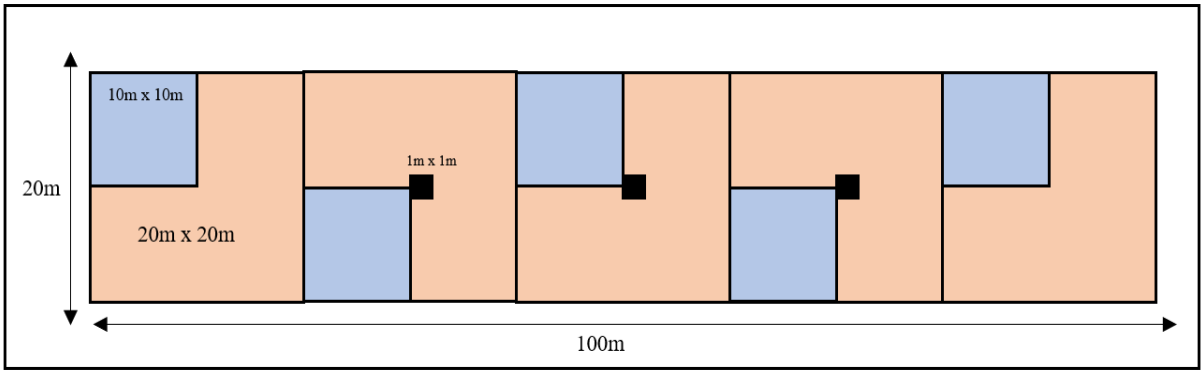

Figure 2: The shape of the research plot

The diameter at breast height of each individual tree was recorded. Tree-level biomass was estimated using the allometric equation W = 0.1886 ρ D2.3702 with R2=95%, developed by Istomo (2002) in the peat swamp forest of PT Diamond Raya Timber, Rokan Hilir Regency, Bengkalis, Riau Province [18-21] (Ketterings et al., 2001; Istomo, 2002; Murdiyarso et al., 2004; Hairiah et al., 2011).

The understorey biomass and litter was calculated by cutting and weighing all the total weight, taking a sub-sample of ± 200 g and weighing the wet weight. Furthermore, the snippets were dried in an oven at 80°C for 48 hours and weighed dry weight.

The carbon content of each biomass was calculated using the formula C = 0.47 W [22] (IPCC, 2006). The total above-ground carbon was then calculated by summing up the carbon content of all density classes.

III. RESULTS AND DISCUSSIONS

Vegetation Types in the Proboscis Monkey Ecosystem of PT AGM Conservation Area

The probosci's monkey ecotourism area is managed by PT AGM and the Tapin Regency Government. Geographically, the proboscis monkey ecotourism area is located at 3°0"20" - 3°0"59" N.E. and 115°2"25" - 115°3"16" East with a length of 1.3 km and a width of 1.1 km. The area is located on the side of the Muning Riverr canal. Proboscis monkey ecotourism is an area with a type of gelam swamp forest. The gelam swamp forest on the side of the Muning River Canal is dominated by gelam (Melaleuca leucadendron) and associated with several species of shallow swamp plants such as pulantan (*Alstonia angustifolia*), mangobi (*Decaspermum fruticosum*) and jelutung (*Dyera castulata*). The probosci's monkey ecotourism area has undergone restoration since early 2015, therefore there are several species that have been deliberately planted such as bungur (*Lagerstomia speciosa*) and moon wood (*Endospermum malaccense*). The swamp is also dotted with lotus plants, rat purun, several types of weeds, and water hyacinth. Some types of vegetation found in the probosci's monkey ecotourism area can be seen in Table 1.

Table 1: Vegetation in the PT AGM Proboscis Monkey Ecotourism Area

No	Local Name	Scientific Name	Habitus
1	Galam	*Melaleuca cajuputi*	Tree
2	Pulantan	*Alstonia angustifolia*	Tree
3	Kayu bulan	*Endospermum malaccense*	Tree
4	Bungur	*Lagerstomia speciosa*	Tree
5	Mangobi	*Decaspermum fruticosum*	Tree
6	Jambu hutan	*Syzigium ssp*	Tree
7	Pantung/ Jelutung	*Dyera castulata*	Tree
8	Kelakai	*Stenochlaena palustris*	Ferns
9	Parupuk	*Phragmites karka*	Tree
10	Wlingi	*Scirpus grossus*	Herb
11	Karamunting	*Melastoma malabathricum*	Shurb
12	Banta	*Leersia hexandra*	Herb
13	Bilaran	*Lindernia diffusa*	Herb
14	Kait-kait	*Uncaria acida*	Shurb
15	Kersen	*Muntingia ssp*	Tree
16	Lambok / Keladi	*Colocasia esculenta*	Herb
17	Paku hijau	*Blechnum indicum*	Ferns
18	Papisangan	*Jussieua erecta*	Herb
19	Melati-melatian	*Jasminum*	Shurb
20	Jungkal	*Crinum asiaticum*	Herb
21	Kumpai minyak	*Hymenachne acutigluma*	Herb
22	Ilalang/gelagah	*Saccharum spontaneum*	Herb
23	Kasisap/kremah	*Alternanthera sessilis*	Herb
25	Saringsing	*Benstonea kurzii*	Shurb
26	Rumput menjangan	*Eupatorium odoratum*	Herb
27	Ketapi	*Sandoricum koetjape*	Tree
28	Waru	*Hibiscus tiliaceus*	Tree
29	Nanangkaan	*Ficus sp*	Tree
30	Sengon	*Albizia chinensis*	Tree
31	Sangkuang	*Dracontomelon dao* (Blanco)	Tree
32	Petai	*Parkia speciosa*	Tree
33	Belangeran	*Shorea balangeran*	Tree
34	Kasisap	*Dipteracanthus sp*	Herb

Carbon Reserves Ecosystem Ecotourism Proboscis Monkeys PT AGM Conservation Area

The calculation of biomass and carbon in the proboscis monkey ecotourism area was carried out in 3 types of density, namely low, medium and high density. Based on Tapin Regent Decree No. 188.45/060/KUM/2014, the area of important value for proboscis monkey (*Nasalis larvatus*) conservation is 90 ha and only 74.4 ha has been realised by PT AGM. Based on the results of the Normalised Difference

Vegetation Index (NDVI) interpretation of the 2021 image, the proboscis monkey ecotourism area is divided into three land covers based on stand density, namely low density, medium density and high density. Table 2 shows the area of each density.

Table 2: Extent of proboscis monkey ecotourism area based on stand density class

Density Type	Area (ha)
1. High Density	27.6
2. Medium-density	39.1
3. Low density	7.7
Total	74.4

Biomass is the weight per unit area consisting of the weight of leaves, flowers, fruits, branches, twigs, trunks, roots, and dead trees [23]. Wood density, diameter, height, and soil fertility are variables that can affect the amount of biomass [24,25] (Dharmawan 2013; Siregar and Heriyanto 2010). Biomass estimation affects the carbon cycle, especially in tropical plantations [26,27] (Heriyanto et al. 2019; Putri and Wulandari 2015). Forest biomass contains about 47% carbon (IPCC 2013). In addition, biomass data are very useful for evaluating the productivity of various ecosystems [28,29] (Chave et al. 2014; Natalia et al. 2014). Young tree plants have a good chance of binding and reducing carbon dioxide in the air. Older trees grow more slowly than younger trees. Through the metabolic process of nucleic acids, lipids and proteins are converted into plant organs after undergoing the photosynthetic mechanism of carbon dioxide, and water is converted into carbohydrates [30] (Campbell et al. 2002).

The total tree biomass contained in the gelam swamp area in the PT AGM proboscis monkey ecotourism with a total of 45 observation plots was 26.11 tonnes. The highest value for tree biomass content was found in high density with a total of 7.05 tonnes. This situation is due to the fact that in high density conditions there are many trees with pole vegetation levels, thus providing a higher estimated value compared to medium and low density. Figure 3 shows the estimated amount of tree biomass contained in the study area. The estimated understorey biomass obtained at the study site can be seen in Figure 4, where the highest understorey biomass was obtained at a high density level of 0.088988 tonnes.

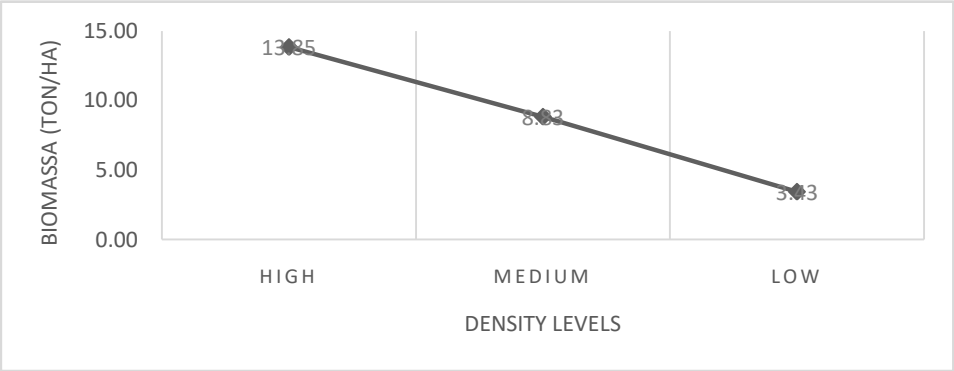

Figure 3: Estimation of tree biomass in the PT AGM proboscis monkey ecotourism area

Figure 4: Estimation of understorey biomass in the PT AGM proboscis monkey ecotourism area

The carbon content of a tree species is highly dependent on the number, diameter and height, as well as the specific gravity of the wood [31]. Based on the area of the samples taken, 12.35 tons/ha of carbon stocks were obtained. Figure 5 shows the results of calculating aboveground carbon stocks in the probosci's monkey ecotourism area of PT AGM. The carbon stock in PT AGM's probosci's monkey ecotourism is much better than the calculation results in PT Jorong Barutama Grestone's galam swamp forest in Tanah Laut, which is 7.85 tonnes/ha [32]. When compared with the potential for the carbon stored in mangrove stands in Pagatan Besar [33] of 18.85 tons/ha, the carbon value in the PT AGM probosci's monkey ecotourism area is relatively smaller.

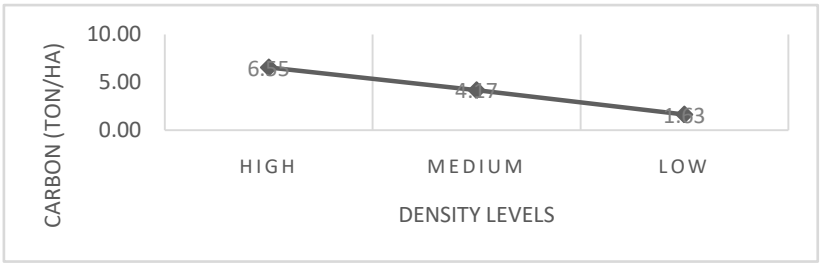

Figure 5: Estimated carbon stock (tonnes/ha) in PT AGM's proboscis monkey ecotourism

The results of this study when compared with the results of measurements of carbon stocks in the peat swamp forest in the conservation area of PT Nasional Sago Prima (NSP) Kepulauan Meranti Riau [33] of 24.06 tons/ha, the carbon stocks in PT AGM's proboscis monkey ecotourism are smaller, this is because the area is much different, the dominant vegetation types are tree species and poles with a diameter of >20 cm and there are types of vegetation originating from the Dipterocarpaceae family, namely *Shorea rugosaand Shorea teysmanniaa*, the two species have higher biomass and high carbon value. After converting to the area of each stand density, the final carbon stock value is 356.45 tons with details as shown in Figure 6. Overall the proboscis monkey ecotourism area has experienced a succession from burnt areas to secondary forests.

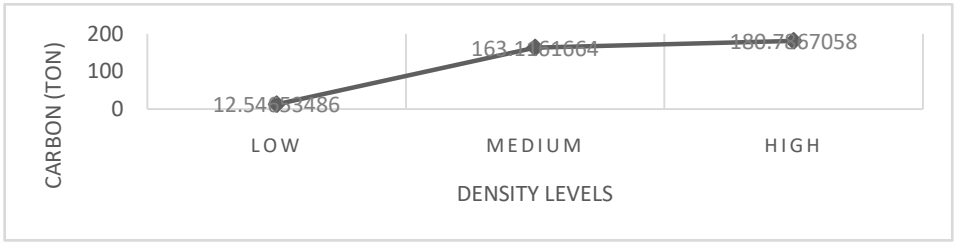

Figure 6: Estimation of carbon stocks (tons) in the PTAGM proboscis monkey ecotourism

To increase the carbon value, land rehabilitation and restoration is still needed, especially on land with low and medium density. PT AGM can plant several types of plants that have a high specific gravity, for example from the Dipterocarpaceae family, namely the species Shorea balangeran and ramin. Both types are endemic to peat swamps and can be a source of food for proboscis monkeys *(Nasalis larvatus*) in the area.

IV. CONCLUSION

The peat swamp forest in the proboscis monkey ecotourism area of PT Antang Gunung Meratus is a burnt forest with a large proportion of its flora consisting of galam. The area has important value for conservation. The value of biomass and carbon content in the ecotourism area of PT AGM was 26.28 tons/ha and 12.35 tons C/ha. This value is still below the range of biomass and carbon content in primary peat swamp forest. The forest fires that occurred in 2015 have reduced the current forest biomass. However, with land restoration activities that have been carried out by PT AGM, the area has shown an improvement direction towards secondary succession.

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