E-ISSN : 2986-0326, P-ISSN : 2986-089X
DOI: https://doi.org/10.38035/gijes..v1i2
Received: 29 July 2023, Revised: 19 August 2023, Publish: 3 September 2023

GIJES
Greenation International Journal of Engineering Science
+62 81210467572 https://research.e-greenation.org/GIJES egreenation.info@gmail.com
GREENATION Research

Carbon Reserve Potential, Carbon Dioxide Absorption Capacity, and Oxygen Release in The Conservation Forest of Kamojang, West Java

Dadang Maulana Abdul Ghani[1], Raizal Fahmi Solihat[2], Sri Wilujeng[3]
[1]Fakultas Kehutanan Universitas Winaya Mukti Sumedang, Jawa Barat, Indonesia
[2]Fakultas Kehutanan Universitas Winaya Mukti Sumedang, Jawa Barat, Indonesia, email. raizal.fahmi@gmail.com
[3]Fakultas Kehutanan Universitas Winaya Mukti Sumedang, Jawa Barat, Indonesia

Corresponding Author: raizal.fahmi@gmail.com

Abstract: This research aims to identify and measure the carbon reserve potential, carbon dioxide absorption capacity, and oxygen release of tree vegetation in the conservation forest area of Kamojang, West Java. The research method includes field data collection by measuring tree biomass and specific gravity analysis, using systematic sampling techniques to determine research plots. The results of the study indicate that the Cikaro and Cibeunying blocks have a potential carbon reserve of approximately 202,577 tons, a karbon dioxide absorption capacity of around 742,781 tons, and an oxygen release of about 540,132 tons. Tree species such as Pinus (Pinus merkusii), Kibeureum (Dystilium stellare), Manglid (Maglietia glauca), Puspa (Schima wallichii), and Ki Badak (Fagraea fragrans) contribute the most to the total carbon amount. This research provides essential information for the management of the Kamojang conservation forest area in forest management policies as a crucial carbon reserve source for climate change mitigation.

Keyword: Conservation forest, Carbon reserve, Carbon absorption, Oxygen release.

INTRODUCTION

Background

Indonesia's forest areas possess vast potential in terms of biodiversity, including flora, fauna, and other natural resources. According to data from the Directorate General of Forestry and Environmental Planning of the Ministry of Environment and Forestry (2019), monitoring results show that Indonesia's forest land covers 94.1 million hectares or 50.1% of the total land area. The extensive forests in Indonesia offer potential benefits in terms of biodiversity, wildlife, and other sectors such as nature tourism and potential natural energy resources. This necessitates the implementation of a zoning mechanism in Indonesia that aligns with the characteristics and potential of these areas. Conservation forest areas play a crucial role in climate change mitigation as forests act as natural carbon sinks, helping to reduce carbon emissions in the atmosphere.

In the current era of global climate change, addressing issues like global warming and climate change is of utmost urgency. One of the efforts to mitigate the impact of climate change is to identify and understand the role of ecosystems in carbon sequestration and carbon dioxide absorption.

The greenhouse gas effect is one of the consequences of land degradation, deforestation, and environmental pollution. The greenhouse gas effect leads to increased concentrations of carbon dioxide (CO_2), Chloro Fluoro Carbon (CFC), nitrogen dioxide (N2O), methane (CH4), and freon (SF6, HFC, and PFC) in the atmosphere. According to data from the United States National Aeronautics and Space Administration (NASA), the average concentration of carbon dioxide in the global atmosphere reached 417.6 parts per million (ppm) on May 17, 2022. This concentration has increased by 50% compared to the beginning of the industrial era in 1750, with a rise of approximately 6.2% from the year 2011. The consequences of the increasing concentration of carbon dioxide in the atmosphere include rising global surface temperatures, leading to global climate change, natural disasters, and potential disruptions to economic activities.

Research Objective

This study aims to identify and measure the potential carbon reserves, carbon dioxide absorption, and oxygen release in the tree vegetation of the Kamojang conservation forest area in the Cikaro and Cibeunying blocks, which are located near the central geothermal power plant, Kamojang Power Generation O&M Service Unit (POMU). The Kamojang geothermal power plant has three generating units with a capacity of 140 MW each. According to data published by Rianta (2020) on their website, a geothermal power plant emits 122 kg of carbon dioxide per megawatt-hour (MW.h) of electricity generated. This means that if the Kamojang POMU operates for 24 hours, it will emit 17.1 tons of carbon dioxide.

The research aims to determine the potential amount of carbon reserves, carbon dioxide absorption, and oxygen release in the vegetation within the mentioned area. The findings of this study are expected to provide valuable information and insights for the management of the Kamojang conservation forest, particularly the Kamojang Resort, in formulating forest management policies as one of the carbon reserve sources.

METHOD

Time and Location of Research

This research was conducted in August 2022 in the conservation forest areas of Kamojang Block Cibeunying and Block Cikaro.

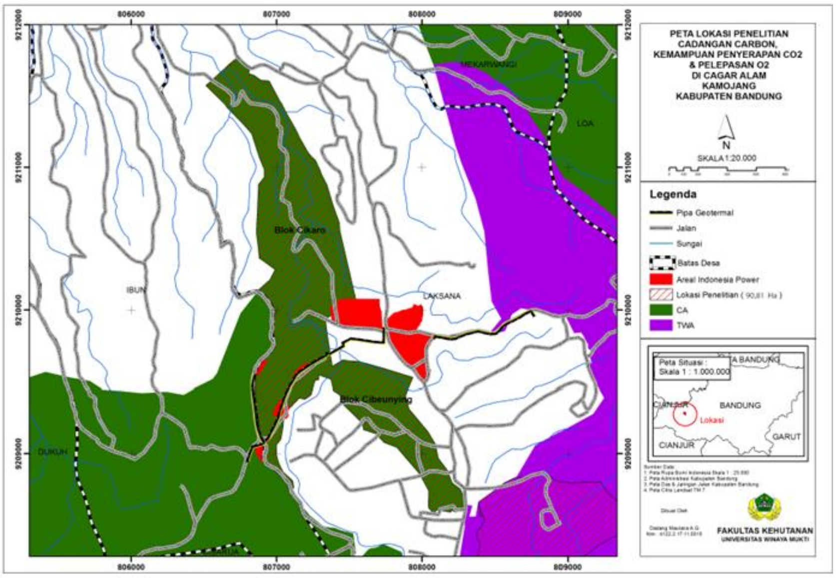

Figure 1. Research Location Map

Tools and Materials

The tools used in this research included working maps, phiband, plastic ropes measuring 40m x 50m and 100m x 20m, haga hypsometer, camera, compass, GPS (Global Positioning System), writing tools, tally sheets, sample plastic bags, and an oven.

Data Collection

Data collection was carried out by field data collection, measuring the biomass of trees with a DBH (Diameter Breast Height) of 5cm to 30cm in plots measuring 50m x 4m, and trees with DBH ≥ 30cm in plots measuring 100m x 20m. Additionally, data collection was performed on tree branches to measure their diameter and height/length.

Determination of Sampling Plots

The determination of sampling plots used in this research was the Systematic Sampling technique, where samples were systematically determined based on specific intervals that were considered most representative and suitable for sampling locations (Hairiah & Rahayu, 2007). The research area of Kamojang Conservation Forest, Blok Cibeunying, and Cikaro had an area of 988,100 m² or 90.81 ha, and the minimum sampling location area (sampling intensity) taken was 5%.

Sampling Method

The method used in this research was Non-destructive sampling. Sampling was carried out through the following steps:

Observation Plot

The observation plot was 40m x 5m in size for measuring carbon reserves in vegetation with a DBH of 5cm to 30cm (circumference of the tree ranging from 15cm to 95cm) and 100m x 20m for larger trees with DBH ≥ 30cm (Hairiah et.al, 2011).

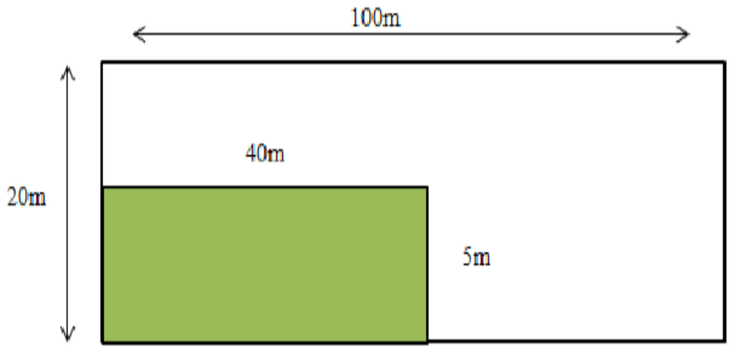

Figure 2. Sample Plot Design

Explanation:

- Plot observation for trees with DBH 5cm - 30cm
- Plot observation for trees with DBH ≥ 30cm

Determination of Tree Names and Wood Density

The identification of tree species was obtained directly from the field and then recorded on a tally sheet to find the wood density (BD) of the tree, which was obtained from the website db.worldagroforstry.org (Tree Functional Attributes and Ecological Database Wood Density). For tree species that were not registered, wood samples were collected by cutting wood samples from the nearest tree branch (length/height = 5cm, diameter 1cm). The wood samples were then tested in the laboratory by being placed in an oven at 100º Celsius for 48 hours, and then weighed to determine the dry weight of the wood (Hairiah et.al, 2011). The calculation of wood density was done using the following formula (Sarinah & Jemi, 2019):

Bjvkt = Bkt / Bvkt

Where:

Bjvkt = Wood Density (g/cm³)

Bkt = Dry weight of the oven-dried sample (g)

Bvkt = Dry volume weight of the test sample (cm³)

Measurement of Tree Biomass

Measurement of tree biomass (above-ground vegetation) was done by estimating the volume of trees without causing any damage. The tree volume was estimated from the measurement of the diameter at breast height (DBH) or 1.3 m above the ground and the height of the tree, which was then calculated using the formula for calculating tree volume.

Data Analysis Method

Calculation of Wood Density of Trees

To determine the wood density, the formula (Hairiah et.al, 2011, SNI 7724:2011) was used:

Bj (g/(cm^3))= (BK (g))/(V(cm^3))

Where:

Bj = Wood Density (g/cm³)

BK = Dry Weight (g)

V = Volume (cm^3)

RESULTS AND DISCUSSION

General Condition of Kamojang Conservation Forest, Cikaro and Cibeunying Blocks

Minister of Environment and Forestry Decree No. SK.25/MENLHK/SETJEN/PLA.2/1/2018, dated April 10, 2017, accommodates the total area of Kamojang Conservation Forest covering 5,140 hectares. Within the Kamojang Conservation Forest, there are two blocks, namely Cikaro Block and Cibeunying Block, which together cover an area of 90.81 hectares, accounting for 1.77% of the total area. These blocks are located within the administrative region of Cibeet Village, Paseh District, Bandung Regency. They are bordered by the South Bandung Forestry Corporation (Perum Perhutani KPH Bandung Selatan) to the east, west, and north, while the southern boundary is demarcated by a provincial road.

Kamojang Conservation Forest, Cikaro and Cibeunying Blocks, possess significant carbon reserves, carbon dioxide absorption, and oxygen release (O_2). The proximity of Cikaro and Cibeunying Blocks to the Kamojang Geothermal Power Plant Unit (POMU), one of the industries producing a considerable amount of carbon dioxide emissions, is notable. The estimated emissions from the Kamojang POMU geothermal power plant are approximately 17.1 tons of carbon dioxide. The emission disposal sites are located around the Cikaro and Cibeunying Conservation Forest areas, at distances of approximately ±300m and ±500m, with some being even closer to the conservation forest area.

Based on field data collected from Cikaro and Cibeunying Blocks, with a total area of 90.81 hectares, it is evident that there are variations in the condition of the areas. These differences are influenced by natural factors and human interventions.

During field data collection in Cikaro and Cibeunying Blocks within the Kawah Kamojang Nature Reserve, a total of 34 plant species were found. Table 1 shows several dominant tree species encountered during the study, with the five most frequently encountered species being Pinus (Pinus merkusii) with 76 trees, Kibeureum (Dystilium stellare) with 72 trees, Manglid (Maglietia glauca) with 32 trees, Puspa (Schima wallichii) with 28 trees, and Ki Badak (Fagraea fragrans) with 18 trees.

The Kamojang Conservation Forest, Cikaro, and Cibeunying Blocks store a carbon reserve potential of 202.577 tons (as shown in Table 2), carbon dioxide absorption of 742.781 tons (as shown in Table 3), and oxygen release of 540.132 tons (as shown in Table 4). When these figures are converted to the area of Cikaro and Cibeunying Blocks, which covers 90.81 hectares, the total potential carbon amounts are presented in Table 5, with a total carbon reserve of 20,848.787 tons, carbon dioxide absorption of 78,918.792 tons, and oxygen release of 36,653.341 tons for a plot size of 40m x 5m. For a larger plot size of 100m x 20m, the potential carbon reserve is 4,047.118 tons, carbon dioxide absorption is 14,592.107 tons, and oxygen release is 10,611.013 tons. Thus, the total conversion results in a carbon reserve of 57,387.757 tons, carbon dioxide absorption of 93,510.900 tons, and oxygen release of 67,998.770 tons.

The potential carbon amounts were derived from a total of 34 tree species found in the observation plots. Certain species were more abundant in the observation plots, and their contribution to the total carbon reserve, carbon dioxide absorption, and oxygen release is presented in Table 1 and Figure 5. For instance, Pinus (Pinus merkusii) constituted 23.12% of the total carbon reserve, Kibeureum (Dystilium stellare) accounted for 4.59%, Manglid (Maglietia glauca) for 2.3%, Puspa (Schima wallichii) for 3.8%, and Ki Badak (Fagraea fragrans) for 5.8%. From the five most frequently encountered species in the observation plots, it is evident that 40% of the total carbon reserve is attributed to these species, with a breakdown of 9,958.362 tons for carbon reserve, 37,404.360 tons for carbon dioxide absorption, and 27,199.510 tons for oxygen release.

Furthermore, the potential carbon reserve, carbon dioxide absorption, and oxygen release from tree vegetation with the largest carbon amounts are presented in Figure 6. The tree species with the highest carbon content include Pinus (Pinus merkusii) at 23%, Kihujan (Engelhardtia spicata) at 16%, Huru (Actinodaphne procera) at 12%, Ki Badak (Fagraea fragrans) at 6%, and Kibeureum (Dystilium stellare) at 5%. These five species contribute to 62% of the total carbon reserve, with 15,435.46 tons for carbon reserve, 57,976.76 tons for carbon dioxide absorption, and 42,159.24 tons for oxygen release.

Based on the comparison between the most frequently encountered vegetation in the observation plots and the tree vegetation with the largest carbon amounts, it is evident that the carbon amount is not solely determined by the number of vegetation found. The diameter and wood density of the vegetation, which significantly impact biomass content, carbon reserve, carbon dioxide absorption, and oxygen release, play crucial roles. This observation is supported by Tuah et al. (2017), who stated that the relationship between diameter and wood density of plants positively correlates with biomass content. Larger diameters and wood densities result in greater biomass content, carbon reserve, carbon dioxide absorption, and oxygen release, and vice versa.

Based on this research, it can be concluded that the tree vegetation in Cikaro and Cibeunying Blocks of the Kawah Kamojang Conservation Forest holds a substantial amount of carbon reserve, influenced by factors such as diameter, height, and wood density of the trees. Yahmani (2013) stated that the highest biomass content is found in trees with diameters ≥ 20cm. Additionally, the research conducted by Tuah et al. (2017) explained that the carbon reserve derived from tree vegetation is larger compared to that from other sources, such as litter, understory plants, and organic soil material. Thus, this research shows that the Cikaro and Cibeunying Blocks of the Kawah Kamojang Conservation Forest have a significant amount of carbon reserve originating from tree vegetation.

CONCLUSION

In conclusion:

a. The potential amount of carbon reserves in the Kamojang Conservation Forest, Block Cibeunying, and Cikaro is 24,895.905 tons.
b. The potential carbon dioxide sequestration capacity in the Kamojang Conservation Forest, Block Cibeunying, and Cikaro is 93,510.900 tons.
c. The potential oxygen release capacity in the Kamojang Conservation Forest, Block Cibeunying, and Cikaro is 67,998.770 tons.

REFERENSI

Direktorat Jenderal Planologi Kehutanan dan Tata Lingkungan (PKTL) KLHK. 2019. P.4/PKTL/SETDIT/KUM.1/3/2020 Tahun 2020 Pedoman Pengelolaan Dan

Penyebarluasan Informasi Geospasial Lingkup Kementerian Lingkungan Hidup Dan Kehutanan.(Jakarta : Kemen PU).

Hairiah, K., Sitompul, S., et al. 2001. Methods for sampling carbon stocks above and below ground Dalam http://apps.worldagroforestry.org/downloads/ Publications/PDFS/LN01114.PDF Diakses pada 27 Juli 2022.

Hairiah, K., et al. 2011. Pengukuran Cadangan Karbon dari Tingkat Lahan ke Bentang Lahan. (Bogor :World Agroforestry Centre).

Kementerian Lingkungan Hidup dan Kehutanan.2018.SK. 25/Menlhk/Setjen/PLA.2/1/2018 https://sadarkawasan.files.wordpress.com/2019/01/sk-25-klhk-2018.pdf diakses pada 30 Juli 2022

Oktadiani, D., et al. (2005). Keanekaragaman Tumbuhan di Kawasan Hutan Konservasi Kawah Kamojang. Jurnal Konservasi Alam dan Lingkungan, 1(1), 35-45.

Rianta. 2020. Pembangkit Listrik Tenaga Panas Bumi (PLTP) dalam https://www.indonesiare.co.id/id/article/pembangkit-listrik-tenaga-panas-bumi-pltp diakses pada 31 Oktober 2022.

Sarinah & Jemi. 2019. Petunjuk Praktikum Sifat-sifat dasar Kayu. Jurusan Kehutanan Fakultas pertanian Universitas Palangkaraya. Palngkaraya (Tidak Dipublikasikan)

Salisbury, F. B., & Ross, C. W. (1978). Fisiologi Tumbuhan Jilid 2. Jakarta: Penerbit Erlangga.

Tuah, N., et al. (2017). Pengukuran Biomassa Vegetasi Pohon di Kawasan Hutan Konservasi. Jurnal Penelitian Hutan dan Konservasi Alam, 14(2), 105-118.

Yahmani. (2013). Faktor Penentu Cadangan Karbon dalam Vegetasi Pohon. Jurnal Ilmiah Pertanian, 20(3), 163-175.