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RESEARCH ARTICLE Open Access

Biodiversity and Carbon Storage Potential in the Lambosir Hill Area, Mount Ciremai National Park, Kuningan Regency, West Java Province

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Abstract
The potential for biodiversity, including a variety of tree, shrub, and bush species, is particularly pronounced in ecosystems characterized by high biodiversity, which influences the soil's capacity to retain water—the greater the species diversity within an ecosystem, its ability to sequester CO2 increases. Lambosir Hill is one of the hills located within the protected forest area of Mount Ciremai National Park (TNGC). This study aimed to assess the level of plant vegetation diversity on Lambosir Hill and examine the relationship between biodiversity and carbon stocks. This study was conducted in Lambosir Hill, Mount Ciremai National Park in Kuningan Province, West Java. This study began in November 2022 and ended in March 2023. Activities related to data processing were carried out at the Land Resources Laboratory, Faculty of Agriculture, National Development University “Veteran” East Java. The study results showed low diversity at the shrub level and moderate at the tree level. The highest carbon stock was found in Sonokeling and the weakest in Hamerang. The land use type, slope, and vegetation composition influence these values’ differences. These results show the importance of permanent vegetation in supporting carbon stocks and ecosystem stability. It is recommended that woody tree vegetation such as Sonokeling be preserved to maintain the sustainability of carbon reserves in this conservation area.

Keywords: Biodiversity, Carbon Stock, Forest Conservation, Lambosir Hill, Vegetation

1. Introduction

Indonesia is one of the countries with the highest levels of biodiversity in the world. The diverse physical environments found throughout the archipelago support a wide range of life forms. The forests provide essential survival resources, contributing to the rich variety of plant and animal species. Climate change significantly affects biodiversity, which in turn impacts carbon storage. Biodiversity is crucial for the absorption and storage of carbon in forest ecosystems.

Many tree, shrub, and bush species can be found in ecosystems with high biodiversity. This ecological diversity has impacted the soil’s capacity to retain water. It has been demonstrated that the greater the species diversity of an ecosystem, the greater its capacity to store carbon dioxide (CO_2) (Satriawan et al., 2022).

Lambosir Hill is located within the protected forest area that constitutes part of the Mount Ciremai National Park (TNGC). The Mount Ciremai National Park area exemplifies the significance of mixed forest vegetation in supporting ecosystem functions (Drupadi et al., 2021). Consequently, extensive research and conservation efforts are imperative, as our comprehension of the biodiversity of the Lambosir hills remains rather rudimentary, encompassing both taxonomic and ecological dimensions. The site under consideration is situated in Setianegara Village, Cilimus District, Kuningan Regency, and is administratively located within the Lambosir Hill area, which encompasses an area of 3.54 Km2 (Central Statistics Agency, 2023). Lambosir Hill is home to various use systems, including tourism and nature reserves with forest areas that support a variety of plants and animals. The vegetation types in the Lambosir hills consist of pine forests and mixed forests, which contribute to the high

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potential for biodiversity, as evidenced by the varying spatial heterogeneity of vegetation (Wijayanto et al., 2022).

This research is necessary because although the TNGC area is known as a conservation area, specific information on carbon stocks and vegetation diversity in Bukit Lambosir is still very limited. This research is urgent to provide scientific data to support conservation and climate change mitigation programs at the local level.

Identifying biodiversity involves identifying and capturing various life forms in an area, such as genes, species and ecosystems (Saputra et al., 2021). The aim is to understand the biodiversity in an area and the relationship between animals and their environment. The expected results of this study are that it can be helpful for land management to obtain flora diversity in Bukit Lambosir, Gunung Ciremai National Park, by becoming a source of reference and information.

Biodiversity is caused by two main factors: environmental and genetic factors. Environmental factors include temperature, soil, rainfall, and light intensity (Zaida, 2020). Genetic factors include genetic mutations, genetic recombination, inheritance of traits, and cross-breeding. Mutations and recombination produce new genetic variations, while inheritance and cross-breeding maintain and enrich diversity between individuals in a population. In addition, genetic isolation can also trigger the formation of new species through separate genetic development. These factors work together with the environment to shape existing biodiversity.

The term “biodiversity” describes a biological community. There are several options for measuring and quantifying biodiversity. The number of species in an area is known as species richness. The quantity of species richness must be the only factor considered, not the number of individuals in each species or their relative rarity. The relative abundance of a species is the number of individuals, which is the total number of individuals of all species in a living space, ecosystem, or biome. It is common for the major species (primary producers) to show the highest relative elasticity. This study aims to identify the level of plant vegetation diversity in Lambosir Hill and determine the relationship between biodiversity and carbon stocks.

2. Material and Methods

Lambosir Hill in Mount Ciremai National Park in Kuningan Province in West Java with coordinates 6°51' S and 108°24' E, at an altitude of around 1,000–1,200 meters above sea level. This research began in November 2022 and ended in March 2023. Activities related to data processing were carried out at the Land Resources Laboratory, Faculty of Agriculture, National Development University “Veteran” East Java.

The tools used in this study include Garmin 65s GPS (position coordinate measuring device), Phi-band, inclinometer (clinometer), compass, mass measuring device (balance), open, counting list, stationery, plastic, and camera. Tree vegetation and litter are the materials used in this study.

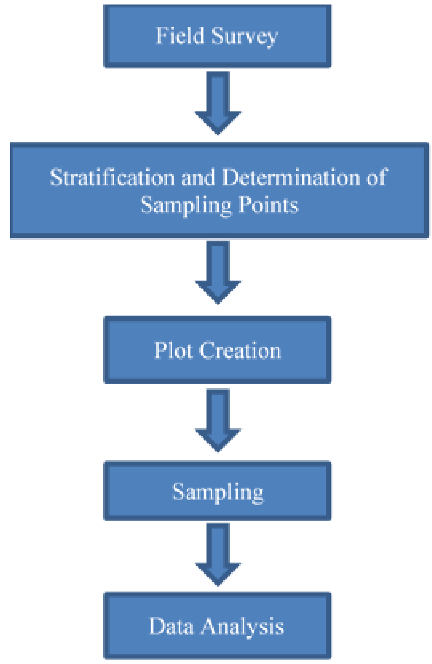

Figure 1. Research Flow Diagram

3. Results and Discussion

3.1. Importance Value Index and Vegetation Diversity of Lambosir Hill

The vegetation community of the Bukit Lambosir research site in the Ciremai Forest National Park consists of 18 tree species and five shrub species. The dominant strain in the research community is Lantanan (Lantana camara), a plant sometimes called Tembelekan leaves (Table 1). According to Battase and Attarde (2021), these leaves have enzymatic properties developed as a medicine to treat wounds, ulcers, rheumatism, leprosy, and pneumonia.

Based on the analysis of shrub vegetation in Table 1, the Lantana type (Lantana camara) has the highest importance value index at the shrub level, with an INP of 120.36 percent. In contrast, the Harendong type (Melastoma affine) has the lowest INP, 28.99 percent.

The tree species that dominate the inspection standards are shown in Table 2.

Table 2 shows that Bisoro (Ficus hispida) has the lowest INP value in tree vegetation, 13.76%, while Sonokeling (Dalbergia latifolia) has the highest INP value, 115.13 percent.

The diversity index of shrub vegetation, which includes the Ciremai forest community, is based on the Diversity Index (Shannon, 1948) and is classified as low with an H’ value of 0.74. The tree species Diversity Index is also included with an H' value of 2.82 as a medium.

Table 1. Types of Shrubs in Lambosir Hill, Ciremai Forest National Park

No	Name of the Bush		Amount	INP (%)
1	*Affine melastoma*	Harendong	5	28.99
2	*Chromolaena odorata*	Kirinyuh	29	83.18
3	*Lantana camara*	Lantanan	30	120.36
4	*Tithonia diversifolia*	The Bitter One	27	105.70
5	*Nephrolepis biserrata*	Harupat	7	31.65

Figure 2. Haredong and Lantanan plants

Table 2. Types of Trees in Lambosir Hill, Ciremai Forest National Park

No	Tree Name		Amount	INP (%)
1	*Parkia speciosa*	Mlanding/Petai	6	28.75
2	*Dalbergia latifolia*	Rosewood	34	115.13
3	*Syzygium densiflorum*	Peutag/Kopo Guava	33	98.76
4	*Codiaeum variegatus*	Cypress/Pine	26	87.78
5	*Ficus fistulosa*	Beunying	16	71.05
6	*Dillenia indica*	The Simpur	17	80.54
7	*Schima wallichii*	flower	12	41.72
8	*Persea americana*	Avocado	15	43.76
9	*Ficus variegata*	The gong	12	40.89
10	*Nauclea subdica*	The Curse	11	35.47
11	*Calliandra calothyrsus*	Calliandra	22	68.40
12	*Toona sureni*	Suren Wood	23	43.51
13	*Phyllanthus emblica*	Malacca	12	32.34
1 4	*Coffea* spp	Coffee	14	46.12
1 5	*Ficus fistulosa*	Beunying	16	21.66
1 6	*Ficus hispida*	Bisoro	4	13.76
1 7	*Ficus palmata*	Hammer	7	15.67
1 8	*Borassus flabellifer*	Palm	8	28.70

Figure 3. Coffee and Sonokeling Plants

Due to the dominance of fewer species and uneven distribution of individuals, ecosystems with low diversity indices have fewer species (Siregar et al., 2022). In other words, this associates lower diversity indices with less diverse and challenging-to-manage ecosystems. One reason for low diversity scores is the lack of organic matter. There is often a decrease in plant diversity at certain times because each species takes a different time to reach its reproductive stage and because environmental factors cause changes in plant communities and coincide with changes in wild species. (Baderan et al., 2021).

This point is based on the assumption that a community contains a variety of plant species, and the more diverse the species, the older and more stable the community.

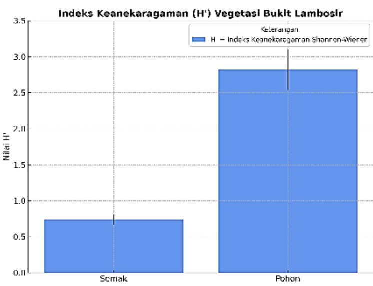

Figure 4. Diversity Index (H’) Graph of Lambosir Hill

Unlike shrubs, the Biodiversity Index at the tree level is highly valued. This highlight is because trees at the vegetative level can use all the sun's energy for photosynthesis. The availability of sufficient sunlight ensures good plant growth.

3.2. Calculation of Lambosir Hill Carbon Stock

The initial step in calculating carbon stocks in Lambosir Hill is to calculate the carbon stocks of 19 tree species using Table 3 and Table 4. Table 4 shows that the tree with the highest carbon reserves of rosewood is the tree with carbon reserves of 1467.37 g. Among the trees with the highest carbon reserves is Hamerang (67.07 g).

In this study, carbon stock results were taken from the Lambosir Hills at 7 points with Andisol soil type, using shrubland at points 1 to 4 and jungle at points 5 to 7 with varying angles, based on the laboratory analysis of soil chemical quality.

Table 5 shows the differences in carbon stock values at points 1 to 7. Land use and attachment to these points influence the differences in carbon stock values. Table 6 presents the results of the observation findings. This point shows that the results of calculating the total carbon content in Bukit Lambosir show the highest value at point 5, 8884.47 g, and the lowest value at point 1, 3304.39 g.

This observation aligns with field conditions when rosewood trees at Point 5 appear in large numbers. A value of 3304.39 (g) with a very low category is found at Point 1 with a 41–60% slope. The slope of the field also affects the high and low values of carbon stocks. This highlight is because organic matter at the bottom is eroded by intense erosion in the middle and upper parts.

The use of shrub species generally results in high carbon stocks because environmental factors, plant species, and the process of organic matter decomposition are considered. The more plants that grow on the soil, the more organic matter is removed and the soil carbon content increases. As soil depth increases, the carbon stock in the soil often becomes vertical. According to Ellerbrock and Gerke (2013), soil carbon content is usually higher in the upper and lower layers. The increase in fertile land in Bukit Lambosir may have occurred due to the diversity of land uses.

Table 3. Calculation of Carbon Stock of Tree Stands on Lambosir Hill

No	Tree Name	Amount	Tree Trunk Circumference (cm)	DBH (cm)	Tree Height (m)	Tree BJ (g/cm^3)	Y Total Biomass (g)	C-Carbon Stock (g)
1	Mlanding/Petai	6	55	54.00	14.2	0.68	1433.19	716.59
2	Rosewood	34	64	58.08	22.2	0.77	2934.73	1467.37
3	Peutag/Kopo Guava	33	48	47.50	4.4	0.73	364.68	182.34
4	Cypress/Pine	26	43	33.57	13.9	0.45	359.56	179.78
5	Beunying	16	65	45.94	7.9	0.37	314.71	157.36
6	The Simpur	17	54	43.75	19.5	0.67	1271.24	635.62
7	flower	12	23	13.00	18.9	0.65	105.49	52.75
8	Avocado	15	63	46.00	3.6	0.53	202.65	101.32
9	The gong	12	45	44.60	23.4	0.26	616.52	308.26
10	The Curse	11	32	45.25	31.4	0.7	2292.60	1146.30
11	Calliandra	22	33	33.33	18.5	0.55	574.07	287.04
12	Suren Wood	17	37	41.75	3.6	0.42	699.63	349.81
13	Malacca	12	65	36.20	10.1	0.67	449.58	224.79
14	Suren Wood	6	68	39.88	16.7	0.55	745.03	372.51
15	Coffee	14	21	47.00	18.1	0.52	1058.75	529.38
16	Beunying	16	32	31.00	15.6	0.52	396.16	198.08
17	Bisoro	4	35	37.67	17.3	0.56	699.63	349.81
18	Hammer	7	43	48.20	13.4	0.51	134.15	67.07
19	Palm	8	32	33.33	21.7	0.65	797.72	398.86

Table 4. Calculation of Standing Carbon Stock & Standard Error in Lambosir Hill

No	Tree Name	Amount	DBH±SE	Height ± SE	Biomass ± SE	Reserves Carbon ± SE
1	Mlanding/Petai	6	54.00 ± 22.04	14.20 ± 5.80	1433.19 ± 584.88	716.59± 292.32
2	Rosewood	34	58.08 ± 9.96	22.20 ± 3.81	2934.73 ± 503.36	1467.37± 251.68
3	Peutag/Kopo Guava	33	47.50 ± 8.26	4.40 ± 0.77	364.68 ± 63.45	182.34 ± 31.72
4	Cypress/Pine	26	33.57 ± 6.58	13.90 ± 2.73	359.56 ± 70.51	179.78 ± 35.25
5	Beunying	16	45.94 ± 11.49	7.90 ± 1.98	314.71 ± 78.68	157.36 ± 39.34
6	The Simpur	17	43.75 ± 10.61	19.50 ± 4.73	1271.24 ± 308.35	635.62 ± 154.18
7	flower	12	13.00 ± 3.75	18.90 ± 5.46	105.49 ± 30.45	52.75 ± 15.23
8	Avocado	15	46.00 ± 11.88	3.60 ± 0.93	202.65 ± 52.33	101.32 ± 26.91
9	The gong	12	44.60 ± 12.88	23.40 ± 6.76	616.52 ± 178.00	308.26± 89.00
10	The Curse	11	45.25 ± 13.64	31.40 ± 9.47	2292.60 ± 690.96	1146.30± 345.48
11	Calliandra	22	33.33 ± 7.10	18.50 ± 3.94	574.07 ± 122.35	287.04± 61.18
12	Suren Wood	17	41.75 ± 10.13	3.60 ± 0.87	699.63 ± 169.70	349.81± 84.85
13	Malacca	12	36.20 ± 10.45	10.10 ± 2.92	449.58 ± 129.83	224.79± 64.92
14	Suren Wood	6	39.88 ± 16.28	16.70 ± 6.82	745.03 ± 304.06	372.51± 152.03
15	Coffee	14	47.00 ± 12.56	18.10 ± 4.83	1058.75 ± 282.72	529.38±141.36
16	Beunying	16	31.00 ± 7.75	15.60 ± 3.90	396.16 ± 99.04	198.08± 49.52
17	Bisoro	4	37.67 ± 18.83	17.30 ± 8.65	699.63 ± 349.81	349.81± 174.90
18	Hammer	7	48.20 ± 18.21	13.40 ± 5.07	134.15 ± 50.70	67.07± 25.35
19	Palm	8	33.33 ± 11.78	21.70 ± 7.67	797.72 ± 281.96	398.86±140.98

Table 5. Carbon Stock Value of Lambosir Hill Vegetation at Several Observation Points

Point	Total Tree Biomass (ton/h)	Total Shrub Biomass (ton/h)	Total Carbon Stock (g)
1	1.43	2.32	3304.39
2	1.22	4.73	5954.72
3	0.98	3.76	3765.40
4	0.76	2.65	3410.00
5	7.37	1.51	8884.47
6	5.15	1.86	7015.89
7	5.65	1.54	7190.00

Table 6. Carbon Stock Values and Standard Errors in Lambosir Hill

Point	Total Tree Biomass (ton/h)	Total Shrub Biomass (ton/h)	Total Carbon Stock (g)
1	1.43 ± 0.22	2.32 ± 0.22	3304.39 ± 0.22
2	1.22 ± 0.22	4.73 ± 0.22	5954.72 ± 0.22
3	0.98 ± 0.22	3.76 ± 0.22	3765.40 ± 0.22
4	0.76 ± 0.22	2.65 ± 0.22	3410.00 ± 0.22
5	7.37 ± 0.22	1.51 ± 0.22	8884.47 ± 0.22
6	5.15 ± 0.22	1.86 ± 0.22	7015.89 ± 0.22
7	5.65 ± 0.22	1.54 ± 0.22	7190.00 ± 0.22

3.3. Vegetation of Plants at the Research Location Against Analysis Results

Soil carbon content is strongly correlated with vegetation from a research perspective. According to laboratory experiments, vegetation type and density variations impact organic C content, ranging from very low to high. This point strengthens the idea that vegetation—including leaves, herbs, and roots—is a significant source of organic soil life through biomass decomposition.

Carbon concentrations are relatively high in areas that are mostly covered with permanent vegetation, such as shrubs and ferns. This result is due to the deep root system and the continuous accumulation of leaf litter, which can accelerate the digestion of organic matter and increase microbial activity in the soil.

On the other hand, carbon content is found in areas with low to very low vegetation or with many valuable crops such as watermelon or corn. Severe soil degradation can be caused by ongoing soil cultivation and little organic matter input.

The vegetation of the highland areas significantly impacts the amount of organic carbon (C-Organic) in the soil. The highlands' cold and humid climate worsens organic matter's decomposition, thereby increasing the amount of carbon stocks accumulated, especially in areas with natural vegetation such as forests or flora. This point means that the number and type of plants in the highlands significantly impact the soil's carbon amount. Using appropriate vegetation management techniques, such as agroforestry systems or natural forest protection, the C-Organic content supports the fertility and sustainability of the highlands.

4. Conclusion

Based on the research findings and laboratory analyses presented above, the following conclusions can be drawn:

1. Melastoma affine exhibited the lowest INP at 28.99%, whereas Lantana camara recorded the highest INP at the shrub level at 120.36%. At the tree level, Dalbergia latifolia also had a high INP of 115.13%, while Ficus hispida had the lowest INP of 13.76%.
2. The diversity of shrub vegetation in Ciremai Forest is classified as low (H' = 0.74), whereas the diversity at the tree level is classified as medium (H' = 2.82).
3. Sonokeling exhibits the highest carbon stock at 1,467.37 g, whereas Hamerang has the lowest at 67.07 g. The total carbon stock is highest at Point 5, measuring 8,884.47 g, while the lowest total carbon stock is found at Point 1, at 3,304.39 g.
4. High carbon stocks are typically found in areas with permanent vegetation, such as woody trees, while low in intensive agricultural lands, such as those used for watermelon and corn cultivation. Highland petal plants exhibit a high carbon content, and kipahit compost contains up to 48.69% organic carbon levels.

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