REINWARDTIA
Vol. 25. No. 1. pp: 1–11
DOI: 10.55981/reinwardtia.2026.623

CARBON STOCK AND CARBON ECONOMIC VALUE OF FOREST ECOSYSTEM IN THE SUWANGI ISLAND NATURE PARK, TANAH BUMBU REGENCY, SOUTH KALIMANTAN, INDONESIA

Received December 11, 2024; accepted May 16, 2026

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ABSTRACT
REZEKIAH, A. A., FITHRIA, A., YAMANI, A., ROSIDAH, RUDY, G. S., ALI, S. D. & SHIBA, Y. N. 2026. Carbon stock and carbon economic value of forest ecosystem in the Suwangi Island Nature Park, Tanah Bumbu Regency, South Kalimantan, Indonesia. *Reinwardtia* 25(1): 1–11. — The forests on Suwangi Island are currently facing significant challenges arising from human activities, land degradation, and potential land-use conflicts, all of which critically undermine their capacity to absorb and store carbon. The purpose of this study was to analyze the carbon stock value and economic value of carbon stored in Suwangi Island Nature Park. The allometric method was employed to calculate carbon stocks, with sampling locations determined using purposive sampling. The carbon stock results were subsequently converted to estimate the economic value of carbon. The land cover types identified in Suwangi Island Nature Park include primary forest, secondary forest, plantation, medium-density mangrove forest, and high-density mangrove forest. The analysis revealed that the highest biomass was stored in the primary forest and the lowest in the medium-density mangrove forest. The total carbon that can be stored at the research site is 80.45554667 tons/ha, and the resulting carbon economic value is IDR 2,851,347,872.68. These findings highlight the significant variation in carbon storage across different land cover types and underscore the critical role of primary forests as major carbon sinks. The novelty of this study lies in the integration of spatial (ArcGIS), ecological (allometric), and economic approaches within a single analytical framework, which remains rarely applied. The practical implications of this research emphasize the importance of management strategies based on carbon economic valuation and the potential utilization of carbon trading schemes, such as REDD+, to enhance conservation incentives and ensure the sustainability of Suwangi Island Nature Park management.

Key words: Carbon, economic value, forest, nature park, Suwangi Island.

ABSTRAK
REZEKIAH, A. A., FITHRIA, A., YAMANI, A., ROSIDAH, RUDY, G. S., ALI, S. D. & SHIBA, Y. N. 2026. Cadangan dan nilai ekonomi karbon ekosistem hutan di Taman Wisata Alam Pulau Suwangi, Kabupaten Tanah Bumbu, Kalimantan Selatan, Indonesia. *Reinwardtia* 25(1): 1–11. — Hutan di Pulau Suwangi saat ini menghadapi tantangan yang signifikan yang berasal dari aktivitas manusia, degradasi lahan, dan potensi konflik penggunaan lahan, yang semuanya secara kritis melemahkan kapasitas hutan untuk menyerap dan menyimpan karbon. Tujuan penelitian ini adalah untuk menganalisis nilai cadangan karbon dan nilai ekonomi karbon yang tersimpan di Taman Wisata Alam Hutan di Pulau Suwangi saat ini menghadapi tantangan yang signifikan yang berasal dari aktivitas manusia, degradasi lahan, dan potensi konflik penggunaan lahan, yang semuanya secara kritis melemahkan kapasitas hutan untuk

menyerap dan menyimpan karbon. Tujuan penelitian ini adalah untuk menganalisis nilai cadangan karbon dan nilai ekonomi karbon yang tersimpan di Taman Wisata Alam Pulau Suwangi. Metode yang digunakan untuk menghitung karbon stok yaitu metode allometrik dengan penentuan lokasi pengambilan sampel secara *purposive sampling*. Hasil karbon stok dikonversi untuk mendapatkan nilai ekonomi karbon. Jenis tutupan lahan yang terdapat di Taman Wisata Alam Pulau Suwangi adalah hutan primer, hutan sekunder, perkebunan, hutan mangrove kerapatan sedang, dan hutan mangrove kerapatan tinggi. Hasil analisis cadangan karbon menunjukkan bahwa biomassa tertinggi yang dapat disimpan di lokasi penelitian terdapat pada hutan primer dan terendah pada hutan mangrove kerapatan sedang. Total karbon yang dapat disimpan di lokasi penelitian adalah 80.45554667 ton/ha dan nilai ekonomi karbon yang dihasilkan sebesar Rp 2.851.347.872,68. Temuan ini menegaskan perbedaan signifikan antar tipe tutupan lahan dalam menyimpan karbon dan menunjukkan kontribusi penting hutan primer sebagai penyerap karbon utama. Keunikan penelitian ini terletak pada integrasi aspek spasial (ArcGIS), ekologi (alometrik), dan ekonomi dalam satu kerangka analisis, yang masih jarang diaplikasikan. Implikasi praktis hasil penelitian ini mendukung pentingnya strategi pengelolaan berbasis nilai ekonomi karbon serta peluang pemanfaatan skema perdagangan karbon, seperti REDD+, untuk meningkatkan insentif konservasi dan keberlanjutan pengelolaan Taman Wisata Alam Pulau Suwangi.

Kata kunci: Hutan, karbon, nilai ekonomi, Pulau Suwangi, taman wisata alam.

INTRODUCTION

Trees take in and store an enormous quantity of carbon dioxide in the air. That is why forests are so important to keep the earth's ecosystem balanced. Forest ecosystems, mangroves, and tropical rainforests among them being significant, through their carbon storage, play vital roles in the process to reduce atmospheric levels of greenhouse gases and meet global climate objectives (Raihan *et al.*, 2021). In addition to this, these ecosystems have the ability to increase their capacities for carbon storage through proper reforestation and environmentally friendly management strategies. The enormous carbon stock of forests is of immense economic significance. The potential of these ecosystem services to sequester carbon is one of the factors in programs highlighting the economic value of forest conservation and trigger investments with a balance of profitability-ecological sustainability (Raihan *et al.*, 2021). Among its many benefits that forests can offer are biodiversity, reduced impacts of climate change, and economic importance due to improved conservation techniques and ecological dividends (Liu *et al.*, 2022; Openko *et al.*, 2023).

Suwangi Island, which is presently a nature park, provides a large range of ecosystems from primary and secondary forests to plantation and mangrove forests varying in densities from moderately dense to very dense. As forests all over the world contribute significantly towards carbon sequestration, this diversity of ecosystems is also vital in order to sequester carbon. However, human activity, land degradation, and potential land-use conflicts endanger Suwangi Island to be capable of sequestering carbon (Li, 2023). According to studies, the ecological integrity of such forest ecosystems as on Suwangi Island can depend on efficient forest management regimes that maximize carbon sequestration while ensuring ecological integrity and economic return (Li *et al.*, 2021; Gren & Amuakwa-Mensah, 2018; Ameray *et al.*, 2021). Furthermore, the urgent need to measure the carbon storage potential on Suwangi Island is underscored by evidence that effective management practices can enhance carbon stocks and are vital for supporting climatic stability (Qi *et al.*, 2023; Theuerkauf & Rodriguez, 2017; Li *et al.*, 2023). In light of growing external pressures, estimating the economic value of carbon storage in this region not only helps to understand its ecological significance but also offers a framework for management strategies to preserve and maximize carbon storage capabilities (Raihan *et al.*, 2021; Gren & Amuakwa-Mensah, 2018; Theuerkauf & Rodriguez, 2017).

To date, the majority of Indonesian research has concentrated on quantifying carbon stocks in specific ecosystems, such as mangroves and production forests, often neglecting an integrated assessment of different types of land cover in smaller island contexts. Additionally, the majority of research focuses on estimating carbon stock and biomass independently; few attempts integrate ecological methods such as allometric equations, economic carbon resource valuation, and spatial analytical tools like ArcGIS. This lack of multidisciplinary studies is particularly so with Suwangi Island, where no multidisciplinary survey has been undertaken with a view to assessing possible carbon reserves and economic valuation. The lack of such integrative studies underlines the sheer research gap and the need for a more integrated approach to determine carbon dynamics in small island ecosystems. Closing this gap can help Indonesia make better policies and protect sustainable land use and fight climate change. Future studies must try to connect these components in order to have a better view of carbon stocks and their economic valuation.

Based on description of this study, the research questions posed in this study are: (1) How much carbon is stored in various types of land cover in Suwangi Island Nature Park? (2) What is the economic value of the carbon produced from these

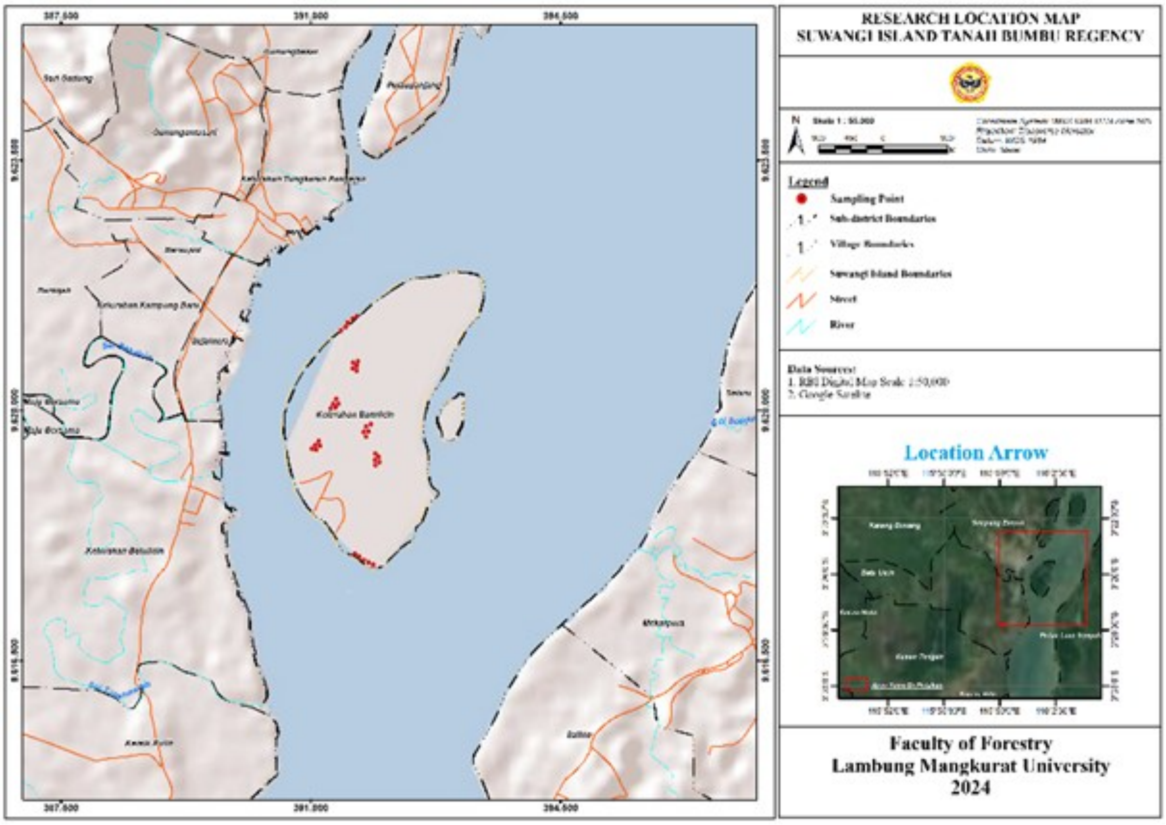

Fig. 1. Research location at Suwangi Island Nature Park.

carbon stocks? and (3) How can the results of this study contribute scientifically to the management of conservation areas while supporting carbon trading mechanisms as a climate change mitigation strategy?

MATERIALS AND METHODS

Study Area

This research was conducted in the Suwangi Island Nature Park (TWA Pulau Suwangi), Batulicin District, Tanah Bumbu Regency, South Kalimantan Province (Fig. 1). Based on the Decree of the Minister of Environment and Forestry No. SK.652/ MENLHK/SETJEN/PLA.2/8/2019, this area represents a functional change from the Teluk Kelumpang Nature Reserve in the Selat Laut and Sebuku Strait to the Suwangi Island and Burung Island Nature Park, covering an area of approximately 1,239 ha.

The observed land cover consists of five types: primary forest, secondary forest, plantation, high-density mangrove forest, and medium-density mangrove forest. Geographically, Suwangi Island is located at coordinates 03°25'10.7”S–116°02'25.8”E to 03°27'26.6”S–116°00'55.4”E. According to the Schmidt and Ferguson climate classification, the site falls into climate type A, characterized by an average monthly rainfall of ≥ 200 mm for nine months of the year. Data from the Gusti Syamsir Alam Meteorological Station in Kotabaru indicate relative humidity ranging from 77% to 85% (Ridwan *et al.,* 2024). The island’s topography is relatively flat, with slopes varying from 0–40% (Pusfatekgan, 2009).

Data Collection

The method employed was a non-destructive approach following the protocol of Kauffman & Donato (2012). This study specifically assessed aboveground carbon (AGC), which included the biomass of saplings, poles, trees, and mangrove vegetation. Belowground carbon (BGC) and soil carbon were not included in this study. Biomass measurements in this study were carried out using the path method with plot lines (Sutaryo, 2009) and can be seen in Fig. 2.

The plot design followed a nested plot method with the following dimensions:

- Saplings (dbh 2–9.9 cm): subplots of 5 m × 5 m.
- Poles (dbh 10–19.9 cm): subplots of 10 m × 10 m.
- Trees (dbh ≥ 20 cm): main plots of 20 m × 20 m

The number and location of plots were

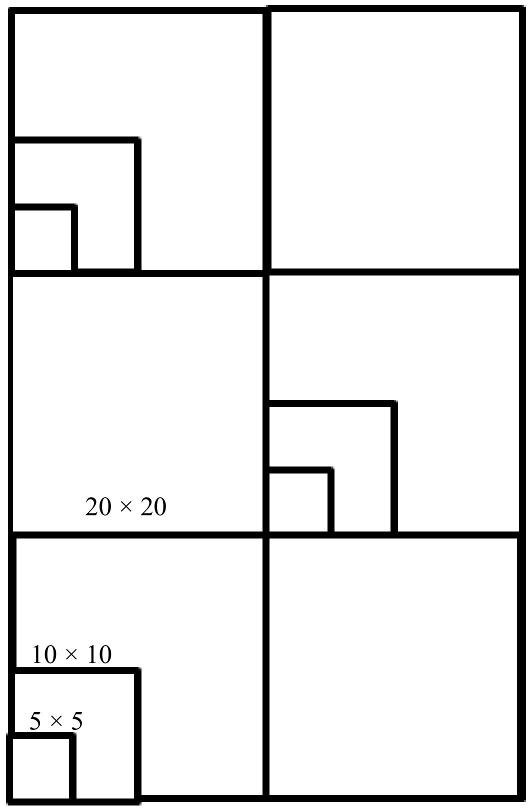

Fig. 2. Plot sketch.

determined using purposive sampling across different land cover types to represent ecosystem conditions and each levels was taken 3–5 plots as samples. For each individual tree or mangrove, data recorded included species, diameter at breast height (dbh, measured at 1.3 m above ground or above the highest prop root/pneumatophore), and total height. For certain mangrove species, specific measurement techniques were applied in accordance with the recommendations of Kauffman & Donato (2012).

Additional data on wood density (ρ) were obtained from various relevant scientific journals and literature, while carbon price information was derived from the official selling exchange rate published by Bank Indonesia in the year of the study.

Data Analysis

Data analysis in this study using biomass analysis to calculate the amount of carbon stored in Suwangi Island Nature Park. Moreover, the economic valuation of carbon was calculated using the market price of carbon at the time of study.

Biomass Measurement

The data analysis used to determine the amount of carbon stock in Suwangi Island Nature Park is the value of plant biomass. Data obtained from direct measurements in the field can be used to measure the level of above ground biomass contained in each plant species or level. Data obtained from the field include circumference and height data. The circumference data measured from the field was then converted into diameter values by dividing the circumference value by phi (D= Circumference/π), so that the diameter value could be entered into the allometric equation. Biomass was calculated using species-specific allometric equations. The equations applied in this study were as follows Table 1.

Carbon Measurement

Carbon was calculated based on biomass data obtained at the seedling, sapling, and tree levels. Carbon stock uses the formula according to Zhao *et al.* (2018), namely:

$$C = \text{Biomass} \times \%\ \text{C-organic}$$

Description:
C : Carbon stock (ton)

Calculation of the Economic Value of Carbon

The economic value of carbon is calculated using the price set by Pratamasari *et al.* (2018) which states that the price of carbon in standard carbon price from World Bank is US$ 10 per ton of sequestered carbon stocks

$$\text{Economic Value of Carbon} = \text{Carbon Stock} \times \text{Total Area (ha)} \times \text{Carbon Price}$$

Table 1. Formula for calculating biomass in Suwangi Island Nature Park.

Species Name	Allometric Model	Sources
Rhizophora sp.	AGB = 0.1466 x $\rho^{2,3136}$	Dharmawan (2010)
Types of mangroves in general	AGB = 0.251 x ρ x $D^{2,46}$	Komiyama *et al.* (2005)
Other types	AGB = ρ x Vk x BEF	Wibowo *et al*. (2013)
All types of stake levels	AGB = exp (-3.23 + 2.17 ln (D))	Marianingsih *et al*. (2023)

Description:
AGB: Biomass (kg)
ρ : Specific gravity (g/cm^3)
D : Diameter (m)
BEF : Biomass Expansion Factor (1.67)

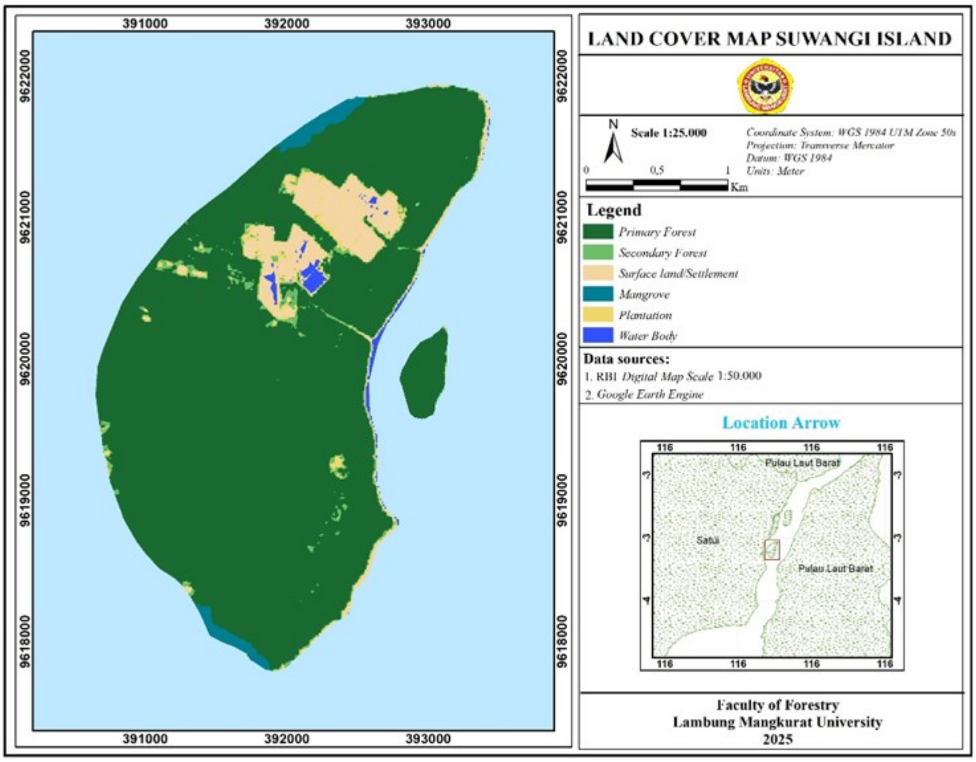

Fig. 3. Land cover map of Suwangi Island.

The exchange rate was calculated for 1 year since this study was analyzed so that US$1 is worth IDR 15,879.93.

RESULTS

Land Cover Type of Suwangi Island Nature Park

Suwangi Island Nature Park is divided into several types of land cover. Land cover type data in Suwangi Island Nature Park obtained from South Kalimantan Environment Department data. The land cover is divided due to differences in the vegetation that grows in it and the intended use of the area. Vegetation growing in the primary forest includes the Anacardiaceae, Araucariaceae, Dipterocarpaceae, Moraceae, Phyllanthaceae, Sapotaceae, Myristicaceae, and Myrtaceae, families. Vegetation growing in the secondary forest is quite diverse includes the Anacardiaceae, Araucariaceae, Arecaceae, Dipterocarpaceae, Fabaceae, Flacourtiaceae, Malvaceae, Moraceae, Myristicaceae, Myrtaceae, Phyllanthaceae, and Rubiaceae families. Vegetation growing in plantations is mostly fruit and rubber vegetation types. Meanwhile vegetation growing in mangrove forests are mangrove vegetation types such as *Sonneratia, Rhizophora*, and *Avicennia.* In general, the types and extent of land cover in Su-

Table 2. Land cover type of Suwangi Island Nature Park.

No.	Land Cover Types	Area (Ha)
1	Primary forest	345.95
2	Secondary forest	28.81
3	Surface land/settlement	65.69
4	Mangrove forest	227.27
5	Plantation	29.57
6	Water body	1.95

Data Source: South Kalimantan Environment Department Data (2024).

wangi Island Nature Park can be seen in Fig. 3 and the explanation of area can be seen in Table 2.

Biomass and Carbon Calculation in Suwangi Island Nature Park

Land cover types in this study include primary forest, secondary forest, plantation, medium density mangrove forest, and high density mangrove forest. For each type of land cover, measurements of tree circumference and height were taken to calculate the volume of wood used in plant biomass analysis. The vegetation levels measured for biomass and carbon in this study were divided into three levels: seedling (D < 10 cm), sapling (10 cm < D < 20 cm), and tree (D > 20 cm). Overall, the diameter of stems growing in the primary forest, secondary forest, plantation, medium density mangrove forest, and high density mangrove forest were ranged from 6 cm to 79 cm. Moreover, field measurements were made to determine the types of plants that live in each type of land cover so that the specific gravity of each plant could be found. The types of plants that live in each type of land have been explained in the previous paragraph.

Diameter, height, and specific gravity data obtained from field observations were then analyzed using allometric equations to measure aboveground biomass. The allometric equation used for analysis is adjusted to the type of plant present. For common plant species such as fruits and mixed hardwoods, the general allometric equation uses the biomass expansion factor (BEF). Based on the data collected, the following research results were obtained as in Table 3.

The largest biomass stored in Suwangi Island Nature Park was in the primary forest land cover type at 104.598188 tons/ha and the smallest stored was in the medium density mangrove forest with a value of 0.301784084 tons/ha. This is because in the primary forest area, the diameter of the trees that grow in it is large and dense and in accordance with the definition of primary forest, this forest is untouched by humans so that it is still maintained its authenticity. Based on the result of previous biomass calculation, the carbon stock contained in Suwangi Island Nature Park can be seen in Table 4.

Data from Table 4 explained that the largest carbon value at the seedling, sapling and tree levels is stored in primary forests with values of 0.000404328 tons/ha, 7.004733179 tons/ha, and 42.15348734 tons/ha, respectively. Followed by carbon values in plantations with 0.000191535 tons/ha, 2.257592581 tons/ha, and 22.50847652 tons/ha, respectively. The lowest total carbon value that can be stored in Suwangi Island Nature Park is found in the mangrove forest land cover type. At the sapling level, the smallest carbon value was found in the high-density mangrove forest at

Table 3. Result of biomass calculation at each vegetation level in Suwangi Island Nature Park.

No	Land Cover Type	Biomass (Ton/Ha)			Biomass Total
		Seedling	Sapling	Tree	
1	Primary forest	0.000860273	14.90368762	89.68827093	104.5928188
2	Secondary forest	0.000132321	2.240742085	10.9328178	13.1736922
3	Plantation	0.00040752	4.803388471	47.89037558	52.69417157
4	Medium density mangrove forest	0.000726817	0.073705048	0.22735222	0.301784084
5	High density mangrove forest	0.002498749	0.030046329	0.389129364	0.419554751
	Total	**0.002498749**	**22.05156955**	**149.1279459**	**171.1820142**

0.014121774 tons/ha and at the tree level, the smallest carbon value was found in the medium-density mangrove forest at 0.14183852 tons/ha. While at the seedling level, the smallest carbon value is in the secondary forest land cover type with a value of 0.00006219 tons/ha. However, overall the smallest carbon value is in the medium density mangrove forest with a value of 0.14183852 tons/ha and the highest in the primary forest type with a total carbon of 49.15862484 tons/ha. This is because in these forest areas the level of vegetation density is not too high compared to other land cover types, and the size of the stem diameter growing in he forest has a smaller range than other land cover types. So based on field data, the total value of carbon stored in Suwangi Island Nature Park is 80.45554667 tons/ha with the highest carbon stock in primary forest and the lowest in moderate mangrove forest.

Carbon Economic Value of Suwangi Island Nature Park

The problem of climate change and greenhouse gas emissions that are increasing every year makes people and environmentalists strive to mitigate the reduction of greenhouse gas emissions. Knowledge of the economic value of carbon is expected to be a stimulus for the wider community to participate in climate change mitigation. This study will analyze the economic value of carbon stocks stored in the Suwangi Island Nature Park forest area. The results of the calculation of the economic value of carbon in Suwangi Island Nature Park can be seen in Table 5.

Table 4 shows the calculation of the economic value of carbon stored in Suwangi Island Nature Park. The carbon price used in trade in this study is US$10 per ton. The exchange rate was calculated for 1 year since this study was analyzed so that US$1 is worth IDR 15,879.93. The economic value of carbon is aligned with the total carbon that can be stored in the forest area. The greater the total carbon, the higher the economic value of carbon. Primary forest has the largest carbon storage per ton, which is 17.006.426264 tons, so it has the highest carbon economic value, which is IDR 2,700,608, 508.02. While the dense mangrove forest has the least carbon storage of 16.117820 tons so that the economic value of carbon produced by the dense mangrove forest is IDR 2,559,498.49. The total economic value of carbon stored in Suwangi Island Nature Park is IDR 2,851,347,872.68.

DISCUSSION

Estimation of Biomass in Suwangi Island Nature Park

Since the diameter of the wood can be determined, the vegetation level examined for carbon value in this study was from seedling to tree level. Table 3 shows the results of biomass calculations conducted at Suwangi Island Nature Park. Biomass is the result of the photosynthesis process carried out by plants or living things that have chlorophyll. In this photosynthesis process, carbon in the air is absorbed by plants and then processed into oxygen and energy. Energy in plants is stored in the form of carbohydrates which are distributed throughout the plant's body (Hairiah & Rahayu, 2007). Based on the results, the tree vegetation level has the highest biomass value of 149.1279459 tons/ha because the diameter and height of the vegetation are large, which means that there is more biomass contained in trees than at the seedling level. The results of this study are in accordance with the statement of Uthbah *et al.* (2017) that the more CO_2 absorbed and stored in the tree trunk causes the diameter of the tree to get bigger. Carbon absorbed and stored in the trunk will be of greater value if the diameter of the trunk is also large. The results of this biomass calculation can be used to calculate the carbon stored in the vegetation growing in Suwangi Island Nature Park and will be explained in the next section.

The results of this research in Suwangi Island Nature Park are greater when compared to research conducted at Sederhana Beach, Bekasi District,

Table 4. Carbon calculation results for each land cover type in Suwangi Island Nature Park.

No	Land Cover Type	Carbon (Ton/Ha)			Carbon Total
		Seedling	Sapling	Tree	
1	Primary forest	0.000404328	7.004733179	42.15348734	49.15862484
2	Secondary forest	0.00006219	1.05314878	5.138424364	6.191635335
3	Plantation	0.000191535	2.257592581	22.50847652	24.76626064
4	Medium density mangrove forest	0.000341604	0.034641372	0.106855543	0.14183852
5	High density mangrove forest	0.000174754	0.014121774	0.182890801	0.19718733
Total		**0.001174412**	**10.36423769**	**70.09013457**	**80.45554667**

Table 5. Carbon economic value of Suwangi Island Nature Park.

No	Land Cover Types	Carbon (Ton)	Carbon Price per Ton (IDR)	Carbon Economic Value (IDR)
1	Primary forest	17.006.426264	IDR 158,799	IDR 2,700,608,508.02
2	Secondary forest	178.381014	IDR 158,799	IDR 28,326,779.34
3	Plantation	732.338327	IDR 158,799	IDR 116,294,810.33
4	Medium density mangrove forest	16.117820	IDR 158,799	IDR 2,559,498.49
5	High density mangrove forest	22.407382	IDR 158,799	IDR 3,558,276.51
	Total	**17.955.670808**		**IDR 2,851,347,872.68**

West Java (Erniasari *et al.*, 2024) whose highest biomass yield was only 79.18 mg/ha and also in the rehabilitated area of Sinjai, South Sulawesi (Malik *et al.*, 2020), with a biomass value of 125.48 tons/ha. Meanwhile, another study conducted in Benoa Bay, Bali (Mahasani *et al.*, 2021) had a higher biomass value than this study with an analyzed biomass value of 364.241 tons/ ha. Similarly, research by Marianingsih *et al.,* (2023) conducted in Kehati Asri Park had a higher biomass value than the research in Suwangi Island Nature Park with a biomass value of 2.745 tons/ha. The difference in biomass yields in each study was caused by differences in the level of plants used, namely in Kehati Asri Park using growth rates from seedlings to trees. In addition, the difference is due to the difference in the size of the research area and also the type of vegetation that grows in the research location.

Calculation of Carbon in Suwangi Island Nature Park

Indonesia's commitment to reduce greenhouse gas emissions was made by issuing Presidential Decree No. 61/2011 on the National Action Plan for Greenhouse Gas Reduction. The way to reduce greenhouse gas emissions is by preserving forests, especially tropical forests in Indonesia. One way to preserve Indonesia's tropical forests is to know the carbon reserves that can be stored in each type of plant. Each plant has carbon stored mostly in the tree trunk. The amount of carbon stock absorbed and stored in the trunk can be calculated based on the amount of tree biomass (Uthbah *et al.*, 2017).

The biomass data obtained in Table 3 was used to calculate the carbon stock presented in Table 4. The carbon results in this study were much greater than the carbon results studied in the Proboscis Monkey Ecotourism Ecosystem of PT. Antang Gunung Meratus Conservation Area and carbon stored in Mangrove stands in Pagatan Besar. In research in the Proboscis Monkey Ecotourism Ecosystem, carbon was analyzed based on the type of forest density with a total carbon stored of 12.35 tons/ha (Rezekiah *et al.*, 2024a) while research on carbon stored in mangrove stands in Pagatan Besar produced a total carbon of 18.85 tons/ha (Rezekiah *et al.*, 2021). In other studies conducted in Kehati Asri Park, Benoa Bay-Bali, Guangdong Province-China (Liu *et al.*, 2014), and Sirik Azini Creek-Ormozgan-Iran (Askari *et al.*, 2022), the value of stored carbon in these studies was greater than the research in Suwangi Island Nature Park with stored carbon values of 1290.15 tons/ha, 171.193 tons/ha, 84.61 tons/ha, and 96 tons/ha, respectively. The value of stored carbon is strongly influenced by the value of biomass. The higher the biomass value, the higher the carbon value. Variations in carbon values can also be caused by the type, age, and environmental conditions of the ecosystem (Sugiana *et al.*, 2024), which mostly come from external factors such as climate and weather.

Carbon Economy Value of Suwangi Island Nature Park

The results of economic value research in other studies such as research by Rezekiah *et al.* (2024b) conducted at Indonesia's Tropical Rainforest Park resulted in a carbon economic value of IDR 26,536,273.31 which is smaller than the results in this study. Research by Farista & Virgota (2021) in Bagek Kembar Mangrove Ecotourism Area had a smaller carbon economy value than the research in Suwangi Island Nature Park, which amounted to IDR 482,384,700 per year. However, in other studies the value of carbon economy in Wakatobi (Manan *et al.*, 2025) reached IDR 18,763,377,420 or USD 1,159,307 and carbon economy research in the U.S. National Wildlife Wetland Ecosystem (Patton *et al.*, 2015) the value based on US Value reached US $ 441,000 or at the current rupiah exchange rate (average US$ 1 in 2015 is IDR 13,397) amounting to IDR 5,908,150,500 while based on global value reached US $ 5,200,000 or IDR 69,665,266,667. The results of the study by Manan and Patton have a higher carbon economic value than the carbon economic value of the results of this study. Some of the reasons that cause variations in carbon prices are the different carbon prices used, such as in Rezekiah and Farista's research which uses carbon prices based on Indonesia's ecological value issued by the Minister of Environment of the Republic of Indonesia, and in research at the U.S. National Wildlife using US value and global value, each of which has a different price.

The results of this study show that the carbon economic value of Suwangi Island Nature Park is relatively significant, although still lower than several international studies. The variation is largely determined by the reference price of carbon—whether national ecological value, domestic market value, or global market value. Furthermore, vegetation with dense and hardwood species tends to store greater amounts of carbon, which leads ecosystems dominated by such species to have higher carbon economic values.

This research provides an important contribution as it integrates aboveground biomass measurement, carbon stock estimation, and conversion into carbon economic value in a comprehensive manner. Such an integrated approach is rarely applied, thereby offering a novel contribution to forest resource conservation based on ecosystem services. The measured carbon economic value is also expected to raise awareness, particularly among local communities, about the importance of forest conservation and the economic opportunities it provides.

Moreover, the findings of this study are highly relevant within three major global contexts. First, they contribute to Indonesia's Nationally Determined Contributions (NDCs), as the carbon stocks in Suwangi Island's mangrove ecosystems can strengthen national emission reduction targets under the Paris Agreement. Second, the results have direct implications for carbon trading mechanisms, both within the domestic registry system (Sistem Registri Nasional Pengendalian Perubahan Iklim/ SRN PPI) and in international carbon markets, thereby potentially supporting economic incentive schemes for sustainable forest management. Third, this study aligns with the framework of Nature-Based Solutions (NbS), as mangrove conservation not only functions as a carbon sink and storage system, but also delivers co-benefits such as coastal protection, biodiversity conservation, and enhanced resilience of coastal communities.

Thus, the findings of this study provide not only academic and scientific value but also serve as a basis for supporting national climate policy, fostering economic opportunities through carbon trade, and advancing the implementation of nature-based solutions that are now central to sustainable development agendas.

CONCLUSION

Suwangi Island Nature Park has five types of land cover: primary forest, secondary forest, plantation, medium mangrove forest and dense mangrove forest. Each of these land cover types can store different amounts of carbon. The biomass per hectare produced by Suwangi Island Nature Park is 171.1820142 tons. So that the carbon produced in this study is 80.45554667 tons/ha. The economic value of carbon stored in Suwangi Island Nature Park amounted to IDR 2,851,347,872.68.

ACKNOWLEDGEMENTS

We greatly appreciate the financial support from the Institute for Research and Community Service of Lambung Mangkurat University for this research. We would also like to thank the management of Suwangi Island Nature Park, South Kalimantan Natural Resources Conservation Center for granting permission to conduct research in their working area.

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