Jurnal Biologi Tropis

Original Research Paper

Potential Carbon Stock and CO_2 Absorption in Star Apple (*Chrysophyllum cainito*) and Javanese Sapodilla (*Manilkara kauki*) in the Unesa Campus Forest

Fitriah Anggun Juwita Ma Rifah[1*] & Fida Rachmadiarti[2]

[1,2]Biology Study Program, Faculty of Mathematics and Natural Science, Universitas Negeri Surabaya, Surabaya, Indonesia;

Article History
Received : February 14th, 2026
Revised : February 25th, 2026
Accepted : March 05th, 2026

*Corresponding Author:
Fitriah Anggun Juwita Ma Rifah, Biology Study Program, Faculty of Mathematics and Natural Science, Universitas Negeri Surabaya, Surabaya, Indonesia;
Email: anggunj116@gmail.com

Abstract: The Unesa Campus Forest is one of the green open spaces that has the to play a significant role in mitigating climate change through carbon storage and sequestration. However, information on the carbon storage capacity and CO_2 absorption of local tree species in this area is still limited. This study aims to analyze the carbon stock and CO_2 absorption in *C. cainito* and *M. kauki* in the Unesa campus forest and their relationship with morphological and physiological characteristics as well as physical and chemical parameters of the environment carbon stocks and CO_2 absorption in *C. cainito* and *M. kauki* in the Unesa campus forest and to examine their relationships with morphological and physiological characteristics, as well as with physical and chemical environmental parameters. The study employed a total census and purposive sampling method, with analysis of the relationship between variables using Pearson's correlation test. The results showed that *M. kauki* has higher carbon stock and CO_2 absorption capacity than *C. cainito*. Carbon stock was positively correlated with height, circumference, diameter, and leaf area of *C. cainito* and *M. kauki*. Meanwhile, chlorophyll content for did not significantly affect carbon stock. The physicochemical parameters of the environment in this study supported the growth of both plant species.

Keywords: Carbon stock, CO_2 absorption, campus forest, morphological characters, physiological characters.

Introduction

A forest is an ecosystem contribute to carbon storage and climate regulation and provide benefits such as groundwater protection, flood prevention, maintenance of soil fertility, reduced runoff, and reduced erosion and sedimentation rates (Fathoni *et al.,* 2021). About 31% of the world's total land area is forested, which contribute significantly to absorbing carbon dioxide (CO_2). Carbon dioxide (CO2) is the largest contributor to greenhouse gas emissions. Every year, about 9 gigatons (Gt) of carbon is released into the atmosphere through human activities (Nayak *et al.,* 2022). Excess carbon disrupts the energy balance between the Earth and the atmosphere, leading to global warming and greenhouse gas emissions. Greenhouse gas emissions in the period 2000-2030 are expected to increase by 50%, with sustained impacts (Chataut *et al.,* 2023). Greenhouse gases can cause climate change phenomena, climate change is also caused by illegal burning and illegal logging (Rakuasa, 2022). Climate change can lead to extreme weather, including floods, storms, and droughts. The problem of climate change can be mitigated by plants' role as CO_2 sinks.

In Indonesia, forest areas cover more than half of the country's land area and play a crucial role in mitigating climate change. At the local level, the city of Surabaya has limited forest areas, including the forest on the campus of Surabaya State University, which covers an area of ± 759,333 m^2. The campus forest can be used as a conservation forest and support education in the campus area. Campus forests are made as an effort to prevent pollution, oxygen providers, and global warming, and play an active role as the most effective carbon sink, so as to reduce the increase in carbon emissions in the atmosphere. Various tree species have been identified in the forest on the Surabaya State University campus, including *Chrysophyllum cainito and Manilkara kauki.* The are plants from the Sapotaceae family, with dense leaf structures and extensive root systems. These trees can absorb carbon dioxide (CO_2) from the atmosphere through photosynthesis and store it as biomass, namely trunks, leaves, roots, and fruit. According to Kanwal *et al.* (2024), plants are an important component in CO_2 absorption because plants in forests absorb CO_2 through photosynthesis and store it as organic matter in plant biomass.

Research on carbon stocks has been conducted, including research by (Reza *et al.,* 2024) with 12 plant species as carbon stocks in the chlorophyll forest park, Kendal Regency, one of which is *Manilkara kauki*, and the results showed that the biomass contained was 3.06 tons and CO_2 uptake was 4.49 tons per year. Meanwhile, research was conducted (Madaputri, 2020) regarding plant carbon stocks located in the Malang city forest. 41 species were found, and one of them was *Chrysophyllum cainito*, which resulted in 8.93 kg of biomass and 4.47 kg of carbon stock. However, studies conducted by Reza *et al.* (2024) and Madaputri (2020) generally focus on biomass estimation without considering morphological and physiological factors such as leaf area and chlorophyll content, which play a direct role in the photosynthesis process. In addition, within the Surabaya State University campus forest, there is no accurate information on carbon stocks in *C. cainito* and *M. kauki.* Thus, there is a research gap regarding the integration of morphological and physiological parameters in the analysis of carbon stocks at the urban campus forest scale.

Based on the above background, this study aims to analyze carbon stocks in Star Apple (*Chrysophyllum cainito)* and Javanese Sapodilla (*Manilkara kauki)* in the Surabaya State University campus forest and the influencing factors. The benefits of this research are that it can support sustainable forest and land management and contribute to climate change mitigation through carbon storage in the city of Surabaya. This research can also support the achievement of the world's Sustainable Development Goals (SDGs), especially SDG 13 on climate action and SDG 15 on terrestrial ecosystems.

Materials and Methods

Study Site and Research Design

This study is a descriptive-exploratory quantitative study that aims to analyze carbon stocks and CO_2 absorption in two plant species, namely Star Apple (*Chrysophyllum cainito*) and Javanase Sapodilla (*Manilkara kauki*). The research was conducted from September-December 2024 and October-November 2025 in the Forest Area of Unesa, Lidah Wetan. Chlorophyll content analysis and leaf area measurements were carried out at the IsDB Biology Research Laboratory, Faculty of Mathematics and Natural Sciences, Surabaya State University.

Population and Sampling

The population consists of all *C. cainito* and *M. kauki* individuals growing in the study area. A total census method was applied to measure carbon stocks and CO_2 absorption data with the aim of producing the most accurate data possible. There were 16 *C. cainito* and 42 *M. kauki* individuals (58 trees in total) in the study area. Leaf samples for leaf area and chlorophyll content analysis were collected using purposive sampling at two observation stations per species (Figure 1). Leaves were taken from three canopy positions (base, middle, and top), resulting in 36 leaf samples.

Morphological and Physiological

Measurements

The morphological parameters measured included tree height, trunk circumference, trunk diameter, and leaf area. Tree height was measured from ground level to the highest tip using the Smart Measure application, while trunk circumference was measured at a height of 1.3 m above ground level and converted to diameter at breast height (DBH). Leaf area was measured from samples collected at three canopy positions. The physiological parameters such as chlorophyll content was measured using a Mapada UV-VIS spectrophotometer. Each leaf sample was crushed to approximately 0.1 g using a mortar and pestle, extracted by mixing with 1 ml of 96% alcohol, and then filtered through filter paper to obtain the filtrate. Chlorophyll content in *C. cainito* and *M. kauki* leaf filtrates was measured using a spectrophotometer at 649 nm and 665 nm. Followed by calculating the absorbance value of chlorophyll a, chlorophyll b, and total chlorophyll using the Wintermans and De Mots formula as follows:

Chlorophyll a = 13.7 × OD 665 – 5.76 OD 649 (mg/L)
Chlorophyll b = 25.8 × OD 649 – 7.7 OD 665 (mg/L)
Total chlorophyll = 20.0 × OD 649 + 6.1 OD 665 (mg/L)

Description:
OD = wavelength (nm)

Environmental Parameters

Measurement of physicochemical parameters was carried out at the observation location, using several research points. Measurements of physico-chemical parameters were carried out in the air and soil which included light intensity, temperature, humidity, pH, and CO_2. In air measurements, light intensity was measured using a lux meter (LX-101AS), while temperature; humidity; and CO_2 were measured with an Air Quality Monitor TVOC PM2.5. In soil measurements, pH and humidity were measured using a soil tester (3-in-1 Soil Moisture Meter), while temperature was measured using a soil thermometer.

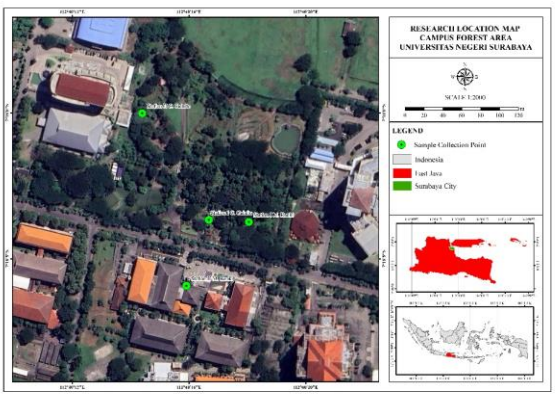

Figure 1. Sampling site

Biomass, Carbon Stock, and CO_2 Absorption

Biomass measurement is based on the formula proposed by (Ketterings et al., 2001), as follows:

$$BK = 0.11 \times \rho \times D2.62$$

Description:
BK = tree biomass (Kg)
D = diameter (1.3 m)
ρ = specific gravity of wood (kg/m3); Weight data can refer to the Indonesian Wood Atlas or Global Wood Density Data.

Then, from the results of the biomass obtained, it is used in the calculation of carbon stocks because SNI 7724: 2011 states that the percentage of carbon in wood, litter, and dead wood is 47%. So the estimation of carbon stocks used the following formula:

$$C = 47\% \times BK$$

Description:
C = carbon content (Kg)
BK = tree biomass (Kg)

To determine the estimation of CO2 uptake, we can use the relative atomic mass ratio of C with the following formula:

$$CO_2 = C \times 3.67$$

Description:
3.67 = equivalent number or conversion of element C to CO_2
C = carbon content (Kg)

Data Analysis

Research data on morphological characteristics (height, circumference, diameter, and leaf area), chlorophyll content, carbon stock, and environmental physical and chemical parameters were analyzed using Pearson correlation tests in IBM SPSS Statistics 23 to assess correlations. Before analysis, statistical assumptions were evaluated, including normality (Shapiro–Wilk test). Pearson's correlation was applied only if the data met the assumption of normality. If normality was not met, Spearman's rank correlation was used as a nonparametric alternative. Statistical significance was determined at a 95% confidence level ($\alpha = 0.05$). If $p < 0.05$, then the correlation is positive/significant. If $p \geq 0.05$, then the relationship between variables is not significant.

Results and Discussion

In this study, several data points were obtained in accordance with the research objectives. The data are: morphological and physiological characteristics, biomass, carbon stock, CO_2 absorption, and environmental physical and chemical parameters of *Chrysophyllum cainito* and *Manilkara kauki* in Unesa campus forest.

Morphological Characteristics and Physiological Characteristics in *C. cainito* and *M. kauki*

Morphological characteristics such as height, around, diameter, and leaf area. Meanwhile, physiological characteristics include chlorophyll content. **Table 1.** Shows the height, around, and diameter values for the species *C. cainito* and *M. kauki* in the Unesa Campus Forest Area. The data shows that *M. kauki* has more dominant growth than *C. cainito*, as seen from its greater height, around, and diameter. This can be influenced by the ability of plants to adapt to the environment. Leaf area in *C. cainito* and *M. kauki* species at two observation stations, where the value of leaf area at the base is greater than the middle and shoot. The largest leaf area in *C. cainito* is in station II while in *M. kauki* is in station I (**Table 2**). Leaf area differences can be influenced by the availability of nutrients in the environment.

Physiological characteristics in the form of chlorophyll content presented in **Figure 2.** Shows varying chlorophyll levels in *C. cainito* and *M. kauki* species with a total of 36 samples. Chlorophyll measurements in three parts, namely the base, middle, and shoot, show that the chlorophyll level is highest at the base, followed by the middle, and lowest at the tip. This applies to both species at station I and station II. At station I, the total chlorophyll content at the base of *C. cainito* was 39.02 mg/L. Meanwhile, at station II, it was 32.02 mg/L. At station I, the total chlorophyll content of the base of *M. kauki* was 30.03 mg/L. Meanwhile, at station II, it was 32.77 mg/L. Overall, *C. cainito* had a higher chlorophyll content than *M. kauki*. The difference in chlorophyll content is thought to be influenced by variations in light intensity, the availability of nutrients, especially nitrogen and magnesium, and the physiological age of the leaves.

Table 1. High, Around, and Diameter of *C. cainito* and *M. kauki*

Species	High (cm)	Around (cm)	Diameter (cm)
C. cainito	333± 72	29,50± 11,79	9,40± 3,75
M. kauki	632± 356	43,68± 13,38	14,31± 4,26

Table 2. Leaf area of *C. cainito* and *M. kauki*

Station	Species	Base (cm^2)	Middle (cm^2)	Shoot (cm^2)
1	*C. cainito*	54.00 ± 20.78	51.60 ± 10.19	43.30 ± 9.87
2		85.30 ± 8.45	77.20 ± 12.23	73.20 ± 7.32
1	*M. kauki*	72.80 ± 9.60	58.70 ± 5.12	46.90 ± 4.51
2		61.40 ± 13.60	52.80 ± 13.11	41.80 ± 13.44

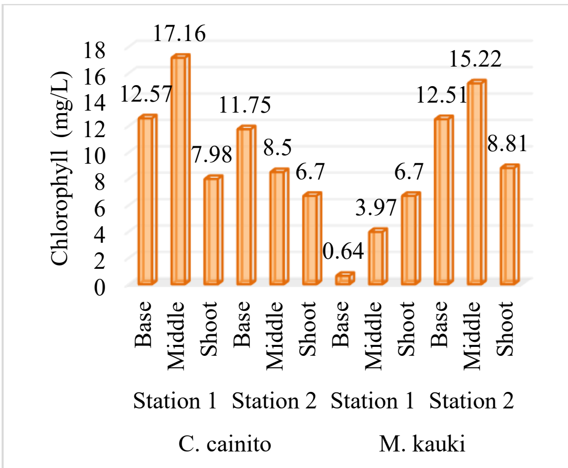

Figure 2. Chlorophyll content in *C. cainito* and *M. kauki*

Analysis of morphological characteristics, including height, around, diameter, and leaf area, in *C. cainito* and *M. kauki* showed differences, even though both species grow in the same environment at the Unesa Campus Forest. There were 16 individuals of *C. cainito* and 42 individuals of *M. kauki*. Table 1 shows that the average height, around, and diameter of *M. kauki* are higher than those of *C. cainito*. This may be influenced by the age of the plants, as younger trees have smaller heights, circumferences, and diameters than mature or older trees (Aldafiana & Murniyati, 2021). In addition, differences in height, width, and diameter can be influenced by the ability of plants to adapt to abiotic environmental components (Pascalino *et al.,* 2024). *M. kauki* has a higher ability to adapt to abiotic environmental components than *C. cainito.*

The leaf area measured at the base, middle, and tip differs between the two species. Based on Table 2, in both *C. cainito* and *M. kauki*, the base of the leaf has the largest area, followed by the middle and the smallest at the shoot. The base has a larger leaf area because it is closer to transport tissues such as xylem and phloem and to the stem, resulting in a more optimal nutrient supply and larger leaf growth. In addition, cell growth is more active at the base of the leaf than in the middle and tip, so that cells divide more actively and the leaf develops more. Morphologically, the leaf area at the base has a larger structure than the middle and tip because it contributes to an increase in surface area for light and gas absorption, as well as increasing efficiency in the transpiration process (Rusdiana *et al.,* 2021) and (Indah, 2021). Overall, *C. cainito* has a larger average leaf area than *M. kauki*. A smaller leaf area may be caused by low water availability (Jia & Wang, 2021).

Looking at physiological characteristics in the form of chlorophyll content shown in Figure 2, measurements of leaf chlorophyll content were taken at the base, middle, and shoot of both species. In both *C. cainito* and *M. kauki*, the highest leaf chlorophyll content was found at the base of the leaf, followed by the middle and the lowest at the shoot of the leaf. The chlorophyll content at the base is higher because, in general, the leaves at the base are the oldest, so the cells have had more time to accumulate chlorophyll. Leaves at the base with high chlorophyll content also have a higher CO_2 absorption capacity than young leaves or leaves at the tip. Overall, the chlorophyll content of *C. cainito* is higher than that of *M. kauki*. The higher chlorophyll content in *C. cainito* is due to its larger leaves, which contain more mesophyll cells, leading to greater chlorophyll accumulation. Chlorophyll content is closely related to CO_2, biomass, and carbon stocks. The higher the chlorophyll content in the leaves, the greater the plant's ability to absorb CO_2 through photosynthesis, which produces biomass. The greater the biomass formed, the higher the carbon stock stored in the plant. Chlorophyll is the main pigment in a plant that performs photosynthesis (Simkin *et al.,* 2020).

The morphological and physiological differences between *C. cainito* and *M. kauki* indicate species-specific growth strategies that influence biomass accumulation potential. Scientifically, these findings reinforce the concept that structural characteristics such as height, diameter, and leaf area are fundamental predictors of biomass and carbon storage capacity in tropical tree species. Ecologically, the dominance of *M. kauki* in growth parameters suggests that this species may contribute more significantly to carbon sequestration and long-term carbon storage in the Unesa Campus Forest ecosystem.

Carbon Stocks and CO_2 Absorption in *C. cainito* and *M. kauki*

Calculations of biomass value, carbon stock, and CO_2 absorption are based on allometric equations. Based on **Table 3**, biomass, carbon stock, and CO_2 absorption vary in value. *M. kauki* has higher biomass, carbon stock, and CO_2 absorption values than *C. cainito*. The carbon stock value of *C. cainito* is in the low category, while that of *M. kauki* is in the medium category. Based on **Figure 3**, carbon stock is directly proportional to CO_2 absorption, the greater the carbon stock, the greater the CO_2 absorption. These differences in biomass value, carbon stock, and CO_2 absorption can be influenced by stem diameter, plant age, wood density, and vegetation density.

Table 3. Biomass, carbon stocks, and CO_2 absortion of *C. cainito* and *M. kauki*

Species	Biomass (Kg. tree. $^{-1}$. year^{-1})	Carbon Stock (Kg C. tree. $^{-1}$. year^{-1})	CO_2 absorption (Kg CO_2. tree. $^{-1}$. year^{-1})
C. cainito	38,51± 41,86	18,10± 19,67	65,36± 72,92
M. kauki	116,41± 101,49	54,71± 47,70	200,76± 175,12

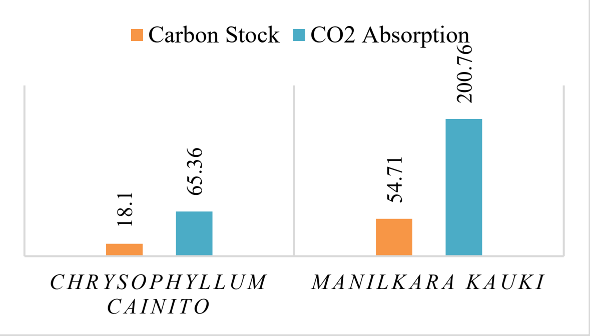

Figure 3. Carbon Stock Diagram versus CO_2 Absorption

Table 3 shows that the carbon stock in C. cainito is lower than that in *M. kauki*. In *C. cainito*, the stored carbon stock is in the low category, while in *M. kauki* it is in the medium category. This is influenced by tree biomass. The size of this biomass is influenced by stem diameter, which plays an important role in calculating the biomass value. The larger the stem diameter of a tree, the greater its biomass value (Sribianti *et al.,* 2022). This statement aligns with the study results: the average stem diameter of *M. kauki* is 14.31 cm, larger than that of *C. cainito* (9.40 cm).

The difference in wood density between the two species also affects the carbon stock produced (Isnaeni *et al.,* 2019). The wood density of *C. cainito* is 0.740 kg/m3, while that of *M. kauki* is 0.830 kg/m3. Wood with high density has a structure that can store large amounts of carbon, thereby increasing the species' total carbon stock (Lestari *et al.,* 2024). In addition, carbon stocks are also influenced by vegetation density. This is in line with the opinion of Dini *et al.,* (2022), which states that dense vegetation can increase carbon reserves and carbon sequestration. This opinion is consistent with research results showing that the number of *M. kauki* individuals is greater than that of *C. cainito* 42 M. kauki individuals were found, compared with 16 *C. cainito* individuals. CO_2 absorption is directly proportional to carbon stocks in plants, as shown in Figure 3. The greater the CO_2 absorption, the greater the carbon stocks formed in plants (Yaqin *et al.,* 2022). This statement is in line with the results of the study, where CO_2 absorption in *M. kauki* is greater than *in C. cainito*, so that the carbon stock in *M. kauki* is greater than in *C. cainito*. CO_2 absorption is influenced by photosynthesis and by factors such as light intensity, temperature, leaf area, water availability, growth phase, and age, which can affect plants' ability to absorb CO_2 (Kareninsekar & Insafitri, 2020).

The results of this study indicate that the carbon stock values of both species are consistent with the results of previous studies conducted by Reza et al. (2024) and Madaputri (2020), where carbon stock values fall into the low to moderate category. The higher carbon stock and CO_2 absorption in *M. kauki* confirm the importance of wood diameter and density in carbon accumulation. These findings reinforce the carbon estimation approach at the species level. Ecologically, *M. kauki* can be prioritized in urban forest carbon management strategies.

Relationship between Morphological and Physiological Characteristics and Carbon Stock in *C. cainito* and *M. kauki*

Pearson's correlation test was conducted to determine the relationship between morphological and physiological characteristics and carbon stock. Based on **Table 4**, it shows that morphological characteristics such as height, around, diameter, and leaf area have a positive correlation or are significantly related to carbon stock because the significance value is <0.05. Height, circumference, and diameter have perfect Pearson's correlation coefficient values. Meanwhile, physiological characteristics such as chlorophyll content have a correlation are not significantly related to carbon stock because the significance value is >0.05. The Pearson correlation coefficient value of chlorophyll content with carbon stock is in the very strong negative correlation range.

Table 4. Pearson Correlation of Morphological and Physiological Characteristics with Carbon Stock in *C. cainito* and *M. kauki*

Parameters	Pearson Correlation	Sig. (2-tailed)
High	0,721	0,00
Around	0,954	0,00
Diameter	0,955	0,00
Leaf area	-0,547	0,00
Chlorophyll	-0,123	0,489

Based on the results of Pearson's correlation statistical test, it was found that carbon stocks in *C. cainito* and *M. kauki* had a positive correlation with morphological characteristics, but a correlation not significance with physiological characteristics, as shown in Table 4. Morphological characteristics such as height, around, diameter, and leaf area were positively correlated with carbon stocks with a significance value of <0.05 and a perfect Pearson correlation coefficient value of 0.81-1.00. Morphological relationships such as height, around, and diameter showed that the greater the height, around, and diameter, the greater the carbon content in the plant. As a tree grows taller, its volume and biomass also increase. Taller trees tend to have longer trunks, larger crowns, and more wood tissue, so the amount of carbon stored in the biomass is greater (Sardi *et al.,* 2021). Meanwhile, the around value is directly proportional to the diameter. The larger the stem diameter, the greater the biomass value, with a higher DBH indicating an older tree and, of course, a larger carbon stock (Erfanifard *et al.,* 2025).

Other morphological traits, such as leaf area, are positively correlated with carbon stocks. Leaf area is a key biophysical parameter for determining photosynthesis, respiration, and transpiration (Duan *et al.,* 2019). Leaf area is positively related to carbon stocks because the larger the leaf area, the greater the tree's photosynthetic capacity. Larger leaves are able to capture more sunlight and absorb more CO_2, thereby increasing biomass production. This biomass serves as a carbon storage site. The assimilation of leaf area and the efficiency of the photosynthesis process are interpreted as biomass accumulation (Márquez-Prieto *et al.,* 2022). The resulting biomass accumulation is directly proportional to the carbon content in plants.

The relationship between physiological characteristics, namely chlorophyll content, is correlated not significance with carbon stocks. Irsadi *et al.,* (2022) stated that chlorophyll content describes photosynthetic capacity, but does not directly indicate the amount of carbon stored in the form of biomass. In addition to chlorophyll, carotenoids also regulate carbon stocks and storage by influencing the rate of photosynthesis (Lulu *et al.,* 2024). *C. cainito* and *M. kauki* are also fruiting plants, where much carbon is allocated to fruit formation, resulting in relatively lower chlorophyll levels and inhibited vegetative growth.

The significant positive correlation between morphological parameters and carbon reserves reinforces the allometric theory, which states that tree size variables are reliable predictors of biomass and carbon accumulation. Scientifically, these results justify the use of height, circumference, and diameter as practical indicators for rapid assessment of carbon reserves in urban forests. On the other hand, the insignificant relationship between chlorophyll content and carbon stocks indicates that short-term physiological properties do not directly reflect long-term carbon storage. Ecologically, this suggests that forest carbon management strategies should prioritize structural growth rather than focusing solely on physiological optimization. These findings contribute to improving the carbon monitoring framework in small-scale tropical forest ecosystems.

Measurement of Environmental Physical-Chemical Parameters in *C. cainito* and *M. kauki*

Measurements of environmental physical and chemical parameters are conducted in the air and soil. Based on **Table 5**, the results show that environmental conditions are relatively constant and there are no significant differences between the two stations for each species. Statistical testing using Pearson's correlation was also conducted to determine the relationship between environmental physical and chemical parameters and carbon stocks. Based on **Table 6**, it shows that light intensity, air temperature, air humidity, pH, soil temperature, and soil moisture are positively correlated or significantly related to carbon stocks with a significance value of <0,05 and are included in the perfect correlation. Meanwhile, environmental CO_2 is not significantly related to carbon stocks with a significance value of >0,05.

Table 5. Physics Chemical Parameters *C. cainito* and *M kauki*

	C. cainito		***M. kauki***	
Parameters	**Station I**	**Station II**	**Station I**	**Station II**

Air				
Ligh intensity (Lux)	4010 ± 0	9720 ± 0	3881,4 ± 1735,34	4416,8 ± 2000,29
Temperatur (°C)	33 ± 0	33 ± 0	33,3 ± 0,52	33,5 ± 0,51
Humidity (%)	76 ± 0	79 ± 0	83,4 ± 4,01	75,7 ± 5,82
CO_2 (°ppm)	461 ± 0	467 ± 0	514,7 ± 15,79	495,7 ± 21,43
Soil				
pH	8 ± 0	8 ± 0	8 ± 0	9 ± 0
Humidity (%)	60 ± 0	60 ± 0	48 ± 24,6	28 ± 20,3
Temperatur (°C)	31 ± 0	28 ± 0	29 ± 1,48	30,4 ± 1,08

Table 6. Pearson Correlation of Environmental Physical and Chemical Parameters with Carbon Stock in *C. cainito* and *M. kauki*

Parameters	Pearson Correlation	Sig. (2-tailed)
Air		
Ligh intensity	-0,362	0,039
Temperatur	0,446	0,009
Humidity	0,637	0,00
CO_2	0,500	0,783
Soil		
pH	0,562	0,001
Humidity	-0,732	0,00
Temperatur	0,580	0,00

Measurements of environmental physical and chemical parameters at two stations for each species showed that environmental conditions did not differ significantly, as shown in Table 5. Measurements of physical and chemical parameters were taken in the air and soil. The light intensity for both species was in accordance with the quality standards for tropical plants (500-10000 lux) (Yasmin *et al.,* 2023). This light intensity was sufficient for photosynthesis because these species are tolerant to partial shade. Low light intensity negatively affects photosynthesis, resulting in low carbon stocks. High light intensity increases photosynthesis and respiration rates, resulting in rapid plant biomass formation. The air temperature for both species is above the average optimal range (25-30°C) (PP No. 41 of 1999), but it is still within the range considered feasible for adaptive tropical plants.

The air humidity for both species is in line with the plant quality standard of 60-80%, which is ideal for supporting tropical plant growth. According to Krause *at al.,* (2025) Excessively high or low air humidity has a negative impact on forest carbon stocks because it reduces nutrient absorption in plants. The CO_2 levels for both species meet the quality standards, ranging from 350-1000 ppm. This CO_2 level is high enough to support photosynthesis rates. The pH values for both species are too alkaline relative to the requirements of *C. cainito* and *M. kauki*, which prefer neutral or more acidic pH levels. The pH quality standard for tropical plants ranges from 6.6 to 7.5 (Juliyanto *et al.,* 2022), so the pH of both species exceeds the optimal range. The soil moisture of both species is adequate for the growth of plants that require moist soil, but not waterlogged. Meanwhile, the soil temperature of both species is suitable for supporting plant growth, ranging from 20-35°C (Kumar *et al.,* 2021). Soil temperature affects the activity of microorganisms that decompose organic matter, and the optimal temperature can increase carbon uptake by increasing the accumulation of organic carbon in the soil.

Based on the results of Pearson's correlation test in Table 6, it shows that light intensity, air temperature, air humidity, pH, soil temperature, and soil moisture are positively correlated with carbon stocks. This indicates that improvements in these physical and chemical environmental conditions are followed by an increase in carbon stocks in the ecosystem. However, CO_2 levels show no significant correlation with carbon stocks. This negative correlation may occur because areas with high carbon stocks tend to have lower environmental CO_2 levels, as plants actively absorb CO_2 for photosynthesis. Conversely, when carbon stocks are low, the ability of vegetation to absorb CO_2 decreases, causing CO_2 concentrations in the environment to increase (Solomon *et al.,* 2024).

The significant influence of environmental factors on carbon stocks highlights the interaction between abiotic conditions and carbon dynamics. Ecologically, maintaining optimal environmental quality is essential for preserving the function of campus forests as carbon sinks.

Conclusion

Based on the study results, it can be concluded that the carbon stock and CO_2 absorption of *M. kauki* are higher than those of *C. cainito*. Carbon stock is positively correlated with morphological characteristics and correlated not significantly related to physiological characteristics. The physical and chemical parameters of the environment are sufficient to support the growth of both species.

Acknowledgments

The author would like to thank all those who have helped in this research. Especially State University of Surabaya, which facilitated this research, enabling the author to complete this article.

References

Aldafiana, S., & Murniyati, A. (2021). Pertumbuhan Tinggi dan Diameter Serta Volume Tanaman Sengon (Paraserianthes Falcataria) Umur 10 Tahun di Desa Perdana, Kecamatan Kembang Janggut, Kutai Kartanegara. *Jurnal Eboni*, *3*(2), 73–78. https://ejournals.umma.ac.id/index.php/eboni/article/view/1198

Chataut, G., Bhatta, B., Joshi, D., Subedi, K., & Kafle, K. (2023). Greenhouse gases emission from agricultural soil: A review. *Journal of Agriculture and Food Research*, *11*, 1–8. https://doi.org/10.1016/j.jafr.2023.100533

Dini, N. L. K., Jauhari, A., & Rachmawati, N. (2022). Prediksi Nilai Karbon Yang Hilang Akibat Kebakaran Hutan Dan Lahan Di Kota Banjarbaru. *Jurnal Sylva Scienteae*, *5*(3), 372–378. https://doi.org/10.20527/jss.v5i3.5708

Duan, B., Liu, Y., Gong, Y., Peng, Y., Wu, X., Zhu, R., & Fang, S. (2019). Remote estimation of rice LAI based on Fourier spectrum texture from UAV image. *Plant Methods*, *15*(124), 2–12. https://doi.org/10.1186/s13007-019-0507-8

Erfanifard, Y., Hosingholizade, A., Griess, V. C., Elena, V., Millan, G., & Pirasteh, S. (2025). Science of Remote Sensing Estimating tree diameter at breast height (DBH) from UAV data : A comparison of oblique – Vertical imagery fusion and allometric modeling. *Science of Remote Sensing*, *12*(November), 100331. https://doi.org/10.1016/j.srs.2025.100331

Fathoni, A., Rohman, F., & Sulisetijono, S. (2021). Karakter Pohon Area Sekitar Sumber Mata Air Di Malang Raya, Jawa Timur. *Biotropika: Journal of Tropical Biology*, *9*(1), 69–79. https://doi.org/10.21776/ub.biotropika.2021.009.01.08

Indah, P. L. (2021). Identifikasi Nilai Konstanta Daun Untuk Pengukuran Luas Daun Pada Dua Varietas Unggul Baru Manggis (Garcinia mangostana L.) : Ratu Kamang dan Ratu Tembilahan. In *Universitas Jambi*. https://repository.unja.ac.id/28456/

Irsadi, A., Martuti, N. K. T., Abdullah, M., & Hadiyanti, L. N. (2022). Abrasion and Accretion Analysis in Demak, Indonesia Coastal for Mitigation and Environmental Adaptation. *Nature Environment and Pollution Technology*, *21*(2), 633–641. https://doi.org/10.46488/NEPT.2022.v21i02.022

Isnaeni, R., Ardli, E. R., & Yani, E. (2019). Kajian pendugaan biomassa dan stok karbon pada Nypa fruticans di kawasan Segara Anakan bagian barat, Cilacap. *BioEksakta: Jurnal Ilmiah Biologi Unsoed*, **1**(2), 151–157. https://doi.org/10.20884/1.bioe.2019.1.2.1823

Jia, Q., & Wang, Y. P. (2021). Relationships between leaf area index and evapotranspiration and crop coefficient of hilly apple orchard in the loess Plateau. *Water (Switzerland)*, *13*(14), 1–19. https://doi.org/10.3390/w13141957

Juliyanto, F., Herawatiningsih, R., & Anwari, M. S. (2022). Jurnal Lingkungan Hutan Tropis. *Jurnal Lingkungan Hutan Tropis*, *1*(2), 441–442. https://jurnal.untan.ac.id/index.php/jlht/article/view/61820/75676596218

Kanwal, A., Sharma, P., & Singh, R. (2024).

Role of Carbon Sequestration to Mitigate the Global Environmental Changes. *Advances in Agricultural Technology & Plant Sciences*, *7*(2), 1–6.

Kareninsekar, C., & Insafitri. (2020). Stok dan Serapan Karbon pada Jenis Mangrove yang Berbeda (Rhizophora stylosa , Avicennia marina dan Bruguierra gymnorrhiza). *Jurnal Trunojoyo*, *1*(2), 220–226. https://doi.org/10.21107/juvenil.v1i2.7576

Ketterings, Q. M., Coe, R., Van Noordwijk, M., Ambagau', Y., & Palm, C. A. (2001). Reducing uncertainty in the use of allometric biomass equations for predicting above-ground tree biomass in mixed secondary forests. *Forest Ecology and Management*, *146*(1–3), 199–209. https://doi.org/10.1016/S0378-1127(00)00460-6

Kumar, A., Kumar, P., Singh, H., Bisht, S., & Kumar, N. (2021). Relationship of physiological plant functional traits with soil carbon stock in the temperate forest of Garhwal Himalaya. *Current Science*, *120*(8), 1368–1373. https://doi.org/10.18520/cs/v120/i8/1368-1373

Krause, J. R., Cameron, C., Arias-Ortiz, A., Cifuentes-Jara, M., Crooks, S., Dahl, M., Friess, D. A., Kennedy, H., Lim, K. E., Lovelock, C. E., Marbà, N., McGlathery, K. J., Oreska, M. P. J., Pidgeon, E., Serrano, O., Vanderklift, M. A., Wong, L. W., Yaakub, S. M., & Fourqurean, J. W. (2025). Global seagrass carbon stock variability and emissions from seagrass loss. *Nature Communications* , *16*(1), 1–9. https://doi.org/10.1038/s41467-025-59204-4

Lestari, N. P., Kariada, N., & Martuti, T. (2024). Potensi Cadangan Karbon Tersimpan dan Serapan Karbon pada Ekosistem Hutan Kota Tinjomoyo Semarang. *Life Science* *13*(2), 119–133. https://doi.org/10.15294/unnesjlifesci.v13.i2.592

Lulu, N., Rachmawati, R., & Siti, N. H. (2024). CARBON EMISSION DISCLOSURE: A Study on Agriculture, Energy, and Industry Companies. *Indonesian Journal of Advanced Research*, *3*(7), 1017–1038. https://doi.org/10.55927/ijar.v3i7.10064

Madaputri, G. N. (2020). Keanekaragaman Pohon dan Potensinya Sebagai Cadangan Karbon di Hutan Kota Malang (Vol. 2507, Issue February).

Márquez-Prieto, A. K., Palacio-Márquez, A., Sánchez, E., Macias-López, B. C., Pérez-Álvarez, S., Villalobos-Cano, O., & Preciado-Rangel, P. (2022). Impact of the foliar application of potassium nanofertilizer on biomass, yield, nitrogen assimilation and photosynthetic activity in green beans. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *50*(1), 1–12. https://doi.org/10.15835/nbha50112569

Nayak, N., Mehrotra, R., & Mehrotra, S. (2022). Carbon biosequestration strategies: a review. *Carbon Capture Science and Technology*, *4*(August), 1–11. https://doi.org/10.1016/j.ccst.2022.100065

Pascalino, E. B., Wahyudiono, S., & Andayani, S. T. (2024). Pengaruh Curah Hujan terhadap Pertumbuhan Tanaman Eucalyptus Pellita di Mineral Soil. *Jurnal Agroforetech*, *2*(1), 626–631.

Rakuasa, H. (2022). Analisis Spasial Temporal Suhu Permukaan Daratan/ Land Surface Temperature (Lst) Kota Ambon Berbasis Cloud Computing: Google Earth Engine. *Jurnal Ilmiah Informatika Komputer*, *27*(3), 194–205. https://doi.org/10.35760/ik.2022.v27i3.7101

Reza, A. D., Pramono, C. L., & Foresty, R. S. (2024). Analisis Serapan Karbon Dioksida Sebagai Penyedia Jasa Lingkungan di Ruang Terbuka Hijau Taman Hutan Klorofil Kabupaten Kendal, Jawa Tengah, Indonesia. *Journal Of Social Science Research,* *4*, 1958–1970. https://j-innovative.org/index.php/InnovativeAnalisis

Rusdiana, R. Y., Widuri, L. I., & Restanto, D. P. (2021). Pendugaan Model Luas Daun Tanaman Pakcoy (*Brassica rapa L.*) Dengan Regresi Kuantil. *Agrin*, *25*(1), 48–58.https://doi.org/10.20884/1.agrin.2021.25.1.576

Sardi, W. D. P. A., Kainde, R. P., & Nurmawan, W. (2021). Cadangan Karbon Pada Pohon Di Taman Hutan Raya Gunung Tumpa H. V. Worang. *Jurnal Cocos*, *14*(3), 1–17.

Simkin, A. J., Faralli, M., Ramamoorthy, S., & Lawson, T. (2020). Photosynthesis in non-foliar tissues: implications for yield. *Plant Journal*, *101*(4), 1001–1015. https://doi.org/10.1111/tpj.14633

Solomon, N., Birhane, E., Teklay, M., Negussie, A., & Gidey, T. (2024). Exploring the role of canopy cover and environmental factors in shaping carbon storage in Desa ' a forest , Ethiopia. *Carbon Balance and Management*, *19*(30), 1–13. https://doi.org/10.1186/s13021-024-00277-x

Sribianti, I., Daud, M., Aziz Abdullah, A., & Sardiawan, A. (2022). Estimasi Biomassa, Cadangan Karbon, Produksi O2 dan Nilai Jasa Lingkungan Serapan CO2 Tegakan Hutan di Taman Hutan Raya Abdul Latief. *Jurnal Hutan Dan Masyarakat*, *14*(1), 12–26. https://doi.org/10.24259/jhm.v14i1.18022

Yaqin, N., Rizkiyah, M., Putra, E. A., Suryanti, S., & Febrianto, S. (2022). Estimasi Serapan Karbon pada Kawasan Mangrove Tapak di Desa Tugurejo Semarang. *Buletin Oseanografi Marina*, *11*(1), 19–29. https://doi.org/10.14710/buloma.v11i1.38256

Yasmin, N. S., Harijanto, M., Nuraini, L., Fisika, P., & Jember, U. (2023). String (Satuan Tulisan Riset Dan Inovasi Teknologi) Rancang Bangun Prototype Sistem Monitoring Suhu, Kelembaban Dan Intensitas Cahaya Pada Tanaman Cabai Berbasis Iot. *7*(3), 300–309. DOI: http://dx.doi.org/10.30998/string.v7i3.15139