

Research Report

A Comparative Study of Carbon Sequestration of Various Perennial Trees at Varee Chiangmai School, Chiang Mai

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Virtual Science Symposium (VSS) 2026

Research Topic: A Comparative Study of Carbon Sequestration of Various Perennial Trees at Varee Chiangmai School, Chiang Mai

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Abstract

The objective of this research was to study and compare the carbon sequestration potential of various perennial tree species within Varee Chiangmai School, Chiang Mai. The study considered canopy cover, ground cover, tree height, and biomass calculations to determine the amount of carbon and carbon dioxide that the trees can sequester.

The research results showed that canopy cover in steps 1–8 ranged from 50–70%, indicating moderate to high canopy density. However, in steps 9–10, canopy cover decreased significantly. Regarding ground cover, it was found that there was 0% green ground cover in every step because the entire area is paved with artificial grass, resulting in no natural ground cover plants in the study area.

Regarding tree height and circumference, it was found that the Golden Shower Tree (*Koon*) had the greatest height and circumference, reflecting a high potential for biomass creation. When calculating biomass and carbon content, it was found that the Queen's Crape Myrtle (*Inthanin Nam*) sequestered the highest amount of carbon (2.5631 tons), followed by the Golden Shower Tree (2.4571 tons). The Silver Trumpet Tree (*Lueang Pridiyathorn*) sequestered the least

amount of carbon (0.1454 tons). This demonstrates that morphology, height, circumference, and growth rate affect the carbon sequestration potential of each tree species.

In conclusion, different types of perennial trees have different abilities to sequester carbon. The data from this study can be used to plan for increasing green spaces, selecting tree species with high potential for carbon absorption, and serving as an environmental learning resource for students in accordance with sustainable development guidelines.

Keywords : Carbon Sequestration, Perennial Trees

Acknowledgements

This report on “A Comparative Study of Carbon Sequestration of Various Perennial Trees at Varee Chiangmai School, Chiang Mai” was completed with the cooperation and support of many parties. We would like to express our gratitude to the administrators of Varee Chiangmai School for providing the opportunity and fully supporting this environmental research.

We would like to thank our teachers: Miss Rattanaorn Waenphet, Miss Tatsaneeya Kulap, Miss Rapeeporn Wareethip, Mr. Suppasit Kiatpattananon, and Mr. Nutchworapol Vongsoontorn. They provided guidance, facilitated the process, and offered close consultation throughout the project, from planning and data collection to the correct academic analysis of results.

We thank the teachers and staff of Varee Chiangmai School for assisting in the area survey and facilitating operations, as well as all our fellow students for their encouragement and exchange of ideas throughout the study period.

Finally, we thank our parents for their support and encouragement in completing this project. Thank you to everyone who contributed to the completion of this research.

We would like to express our gratitude for all assistance on this occasion.

The Research Team

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Chapter 1

Introduction

Background

Currently, the world is facing Climate Change caused by the increase of greenhouse gases, especially Carbon Dioxide (CO₂), accumulating in the atmosphere from human activities such as fossil fuel use, deforestation, and urban expansion. This has resulted in a rise in the global average temperature, more frequent severe disasters, and impacts on human quality of life and natural ecosystems. Reducing and absorbing carbon is, therefore, a crucial measure that many countries worldwide prioritize.

Among the measures used to reduce atmospheric carbon, "Perennial Trees" are considered an effective natural mechanism. Trees can absorb carbon dioxide through photosynthesis and store carbon in their trunks, branches, leaves, and roots for many years, giving them a significant role in reducing global warming. However, each tree species has a different capacity for carbon sequestration due to differing biological characteristics such as height, wood density, and growth rate. Studying carbon sequestration potential by tree species is therefore important for both academics and green space management.

Varee Chiangmai School has a variety of tree species distributed throughout its area, making it a highly suitable location for studying the carbon sequestration potential of perennial trees in a real environment. The data obtained will reflect the ability of each tree species to reduce carbon, which will be useful for planning to increase green spaces, selecting appropriate trees for additional planting, and serving as an environmental learning tool for students to understand the impact of global warming through empirical data collection. For this reason, the research on " A Comparative Study of Carbon Sequestration of Various Perennial Trees at Varee Chiangmai School, Chiang Mai " is important for developing knowledge and sustainable management guidelines for the school.

Research Objectives

1. To measure and calculate the amount of carbon sequestered by various perennial trees within Varee Chiangmai School.
2. To compare the stored carbon quantity among different tree species.
3. To study the relationship between tree structural variables (circumference and height) and the amount of carbon sequestered.
4. To provide recommendations for the school's green space management to increase carbon sequestration potential.

Research Questions

1. Do different perennial tree species in Varee Chiangmai School sequester different amounts of carbon?
2. Is tree size (circumference and height) related to the amount of carbon?
3. Which tree species has the highest potential for carbon sequestration in the study area?

Research Hypothesis

1. The amount of carbon sequestered by each perennial tree species is significantly different.
2. Trunk circumference and tree height have a positive correlation with the amount of sequestered carbon.
3. Large perennial trees and species with high wood density can sequester more carbon than other species.

Expected Benefits

1. Obtain data on the carbon quantity of each perennial tree species in the Varee Chiangmai School area.
2. Use as supporting data for planning to increase green spaces in Varee Chiangmai School.
3. Serve as an environmental learning resource for students.
4. Apply the data to the school's carbon footprint system.
5. Support tree planting activities according to the global warming reduction policy of Varee Chiangmai School.

Scope of Research

1) Content

- Comparative study of carbon sequestration of various perennial tree species within Varee Chiangmai School, Chiang Mai, totaling 10 trees.
- Study only Above-ground biomass.
- Measure 3 variables: Trunk circumference, Height, and calculate Biomass.
- Compare the average carbon quantity of each tree species.

2) Location

- Area of Varee Chiangmai School, Chiang Mai Province.
- Collect data only on trees within the area boundary defined by GLOBE standards.

3) Time

- Field data collection period: November - December 2025.
- Data analysis and report writing period: January 2026.

Chapter 2

Literature

In conducting the research on "A Comparative Study of Carbon Sequestration in Different Tree Species at Varee Chiangmai School, Chiang Mai Province," the research team has studied and reviewed documents and research theories related to the following:

2.1 Concepts regarding climate change and carbon sequestration of trees

2.1.1 Carbon Sequestration is the process of removing carbon from the atmosphere and storing it in a storage site, or simply storing carbon. For example, all green plants absorb carbon dioxide to use in the respiration process and then convert carbon dioxide into wood. In general wood, there is approximately 50% carbon content. Therefore, planting trees is essentially pulling carbon to be stored, causing atmospheric carbon to decrease. For this reason, forests are excellent carbon storage sites.

2.1.2 Carbon Cycle in Forests is the transformation of atmospheric carbon into forms accumulated in the forest. For example, trees and green plants absorb carbon dioxide and store it as wood and leaves. Forest soil also helps store carbon in various forms. Tree roots that are decaying, leaves and wood that are decaying, and forest soil also help absorb methane gas, which has properties that cause global warming much more than carbon dioxide. Finally, products from trees such as house posts, boards, beams, doors, and furniture all help sequester carbon as well. It can be said that living plants, dead organic matter, and various wood products are all sources of carbon collection in the forest.

3 Major Carbon Sources in Forests:

1. Living Biomass:
 - Above-ground biomass: Trees, various undergrowth plants including shrubs, vines.
 - Below-ground biomass: Tree roots of various sizes, but usually excluding roots smaller than 2 mm.

2. Dead Organic Matter or Dead Plant Remains:

- Trees standing dead, fallen logs, or dead wood buried in the soil.
- Plant debris: Various plant debris and leaves that have fallen and accumulated on the soil surface.

3. Soil Carbon: Organic carbon (organic matter) in the soil, including in organic soil. This is usually determined down to a specified soil depth, such as 30 cm, and may include small fibrous roots.

2.1.3 Carbon Fixation Process of Trees

The carbon fixation process of trees is the conversion of carbon dioxide gas (CO_2) from the air into organic substances such as sugar to be used as food. This relies on light energy through the Calvin Cycle, which is divided into 3 main steps: Carboxylation (CO_2 combines with RuBP by the enzyme RuBisCO), Reduction (using ATP and NADPH from the light reaction to create sugar), and Regeneration (recreating RuBP for reuse), allowing plants to create biomass and grow.

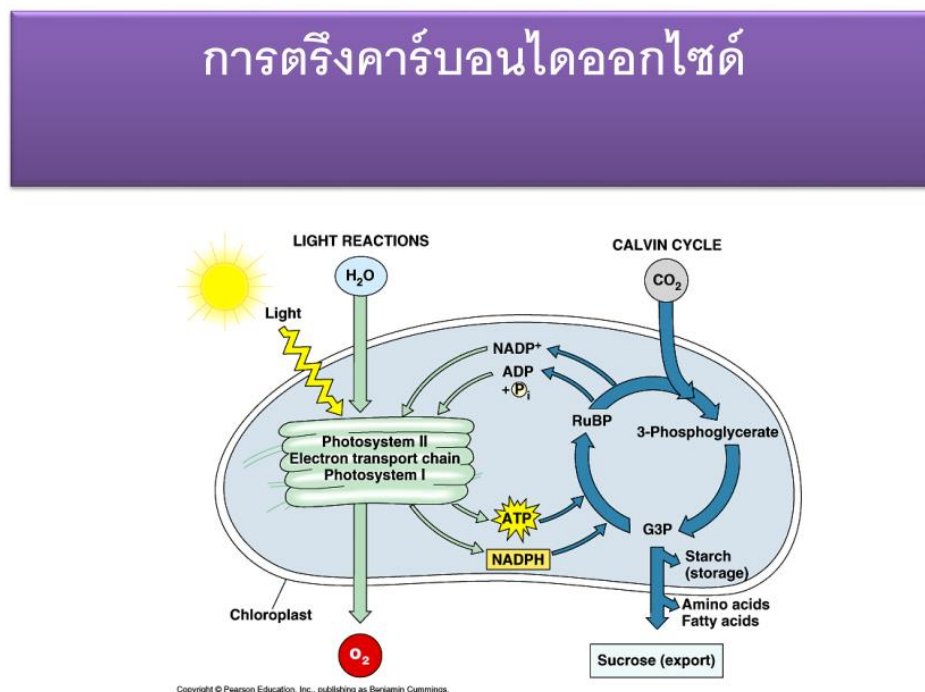


Figure 1: Carbon fixation process

2.2 The importance of perennial trees to the ecosystem and reducing global warming

1. Perennial Trees and Climate Change Mitigation

Carbon Sequestration: The main function of trees is to absorb carbon dioxide gas (CO₂) from the atmosphere through the process of photosynthesis and store it in the wood, trunk, roots, and leaves. This helps reduce the concentration of greenhouse gases in the atmosphere. Forests and mature trees can act as effective "carbon sinks." Protecting existing forests is as important as planting new forests to aim for the goal of reducing global warming.

2. Ecosystem and Biodiversity

Habitat for living things: Forests and trees are part of the world's most critical ecosystems. They support biodiversity as they are sources of food, shelter, and spawning grounds for millions of animal species. **Soil and Water Ecosystems:** Tree roots help anchor the soil, preventing soil erosion, reducing topsoil loss, and helping to maintain soil moisture. Forests play an important role in the water cycle by absorbing rainwater, helping to reduce the severity of floods, and helping to slow down the flow of water into canals and rivers.

3. Impact on Climate and Local Weather

Controlling Temperature and Air Pressure: Trees help lower the surrounding temperature through shade and transpiration, thus helping to alleviate the effects of heat waves, especially in large cities with "urban heat island" problems. **Local Ecosystems Affect Climate:** Research has found that even trees outside forests have an effect on controlling the microclimate by reducing temperature variability and making the area more resilient to climate change.

2.3 Perennial Trees

2.3.1 Golden Shower

- **Scientific name:** *Cassia fistula L.*
- **Common name:** Golden shower, Indian laburnum, Pudding-pine tree
- **Other names:** Chaiyapruk, Koon (Central region), Lom Laeng (Northern region), Ku-phe-ya (Kanchanaburi)
- **Family name:** FABACEAE

- **Habit:** Medium-sized tree, approximately 10-15 m tall. The canopy is rather narrow and tall. Bark is grayish-brown and smooth.
- **Leaves:** Pinnately compound leaves, alternate or spiral arrangement. Leaf rachis is 30-40 cm long. Leaflets are ovate-oblong, arranged in 3–6 opposite pairs, 7-15 cm long. Leaf tip is acute, base is obtuse, margin is entire. Leaf blade is smooth and rather thin. Lateral veins are frequent and curved along the leaf shape.
- **Flowers:** Inflorescence is a hanging raceme, emerging from leaf axils and branch tips. Inflorescence is 20–40 cm long. Many florets, blooming size about 3 cm wide. 5 oblong sepals, about 1 cm long, light green with hairy outer surface. 5 ovate petals, 2-3 cm long, bright yellow, with a mild fragrance.
- **Fruit:** Cylindrical pod, 20–50 cm long, 2-2.5 cm in diameter. Smooth surface. Young pods are green.
- **Propagation:** Propagated by seed, layering, or cutting. Flowers approximately from February to May.
- **Distribution:** South Asia, Southern Pakistan, India, Myanmar, Sri Lanka, and Indochina. Found distributed generally in mixed deciduous forests or dry dipterocarp forests.

2.4 Related Research

2.4.1 Research from the Faculty of Environment and Resource Studies, Mahidol University, Nakhon Pathom 73170 on the topic of Above-ground Biomass, Root Biomass, and Soil Carbon of Teak Plantations. The study of above-ground biomass and root biomass of teak in the Thai Plywood forest plantation aimed to study above-ground biomass, root biomass of teak, and soil carbon of teak plantations at 5 ages: 10, 14, 18, 27, and 28 years respectively. The study used allometric equations to calculate above-ground biomass. For roots, one root sample per age class was excavated to calculate root biomass. Soil carbon was also calculated. Both above-ground and root biomass were converted into carbon quantity.

Results: The study found that the total carbon of teak plantations at each age class, consisting of ages 10, 14, 18, 27, and 28 years, had total carbon values equal to 169.37, 83.72, 99.11, 170.13, and 149.66 tons/hectare respectively. The ratio of carbon in teak stems to roots

at ages 10, 14, 18, 27, and 28 was 31:1, 7:1, 12:1, 33:1, and 27:1 respectively. The variation of carbon above ground, in roots, and in soil differed according to several factors such as topography, plantation management, and especially forest fire problems.

2.4.2 Research from the Civil Technology Program, Faculty of Industrial Technology, Lampang Rajabhat University, Lampang on the topic of Comparison of Methods for Estimating Tree Carbon Sequestration Using a Laser Rangefinder Camera and a Height Stick. Trees are an important source of absorbing carbon dioxide and storing carbon in biomass. One method for estimating carbon dioxide equivalent stored in trees is finding biomass using relationships in the form of allometric equations using tree height and circumference data for calculation. This research aimed to compare tree height measurement tools between using a height measuring stick and using a laser rangefinder camera for assessing tree carbon sequestration. The sample group of trees was defined as general tree types, perennial trees, totaling 97 trees in Lampang Rajabhat University on an area of 15,605.10 square meters. The tree height values from both measurement methods were used to find the average and classified into 5 tree height ranges (H-Class): 2-4, 4-6, 6-8, 8-10, and greater than 10 meters. It was found that the height values of trees measured using the height stick in each range were 3.467, 5.033, 6.980, 9.180, and 11.117 meters respectively. Using the laser rangefinder camera, the average tree heights were 3.290, 4.909, 6.876, 9.062, and 10.940 meters respectively. Statistical calculation found that the use of both measuring tools was not statistically different at a 95% confidence level, and the coefficient of determination (R^2) of both measurement methods was 0.996. When considering the error of values from 3 height measurers using the laser rangefinder camera and repeated measurements by each person, it was found that there was no statistical difference at the 95% confidence level as well. When these results were used to calculate the carbon sequestration quantity of trees from using the height stick and the laser rangefinder camera, it was found that the carbon sequestration quantities were 19,329 and 19,126 kilograms of carbon equivalent (KgCO_2eq) respectively, which is a difference of only 1.3%. This shows that both height measurement methods yield results that are not different.

2.4.3 Research from the Faculty of Environment and Resource Studies, Mahidol University on the topic of Carbon Sequestration of Trees along the Nature Trail in the Royal Initiative Project of Her Majesty Queen Sirikit, Nakhon Sawan Province. The increase of greenhouse gases,

especially carbon dioxide, severely affects the global warming situation. Studying carbon sequestration is therefore a method that many sectors use to promote activities to provide data for preparing greenhouse gas inventories. The area of the Royal Initiative Project of Her Majesty Queen Sirikit, Nakhon Sawan Province, is a dry dipterocarp forest area near community and agricultural areas and still lacks data on carbon sequestration in the area. This research aimed to survey plant species in the nature trail area to know the biomass quantity of trees and know the carbon sequestration quantity in the project area of 3.68 hectares by randomly placing 3 sample plots, accounting for 13% of the total area. The plots were placed based on tree density at 3 levels: high, medium, and low density, size 0.16 hectares. Results: The study found that in the study area, a total of 409 trees, 48 species, 42 genera, and 24 families were found. The most common species was *Dipterocarpus obtusifolius* Teijsm. ex Miq. (Hiang) with an importance value index of 55.18, followed by *Pterocarpus macrocarpus* Kurz (Paduak Pa) at 22.49, followed by *Lannea coromandelica* (Houtt.) Merr. (Kook), *Bombax anceps* Pierre var. *Anceps* (Ngiu Pa), and *Terminalia corticosa* Pierre ex Laness. (Tabak Lueat) at 21.48, 19.77, and 11.93 respectively. Average biomass was 173.88 tons/hectare. Total biomass was 639.86 tons. It can sequester carbon on average 81.71 tons/hectare. Total carbon sequestered was 300.69 tons. This data can be used to promote increasing forest areas and serve as a forest resource database for the Protected Area Regional Office 12 (Nakhon Sawan), Department of National Parks, Wildlife and Plant Conservation.

Chapter 3

Research Methodology

Materials and Equipment

3.1 Materials and Equipment

1. Tape measure
2. Measuring tape
3. Clinometer
4. Calculator or calculation app
5. GPS or mobile phone
6. Data recording sheet
7. Camera
8. Computer for data analysis
9. Excel or SPSS software
10. Compass
11. Data recording sheet
12. Pen or pencil
13. Camera
14. Tape measure
15. Densiometer
16. MUC Local vegetation field guides



Figure 4: Measuring at tree height



Figure 4: Measuring at tree height

3) Measure ground cover and canopy cover.



Figure 6: Measuring canopy cover



Figure 7: Measuring ground cover

2) Tree Height:

Measure with a Clinometer according to the formula:

$$Height = \tan(\theta) \times Distance + EyeHeight$$

3) Calculation of DBH and Biomass:

$$DBH = \frac{C}{\pi}$$

Use Allometric equations to calculate biomass.

Convert to Carbon = *Biomass* × 0.47

Step 5: Data Analysis

Compare average carbon of each species (ANOVA / Kruskal-Wallis).

Analyze the relationship between DBH and Height with Carbon (Correlation or Regression).

Submit obtained data in GLOBE Data entry and use it to analyze and compare study results.

Step 6: Organize data to analyze and draw conclusions, and disseminate knowledge from the study for further education.



Figure 8: Calculation of DBH and Biomass



Figure 9: Data analysis

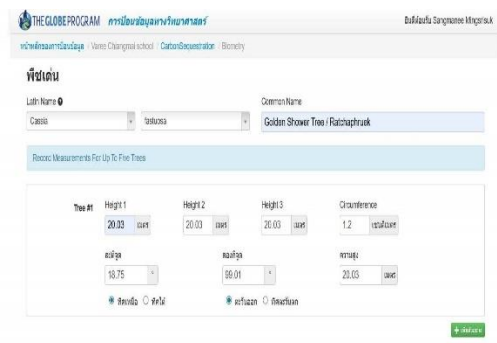


Figure 10: Submit data in GLOBE Data entry and use it to analyze and compare results.

Chapter 4

Research Outcomes

From the comparative study of carbon sequestration of various perennial tree species at Varee Chiangmai School, Chiang Mai Province, the results are as follows:

1. Canopy Cover

Step	Person 1 North	Person 2 South	Person 3 East	Person 4 West	Percentage of Canopy
1	+	+	-	-	50%
2	+	+	-	-	50%
3	+	+	-	+	70%
4	+	+	-	+	70%
5	+	+	-	+	70%
6	+	+	-	+	70%
7	+	+	-	+	70%
8	+	+	-	+	70%
9	-	-	-	+	25%
10	-	-	-	-	0%

Table 1: Percentage of Canopy Cover

2. Ground Cover

Step	Person 1	Person 2	Person 3	Person 4	Percentage of Green Ground Cover	Percentage of Brown Ground Cover
1	-	-	-	-	0%	100%
2	-	-	-	-	0%	100%
3	-	-	-	-	0%	100%
4	-	-	-	-	0%	100%
5	-	-	-	-	0%	100%
6	-	-	-	-	0%	100%
7	-	-	-	-	0%	100%
8	-	-	-	-	0%	100%
9	-	-	-	-	0%	100%
10	-	-	-	-	0%	100%

Table 2: Percentage of Ground Cover

3. Tree Height

Tree No.	Tree Name	Elevation Angle	tan Value	Tree to Observer Distance (m)	Observer Height (m)	Circumference
1	Indian Laburnum	62	1.88	16.5	1.62	1.20
2	Queen's Crape Myrtle	52	1.28	11.63	1.62	1.68
3	Phaya Sattaban	43	0.93	11.17	1.62	1.23
4	Silver Trumpet	50	1.19	7.29	1.62	0.74
5	Asok Nam	33	0.65	8.78	1.62	1.05
6	Golden Shower	60	1.73	26.9	16.2	1.78
7	Ta-go Na	57	1.54	22.6	1.62	1.14
8	Inthanin	75	3.73	13.2	1.62	1.00
9	Ta-go Na	60	1.73	26	1.62	0.82
10	Paduak	50	1.19	7.29	1.62	0.98

Table 3: Tree Height and Circumference

4. Carbon Sequestration

Tree No.	Tree Name	Trunk Circumference (C)	Calculated Diameter (D)	Measured Tree Height (H)	Biomass (Tons)	Carbon	Carbon Dioxide
1	Indian Laburnum	1.20	0.38	20.03	0.7231	0.7231	0.7231
2	Queen's Crape Myrtle	1.68	0.84	14.53	2.5631	2.5631	2.5631
3	Phaya Sattaban	1.23	0.40	13.72	0.5488	0.5488	0.5488
4	Silver Trumpet	0.74	0.24	10.10	0.1454	0.1454	0.1454
5	Asok Nam	1.05	0.33	11.05	0.3008	0.3008	0.3008
6	Golden Shower	1.78	0.57	30.25	2.4571	2.4571	2.4571
7	Ta-go Na	1.14	0.36	25.76	0.8346	0.8346	0.8346
8	Inthanin	1.00	0.32	18.55	0.4749	0.4749	0.4749
9	Ta-go Na	0.82	0.26	30.25	0.5112	0.5112	0.5112
10	Paduak	0.98	0.32	18.80	0.4813	0.4813	0.4813

Table 4: Carbon Sequestration Data

Chapter 5

Conclusion and Discussion

The research on “A Comparative Study of Carbon Sequestration in Different Tree Species at Varee Chiangmai School, Chiang Mai Province” had the objectives to study canopy cover, ground cover, tree height, and the amount of carbon that trees can sequester. The conclusion and discussion of the results are as follows:

1. Canopy Cover

The study results found that canopy cover had different values in each step interval. Steps 1–8 had a coverage percentage of 50–70%, showing that the tree area has a moderate to high level of canopy density. Steps 9 and 10 had clearly less coverage (25% and 0% respectively).

Therefore, high canopy cover is related to the ability to photosynthesize and produce biomass of the trees, which helps increase the potential for carbon sequestration. Meanwhile, the area at the end of the survey line which had low coverage may be due to a lack of trees or being an open area.

2. Ground Cover

The survey results found that in every step area (1–10), there was no natural green ground cover, with a value equal to 0%, and a brown ground cover value of 100%. This is caused by the area being paved with artificial grass, resulting in no actual ground cover plants found in the area.

Therefore, the fact that the study area is paved with artificial grass results in no natural ground cover plants growing at all, making the green ground cover percentage 0% in total, which differs from real soil areas that might find ground cover plants such as bamboo grass, cogon grass, or other herbaceous plants.

Artificial grass has advantages in cleanliness and ease of maintenance, but it has environmental effects as follows:

- Cannot photosynthesize or sequester carbon.
- Causes the soil ecosystem to lack biodiversity.
- May cause the soil underneath to lack moisture because it does not absorb water as well as natural ground.
- Does not help increase biomass that contributes to reducing greenhouse gases.

Therefore, the survey results are consistent with the characteristics of the area paved with artificial grass, causing the green ground cover value to be zero.

3. Tree Height and Circumference

From the results of measuring the height of all 10 perennial trees, it was found that tree height ranged from 10.10–30.25 meters. Circumference ranged from 0.74–1.78 meters. The tallest tree was the Golden Shower Tree (30.25 meters). The tree with the largest circumference was also the Golden Shower Tree (1.78 meters).

Therefore, the Golden Shower Tree has both great height and circumference, thus having high potential for creating biomass, which is consistent with the carbon sequestration results in the next point.

4. Quantity of Carbon and Carbon Dioxide Sequestered

The results of calculating Biomass and Carbon quantity found that the trees that sequestered the most carbon were: Queen's Crape Myrtle (2.5631 tons) and Golden Shower Tree (2.4571 tons). The tree that sequestered the least carbon was the Silver Trumpet Tree (0.1454 tons).

Therefore, the fact that different tree species sequester unequal amounts of carbon is caused by factors such as growth rate, height and circumference, morphological characteristics of the trunk and canopy, and the age of the tree. The Queen's Crape Myrtle and Golden Shower Tree, being large perennial trees, therefore have higher potential for carbon sequestration than other tree species.

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