Research Title: Comparative Study of Carbon Sequestration in *Rhizophora mucronate*, *Xylocarpus granatum* Koenig, and *Avicennia officinalis* L., and Analysis of Physical Factors in the Mangrove Forest of Banbawee district, Hat Samran District, Trang Province,Thailand.

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Abstract

A Comparison of Carbon Sequestration in *Rhizophora mucronate*, *Xylocarpus granatum* Koenig , and *Avicennia officinalis* L., and a Study of Physical Factors in the Mangrove Forest of Ba Wi Sub-district, Hat Samran District, Trang Province. This research aimed to : 1) compare the carbon sequestration capacities of *Rhizophora mucronate*, *Xylocarpus granatum Koenig* , and *Avicennia officinalis* L.. The results revealed that the carbon sequestration amounts, ranked from highest to lowest, were: *Avicennia officinalis* L. (568.67 kgC), *Xylocarpus granatum* Koenig (249.66 kgC), and *Rhizophora mucronate* (236.48 kgC). It was observed that carbon sequestration capacity is primarily dependent on the growth rate of the trees. 2) Study the physical environmental factors in the areas inhabited by these three species using GLOBE protocols. The findings showed that the average soil temperatures were 25°C for *R. mucronate*, 25.3°C for *Xylocarpus granatum* Koenig , and 26.3°C for *Avicennia officinalis* L. Average soil pH levels were 7.2, 6.7, and 7.3, respectively. The average soil moisture for all three species was consistent at 100%. Regarding atmospheric conditions, the average air humidity was 69% for *R. mucronate*, 58.7% for *Xylocarpus granatum* Koenig , and 52% for *Avicennia officinalis* L. Average air temperatures were 28.5°C, 29.5°C, and 31°C, respectively. The average light intensity was 164.3 Lux for *R. mucronate*, 300 Lux for *Xylocarpus granatum* Koenig , and 116.7 Lux for *Avicennia officinalis* L. In conclusion, physical factors differently influence the growth of each mangrove species, which subsequently results in varying carbon sequestration capacities. These findings are consistent with the research by Kanokwan Ngamsom regarding mangrove ecosystems in Thailand.

Keywords: Carbon Sequestration, *Rhizophora mucronate*, *Xylocarpus granatum* Koenig , *Avicennia officinalis* L.

Introduction

At present, the climate change crisis and the greenhouse effect have become critical global issues. The primary cause is the continuous accumulation of carbon dioxide (CO_2) in the atmosphere, leading to rising global temperatures and increasingly severe natural disasters. According to the Department of Marine and Coastal Resources (2023), mangrove ecosystems are among the most efficient environments for carbon sequestration. Mangroves can store significantly more carbon than terrestrial forests because they sequester carbon in both above-ground biomass (trunks, branches, and leaves) and below-ground biomass (roots). Furthermore, the anaerobic conditions in mangrove soil slow down the decomposition of organic matter. However, different mangrove species possess distinct physical characteristics, growth rates, wood densities For instance, *Rhizophora mucronate* (Loop-root mangrove) features strong prop roots, *Xylocarpus granatum* Koenig (Cedar mangrove) has buttress roots, and *Avicennia officinalis* L. (Grey mangrove) possesses pneumatophores (breathing roots). These differences directly influence their respective potentials for carbon absorption and storage

Kanokwan Ngamsom. (2008) noted that mangrove species typically grow in distinct zones stretching from the shoreline inland, which differs from terrestrial forests. This zonation is likely caused by variations in seedling establishment and growth, as each species adapts to different sea levels. Additionally, critical regulatory factors such as tidal flooding, soil type, salinity levels in water and soil, and light intensity contribute to the formation of a plant community that is distinct from other ecosystems.

Recognizing these factors, the research team aims to study and compare the carbon sequestration capacities of three primary structural species: *Rhizophora mucronate*, *Xylocarpus granatum* Koenig, and *Avicennia officinalis* L. in the mangrove forest of Banbawee district, Hat Samran District, Trang Province. This study seeks to identify the true potential of each species, providing essential data for mangrove restoration planning and the selection of species to effectively promote greenhouse gas red Research

Objectives

1.To compare the carbon sequestration amounts of *Rhizophora mucronate, Xylocarpus granatum* Koenig*, and Avicennia officinalis* L.

2.To study the physical environmental factors in the areas inhabited by *Rhizophora mucronate, Xylocarpus granatum* Koenig, and *Avicennia officinalis* L.

Scope of Study

This study focuses on the carbon sequestration of *Rhizophora mucronate*, *Xylocarpus granatum* Koenig, and *Avicennia officinalis* L. within the mangrove forest area of Banbawee district, Hat Samran District, Trang Province, Thailand. The data collection was conducted from November 2025 to January 2026.

Research Question

Are there significant differences in the carbon sequestration capacities among *Rhizophora mucronate*, *Xylocarpus granatum* Koenig, and *Avicennia officinalis* L.

Research Hypothesis

The carbon sequestration capacities of *Rhizophora mucronate*, *Xylocarpus granatum* Koenig, and *Avicennia officinalis* L. are significantly different.

Materials and Equipment

1.Measuring Tape
2.Steel Tape Measure
3.Clinometer
4.3-in-1 Soil Tester
5.Hygrometer
6.Soil pH Meter/Tester
7.Google Maps
8.Photography Equipment
9.Stationery and Field Notebook
10.Tree Carbon Sequestration Assessment Website

Research Methodology
GLOBE Protocols
Biosphere Protocols
Atmosphere Protocols
Pedosphere Protocols

Study Site Selection

The research was conducted within the mangrove forest of Banbawee sub district, Hat Samran District, Trang Province. The specific study site is located at the following geographic coordinates Latitude 7.277392 Longitude 99.574468

Research Methodology

1. Research Preparation Phase

1) Defining the Research Topic: Identify and select the specific area of study.

2) Literature Review: Gather and synthesize relevant knowledge, data, and theories related to the research.

3) Establishing Objectives: Define the specific goals and aims of the study.

4) Site Selection and Sampling Design: Determine the specific sampling points within the study area using a sampling method.

2. Implementation and Data Collection Phase

1) Operational Planning: Develop a detailed research action plan.

2) Site Survey: Conduct a field survey of the designated research area.

Part 1: Biosphere Protocols

The carbon sequestration measurement procedures are as follows:

1) Tree Selection: Select three different species of mangrove trees, with three individual samples per species.

2) DBH Measurement: Measure the tree circumference at Breast Height (1.30 meters above the ground) in centimeters.

3) Tree Height Measurement: Measure the total height of the trees using a clinometer.

4) Data Processing: Use the measured circumference and height values to calculate carbon sequestration via a standardized carbon estimation website.

Part 2: Pedosphere Protocols

1) Soil Properties Measurement: Measure soil moisture, soil pH, and light intensity at each sampling point using a 3-in-1 Soil Tester.

2) Soil Temperature Measurement: Measure the soil temperature using a Soil Thermometer.

Part 3: Atmosphere Protocols

1) Atmospheric Data Collection: Measure air temperature and relative humidity using a hygrometer.

2) Data Submission: Submit the collected research data to the GLOBE Data Entry system.

Mangrove Data Collection

Carbon Sequestration of *Rhizophora mucronate*, *Xylocarpus granatum* Koenig, and *Avicennia officinalis* L., including Physical Factors

1) Carbon Sequestration Survey and Data Collection: Conduct a comprehensive survey and collect carbon sequestration data *for Rhizophora mucronate, Xylocarpus granatum* Koenig and *Avicennia officinalis* L. in the mangrove forest of Ba Wi Subdistrict, Hat Samran District, Trang Province. The data collection period spans from November 2025 to January 2026. The gathered data will be processed through a standardized carbon estimation website to calculate sequestration levels, followed by an analysis to determine the mean values.

2) Study of Physical Factors:

Investigate the physical environmental factors associated with *Rhizophora mucronate, Xylocarpus granatum* Koenig, and *Avicennia officinalis* L. This involves measuring soil temperature, soil pH, soil moisture, air temperature, relative humidity, and light intensity. All recorded parameters will be calculated to determine their respective average values.

Data Analysis and Conclusion

1)Statistical Analysis and Correlation: Analyze the collected data and compare the relationships using descriptive statistics. This includes calculating the mean values for soil temperature, soil pH, soil moisture, air temperature, relative humidity, and light intensity.

2)Data Visualization: Construct comparative graphs to illustrate the average values of the studied parameters.

3) Research Conclusion: Summarize the experimental results based on the analyzed data.

Research Findings

Table 1: Geographic Coordinates

Areas Found	Geographic Coordinates	
	Latitude (N)	Longitude (E)
Mangrove Forest, Ba Wi Sub-district, Hat Samran District, Trang Province	7.277392	99.574468

Table 1 presents the geographic coordinates of the study area located in the mangrove forest of Ba Wi Sub-district, Hat Samran District, Trang Province. This area was selected for the study of carbon sequestration in *Rhizophora mucronate* (Large-leaf Mangrove), *Xylocarpus granatum Koenig* (Cedar Mangrove), and *Avicennia marina* (Grey Mangrove). The site is located at Latitude (N) 7.277392 and Longitude (E) 99.574468.

Table 2 shows the carbon sequestration amounts *Rhizophora mucronate*

Sample No	Circumference (m)	Spacing (m)	Elevation Angle (degrees)	Height (m)	Carbon Storage (kgC)
Tree 1	0.63	9.20	65	21.20	249.06
Tree 2	0.64	8.10	60	15.60	193.05
Tree 3	0.75	7.90	58	14.20	237.34
Average	**0.67**	**8.4**	**61**	**17**	**226.48**

According to Table 2, the carbon sequestration levels of *Rhizophora mucronate* ranked from highest to lowest as follows: Tree 1 (249.06 kgC), Tree 3 (237.34 kgC), and Tree 2 (193.05 kgC).

Table 3 shows the carbon sequestration amounts *Xylocarpus granatum* Koenig

Sample No	Circumference (m)	Spacing (m)	Elevation Angle (degrees)	Height (m)	Carbon Storage (kgC)
Tree 1	0.52	11.90	45	13.40	114.34
Tree 2	0.90	11.60	45	13.10	308.78
Tree 3	1.05	9.65	42	10.20	325.87
Average	**0.82**	**11.05**	**44**	**12.23**	**249.66**

According to Table 3, the carbon sequestration levels of *Xylocarpus granatum* Koenig are ranked from highest to lowest as follows: Tree 3 (325.87 kgC), Tree 2 (308.78 kgC), and Tree 1 (114.34 kgC).

Table 4 shows the carbon sequestration amounts *Avicennia officinalis* L.

Sample No	Circumference (m)	Spacing (m)	Elevation Angle (degrees)	Height (m)	Carbon Storage (kgC)
Tree 1	1.60	5.20	65	12.70	874.18
Tree 2	0.92	6.20	60	12.30	303.38
Tree 3	1.30	6.30	57	11.20	528.46
Average	**1.27**	**5.9**	**60.67**	**12.07**	**568.67**

According to Table 4, the carbon sequestration levels of *Avicennia officinalis* L. are ranked from highest to lowest as follows: Tree 1 (874.18 kgC), Tree 3 (528.46 kgC), and Tree 2 (303.38 kgC).

Table 5: Comparison of Carbon Sequestration among Species

Type	Circumference (m)	Spacing (m)	Elevation Angle (degrees)	Height (m)	Carbon Storage (kgC)
Rhizophora mucronate	0.67	8.4	61	17	226.48
Xylocarpus granatum Koenig	0.82	11.05	44	12.23	249.66
Avicennia officinalis L.	1.27	5.9	60.67	12.07	568.67

Table 5 presents a comparison of carbon sequestration levels within the mangrove forest of Banbawee district, Hat Samran District, Trang Province. The findings indicate that the carbon sequestration amounts, ranked from highest to lowest, are as follows: *Avicennia officinalis* L. (568.67 kgC), *Xylocarpus granatum* Koenig (249.66 kgC), and *Rhizophora mucronate*(226.49 kgC).

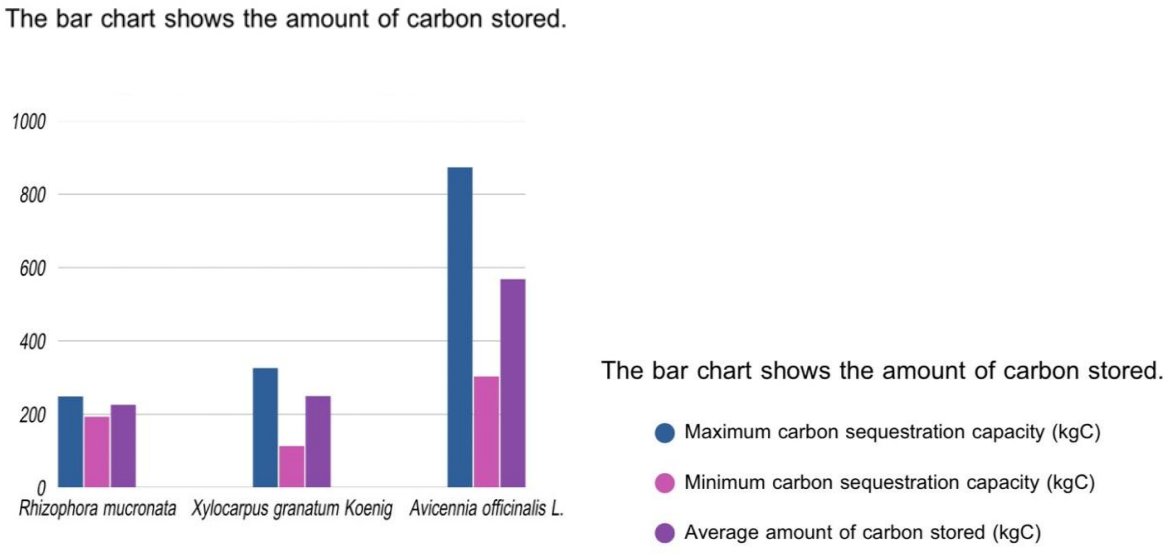

Table 6: Physical Factors

Type	Mean Soil Temperature	Mean Soil pH	Mean Soil Moisture	Average Air Humidity	Mean air tempera-ture	Average light intensity
Rhizophora mucronate	25°C	7.2	100%	69%	28.5°C	164.3 Lux
Xylocarpus granatum Koenig	25.3°C	6.7	100%	58.7%	29.5°C	300 Lux
Avicennia officinalis L.	26.3°C	7.3	100%	52%	31°C	116.7 Lux

According to Table 6, the study of physical factors revealed that the mean soil temperature for *Rhizophora mucronate*, *Xylocarpus granatum* Koenig, and *Avicennia officinalis* L. was 25°C, 25.3°C, and 26.3°C, respectively. The average soil pH values were measured at 7.2 *Rhizophora mucronate*, 6.7 *Xylocarpus granatum* Koenig, and 7.3 *Avicennia officinalis* L., while soil moisture was uniform at 100% across all sites.In terms of air conditions, the mean relative humidity recorded for the three species was 69%, 58.7%, and 52%, with corresponding mean air temperatures of 28.5°C, 29.5°C, and 31°C. Additionally, the mean light intensity varied significantly, with the highest value found at the *Xylocarpus granatum* Koenig site (300 Lux), followed by *Rhizophora mucronate* (164.3 Lux) and *Avicennia officinalis* L. (116.7 Lux).

Discussion

The comparative study of carbon sequestration in mangrove vegetation within Ba Wi Subdistrict, Hat Samran District, Trang Province, focused on three primary species: *Avicennia officinalis* L., *Xylocarpus granatum* Koenig and *Rhizophora mucronate*. The findings revealed that the carbon sequestration levels, ranked from highest to lowest, were 568.67 kgC for *Avicennia officinalis* L., 249.66 kgC for *Xylocarpus granatum* Koenig, and 236.48 kgC for *Rhizophora mucronate*.

These results indicate that carbon sequestration capacity is significantly dependent on tree growth; individuals with greater circumference and height exhibit higher carbon storage potential. Furthermore, air quality analysis showed that the microclimate surrounding *Avicennia officinalis* L.]had the highest average temperature at 31°C, followed by *Xylocarpus granatum* Koenig at 29.5°C, and *Rhizophora mucronate* with the lowest average temperature at 28.5°C.

In terms of relative humidity, *Rhizophora mucronate* recorded the highest average at 69%, followed by *Xylocarpus granatum* Koenig at 58.7%, and *Avicennia officinalis L.* at 52%. It was observed that trees exposed to higher light intensity experienced higher ambient temperatures compared to those in shaded areas. Consequently, areas with higher temperatures demonstrated lower relative humidity, whereas areas with lower temperatures maintained higher humidity levels.

Conclusion

In conclusion, the assessment of carbon sequestration in the mangrove forests of Ba Wi Subdistrict, Hat Samran District, Trang Province, showed that the sequestration levels, ranked from highest to lowest, were: 568.67 kgC in *Avicennia officinalis L.,* 249.66 kgC in *Xylocarpus granatum* Koenig, and 236.48 kgC in *Rhizophora mucronate*. The amount of carbon sequestered is primarily determined by the growth of the trees. Additionally, physical environmental factors significantly influence the growth patterns of different mangrove species, thereby leading to variations in the carbon sequestration potential among *Rhizophora mucronate*, *Xylocarpus granatum* Koenig, and *Avicennia officinalis* L.

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Badges

I am a Collaborator

This study was executed through a collaborative scientific framework, encompassing joint planning, fieldwork, data acquisition, and analysis. The synergy among team members ensured high data integrity and fostered professional collaborative skills, resulting in a high-quality research output ready for dissemination.

I am a Data Scientist

This study focused on measuring carbon storage and environmental factors such as soil conditions (temperature, pH, and moisture) and atmospheric conditions (humidity, temperature, and light intensity). We calculated the average values for each study plot to compare the carbon sequestration performance of *Rhizophora mucronate*, *Xylocarpus granatum* Koenig, and *Avicennia officinalis* L. Additionally, the study analyzed the relationship between these plants' carbon storage abilities and their physical environment.

I make an Impact

Our findings offer a roadmap for tackling the global greenhouse gas crisis by determining which plants are best for carbon capture. Beyond climate benefits, this study promotes a healthier mangrove ecosystem that acts as a nursery for marine life. Ultimately, this leads to a more stable environment for local fishermen, helping them secure their livelihoods and improve their quality of life.