



Comparative Analysis of Carbon Sequestration and Operational Carbon Emissions A Case Study of PhakMaiWittayanukul School

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Research Title : Comparative Analysis of Carbon Sequestration and Operational Carbon Emissions: A Case Study of Phak Mai Wittayanukul School

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Abstract

This study aimed to investigate and compare the amount of carbon sequestration by trees with greenhouse gas emissions resulting from electricity consumption and fuel use within Phak Mai Witthayanukul School. Five main study sites were designated: in front of the Chinese language classroom, in front of the lower secondary classrooms, in front of the flagpole area, in front of the auditorium, and from the music room to the pétanque court.

Tree species and sizes within the designated areas were surveyed. Tree height was measured using the GLOBE Observer application, and carbon sequestration was calculated using the LESS-FOR-01 website developed by the Thailand Greenhouse Gas Management Organization (Public Organization). For greenhouse gas emissions (carbon footprint), data on electricity consumption and fuel use from lawn mowers were collected over a one-year period (2025) and calculated using emission factors in accordance with TGO standards.

The results showed that a total of 60 trees representing 7 species sequestered 43,070.74 kgCO₂eq of greenhouse gases. Among these, *Alstonia scholaris* (20 trees) exhibited the highest carbon sequestration potential at 19,229.60 kgCO₂eq, followed by pine trees (18 trees), which sequestered 17,600.22 kgCO₂eq. Annual greenhouse gas emissions from electricity consumption totaled 3,933.58 kgCO₂eq, with the highest emissions occurring in September. Fuel use from lawn mowers contributed an additional 332.14 kgCO₂eq.

Comparison between carbon sequestration by trees and greenhouse gas emissions from school operations revealed that carbon sequestration was significantly greater than emissions (43,070.74 > 4,265.72 kgCO₂eq). This indicates that the green areas within the school have sufficient potential to offset greenhouse gas emissions and effectively mitigate the impacts of climate change.

Keywords : Carbon sequestration, Greenhouse gases

Introduction

Climate change and global warming have become critical global issues, significantly impacting the environment, ecosystems, economies, and human well-being. These phenomena are primarily driven by the escalating concentration of greenhouse gases (GHGs), particularly carbon dioxide (CO₂), stemming from anthropogenic activities such as electricity consumption, transportation, fossil fuel combustion, and daily operational routines. The accumulation of CO₂ in the atmosphere enhances radiative forcing, trapping thermal energy and leading to a consistent rise in the Earth's average surface temperature.

While educational institutions are not classified as major GHG emitters compared to the industrial or transportation sectors, their daily operations—including building electricity usage, appliance operation, personnel and student commuting, and on-campus activities—contribute to continuous CO₂ emissions. Without effective management, these emissions are projected to increase in tandem with the expansion of educational activities and infrastructure development.

Concurrently, trees and green infrastructure play a pivotal role in mitigating atmospheric CO₂. Through photosynthesis, trees sequester carbon and store it as biomass within their trunks, branches, leaves, and roots. Beyond carbon sequestration, green spaces within school premises improve localized air quality, mitigate ambient temperatures, and foster an environment conducive to learning and student health.

Consequently, a comparative assessment of tree carbon sequestration versus operational carbon emissions is essential for evaluating the "Carbon Balance" within the school area. This study aims to determine whether the existing green infrastructure possesses sufficient potential to offset the carbon footprint generated by institutional activities. Furthermore, the findings will provide a fundamental baseline for strategic planning to expand green spaces, optimize energy efficiency, and transition the school into an eco-friendly and sustainable educational institution in the long term.

Research Question

Based on this understanding, we designed this study to explore the relationship between the operational activities of Phak Mai Wittayanukul School and the carbon sequestration capacity of its green spaces.

The aim is to understand how daily energy consumption and fuel usage compare to the amount of carbon that various tree species within the school can store. This analysis will help determine the school's potential as a "Net Carbon Sink."

Can the trees in Phak Mai Wittayanukul School, Phak Mai Subdistrict, Huai Thap Than District, Sisaket Province store carbon? If so, how?

Research Hypothesis

Trees within the Phakmai Wittayanukul School area have the capacity to sequester carbon.

Research Methods and Materials

The research entitled “A Comparative Study of Carbon Sequestration by Trees and Greenhouse Gas Emissions from Operational Activities at Phak Mai Wittayanukul School, Huai Thap Than District, Sisaket Province” was conducted using field survey methods and statistical data analysis (Survey and Data Analysis) to collect and record data on vegetation and energy consumption statistics. The operational procedures were carried out in accordance with the following steps.

1. Experimental Equipment and Tools

 <p>1) Flexible measuring tape Used to measure the circumference of the tree.</p>	 <p>2) Globe observer Used to measure tree height.</p>
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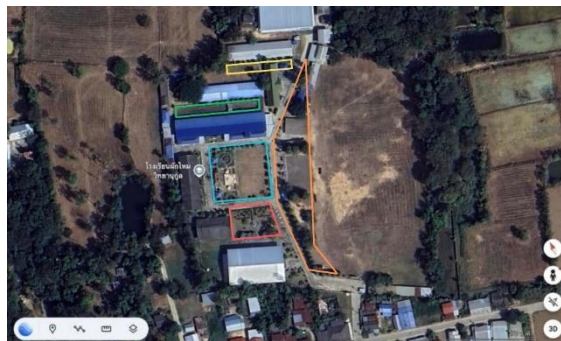
【Figure 1. Experimental equipment and tools】

3) Measuring tape 4) Mobile phone 5) Pencil and pen 6) Data recording sheets

2. Research Methods

1. Determination of study sites:

Five study sites were designated: Site 1 in front of the Chinese language classroom; Site 2 in front of the lower secondary classrooms; Site 3 in front of the flagpole area; Site 4 in front of the auditorium; and Site 5 from the music room to the pétanque court.



【Figure 2. Determination of study sites】

2. Field survey was conducted.

3. Survey the quantity and species of trees

3.1 Measurement of tree size was conducted using a measuring tape to determine the circumference of the tree at a height of 1.35 meters, while a mobile phone was used to measure tree height through the GLOBE Observer application.



【Figure 3. Measurement of tree height】



【Figure 4. Measurement of tree circumference】



【Figure 5. Recording general height characteristics of trees】



【Figure 6. Calculation and summary of tree】

3.2 Measured carbon stock – The method for calculating carbon content in trees involves selecting a group of trees with a minimum height of 5 meters. The carbon values are calculated using the LESS-FOR-01 website (a web-based carbon calculation tool), which produces estimates of carbon stored in trees.

3.3 Enter the height and circumference data, specify the tree species group, and record the results through data entry.

3.4 Measured carbon stock – The method for calculating carbon in trees is to select a group of tall trees with high density and calculate their carbon values using the LESS-FOR-01 website (an online carbon calculation tool). The results show the amount of carbon stored in the trees.

4. Collect electricity consumption data from the school's electricity bills over a period of one year (2025) by recording the electricity units used each month.

4.1 Electricity consumption data are used to calculate greenhouse gas emissions by applying Thailand's Emission Factor.

4.2 Calculate the carbon footprint from electricity consumption using the formula :
Carbon footprint (kgCO₂e) = Electricity consumption (kWh) × Emission Factor (kgCO₂e/kWh)

4.3 Measured electricity consumption – calculation of the carbon footprint from electricity use

1) Electricity consumption (kWh) = the amount of electricity used by the school (as shown on the electricity bill)

2) Emission Factor (EF) = the average greenhouse gas emissions from electricity generation

3) In Thailand (TGO, 2021), the Emission Factor is defined as :
 $EF = 0.561 \text{ kgCO}_2\text{e/kWh}$ $847 \times 0.561 = 475.167$

5. Information was collected by interviewing the janitor about fuel use from the lawn mower over a one-year period.

5.1 Fuel consumption data are used to calculate greenhouse gas emissions by applying the Emission Factor specified for each type of fuel.

5.2 Calculate the carbon footprint from fuel consumption using the formula:

Carbon footprint (kgCO₂e) = Fuel consumption (litres) × Emission Factor (kgCO₂e/litre)

5.3 Measured fuel consumption – calculation of the carbon footprint from fuel use

1) Fuel consumption (litres): the amount of fuel used by the lawn mower in a specific activity, for example, how many litres are used per day.

2) Emission Factor: the average coefficient of greenhouse gas emissions from fuel combustion based on sources in Thailand.

3) Gasoline has an emission factor of 2.32 kgCO₂e/litre. $39.3 \times 2.32 = 216.456$

Research Results

Table 1 Summary of tree measurements and the amount of greenhouse gases sequestered at all five sites within Phak Mai Wittayanukul School, Huai Thap Than District, Sisaket Province.

Order	Common name	Plant species group	Number (trees)	Amount of greenhouse gases sequestered (kgCO ₂ eq)
1	Alstonia scholaris 	General plant species	20	19,229.6
2	Palm tree 	Palm	4	701.24
3	Pine tree 	General plant species	18	17,600.22
4	Spanish cherry tree 	General plant species	11	4,887.41
5	Tropical almond tree 	General plant species	3	233.1
6	Pink trumpet tree 	General plant species	2	3,202.92
7	Golden shower tree 	General plant species	2	2,103.66
Total greenhouse gas emissions: 7043,0.74 (kgCO ₂ eq)				

From Table 1, the survey and measurement of trees within the study area conducted between January and December 2025 found a total of seven tree species. These were classified into two groups: general trees and palm trees. The number of trees and their carbon dioxide sequestration capacities varied among species. The *Alstonia scholaris* (Devil tree), classified as a general tree species, was the most abundant, with 20 trees, and had the highest greenhouse gas sequestration capacity, accounting for approximately 19,229.6 kgCO₂eq. This was followed by pine trees, with 18 trees, which were able to sequester 17,600.22 kgCO₂eq. Tropical almond trees (*Terminalia catappa*), numbering 11 trees, were able to sequester 4,887.41 kgCO₂eq. In addition, pink trumpet trees, tropical almond trees, and golden shower trees, each with 2 trees, had greenhouse gas sequestration capacities of 3,202.92 kgCO₂eq, 2,103.66 kgCO₂eq, and 233.1 kgCO₂eq, respectively. Palm trees, classified in the palm group, totaled 4 trees and were able to sequester 701.24 kgCO₂eq. These results indicate that green spaces within the school play an important role in reducing greenhouse gas emissions and helping to mitigate the impacts of climate change.

Table 2 shows the carbon footprint from electricity consumption over a one-year period in the 2025 academic year within Phak Mai Wittayanukul School, Phak Mai Subdistrict, Huai Thap Than District, Sisaket Province.

Month/Year	Electricity consumption (kWh)	Carbon footprint (kgCO ₂ eq)
January/68	544.68	305.56
February/68	442.78	248.39
March/68	356.80	200.16
April/68	588.74	330.28
May/68	429.62	241.01
June/68	463.28	259.90
July/68	876.38	491.649
August/68	639.85	358.95
September/68	951.97	534.05
October/68	455.63	255.60
November/68	380.66	213.55
December/68	881.59	494.571
Total carbon footprint from electricity consumption : 3,933.58 (kWh)		

From Table 2, the calculation of the carbon footprint from electricity consumption during January–December 2025 shows that monthly electricity consumption ranged from approximately 356.80 to 951.97 kWh. The Emission Factor for electricity use was constant at 0.561 kgCO₂eq/kWh. As a result, the monthly carbon footprint ranged from 200.16 to 534.05 kgCO₂e. The month with the highest carbon dioxide emissions was September (534.05 kgCO₂e), due to the highest electricity consumption, while the month with the lowest carbon dioxide emissions was March. These results indicate that electricity consumption is a significant source of greenhouse gas emissions and plays an important role in the total carbon footprint of the study area.

Table 3 Carbon footprint from fuel combustion (lawn mower) over a one-year period in the 2025 academic year within Phak Mai Wittayanukul School, Phak Mai Subdistrict, Huai Thap Than District, Sisaket Province.

Month/Year	Fuel consumption (Litre)	Carbon footprint (kgCO₂eq)
January/68	11.35	26.33
February/68	11.45	26.56
March/68	11.64	27.00
April/68	12.15	28.18
May/68	12.27	28.46
June/68	12.06	27.97
July/68	12.00	27.84
August/68	12.15	28.18
September/68	12.21	28.32
October/68	12.45	28.88
November/68	12.24	28.39
December/68	11.22	26.03
Total carbon footprint from fuel combustion : 332.14 (kgCO ₂ eq)		

From Table 3, the fuel consumption and carbon dioxide emissions throughout the year 2025 (January–December) show that the average monthly fuel consumption ranged from 11.22 to 12.45 litres per month. The Emission Factor remained constant at 2.32 kgCO₂e/litre each month, resulting in a monthly carbon footprint ranging from 26.03 to 28.88 kgCO₂e. The month with the highest carbon emissions was October (28.88 kgCO₂e), while the lowest emissions occurred in December (26.03 kgCO₂e). Overall, fuel combustion from the lawn mower resulted in total carbon dioxide emissions of 332.14 kgCO₂eq. These findings indicate that although green space maintenance activities are relatively small in scale, they contribute continuously to greenhouse gas emissions throughout the year.

Conclusion and Discussion

From the study and comparison of carbon sequestration by trees and the amount of emissions from activities within Phak Mai Wittayanukul School, the following conclusions can be drawn.

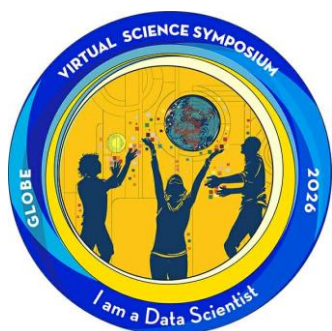
The amount of carbon sequestration by trees, based on a survey of 7 tree species totaling 60 trees across 5 study sites, was found to be 43,070.74 kgCO₂eq in total. *Alstonia scholaris* (Devil tree), with 20 trees, showed the highest sequestration potential at 19,229.6 kgCO₂eq, followed by pine trees with 18 trees, which sequestered 17,600.22 kgCO₂eq. Greenhouse gas emissions from electricity consumption during the entire year (January–December 2025) totaled 3,933.58 kgCO₂eq, with the highest emissions occurring in September at 534.05 kgCO₂eq. Emissions from fuel consumption (lawn mower use) throughout the year amounted to 332.14 kgCO₂eq. When comparing carbon sequestration by trees (43,070.74 kgCO₂eq) with total greenhouse gas emissions from electricity and fuel use within the school (4,265.72 kgCO₂eq), it was found that carbon sequestration significantly exceeded emissions. This indicates that trees within Phak Mai Wittayanukul School are capable of absorbing all greenhouse gases generated from electricity and fuel use within the school and still provide a surplus that contributes to overall climate change mitigation. These findings are consistent with the initial hypothesis that carbon sequestration by trees would be greater than greenhouse gas emissions.

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Optional Badges

I AM A DATA SCIENTIST



This research aligns with the “I AM A DATA SCIENTIST” concept because it begins with data-driven questions to compare carbon sequestration by trees with greenhouse gas emissions within the school (Insight). Quantitative data were systematically collected and analyzed, including data on trees, electricity consumption, and fuel use, based on standards provided by the Thailand Greenhouse Gas Management Organization (TGO) (Analytics). Tools and models were applied to measure and calculate the carbon footprint and carbon sequestration (Measurement/Modeling). The results of the analysis were then

applied to evaluate the potential of green spaces to offset greenhouse gas emissions (Application). This reflects a comprehensive data scientist workflow.

I AM A COLLABORATOR



This research was successfully completed through the collaboration of a four-member team, with each member assigned specific responsibilities. Ms. Akmonchanok Singkrotha served as the team leader, responsible for setting the direction of the project and coordinating activities to ensure smooth implementation. Ms. Jinnapapha Burikong was responsible for field surveys and collecting data on plant species. Ms. Pichyanan Yodjanda collected energy consumption data from the Buildings and Facilities Division. Ms. Piyathida Loonchak was responsible for data processing and final content review to ensure clarity and quality.

The team worked together effectively, demonstrating strong communication, teamwork, and shared responsibility. Therefore, we believe that the team fully meets the criteria for the Collaborator badge.

I MAKE AN IMPACT



This research aligns with the “I MAKE AN IMPACT” concept because the findings clearly demonstrate positive environmental outcomes. The results show that areas with trees within the school can effectively reduce greenhouse gas emissions generated from various activities. The data can be used as guidance for tree maintenance, increasing the number of trees, and promoting energy conservation.

In addition, the research helps raise awareness among students and school personnel about climate change issues and highlights the importance of environmental stewardship. This demonstrates that the research can be practically applied and can create meaningful and positive change.