FACTORS OF ENVIRONMENTAL DIVERSITY AFFECTING THE AMOUNT OF CARBON SEQUESTRATION IN TREES AROUND PAPHAYOMPITTAYAKOM SCHOOL, PHATTHALUNG, THAILAND

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Research Title:	**Factors of Environmental Diversity Affecting the Amount of Carbon Sequestration in Trees around Paphayompittayakom School, Phatthalung, Thailand**
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ABSTRACT

The study on the **Factors of Environmental Diversity Affecting the Amount of Carbon Sequestration in Trees around Paphayompittayakom School** serves three (3) main purposes:

1. To survey and collect data on the variety of trees, temperature, and relative humidity in the air, and the amount of carbon dioxide around the trees.
2. To measure circumference length, height and calculate biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by trees.
3. To examine the relationships between temperature, relative humidity in the air, the amount of carbon dioxide around the trees, circumference length, height, biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by trees.

This involves surveying trees along the Mae Sai Yan Nad Canal road in the Pa Phayom District of Phatthalung Province, covering a distance of 4 kilometers within a 5-meter radius from the road, totaling 219 trees. Carbon dioxide, temperature, and relative humidity in the air were measured, and tree biomass was calculated using allometric equations.

The results revealed 23 diverse species with an average carbon dioxide content of 466.01 ppm. Palm trees (*Arecaceae* sp.) exhibited an average circumference length of 2.72 meters and an average height of 11.79 meters. Upon calculating biomass, palm trees showed the highest above-ground carbon storage. Variance analysis indicated no significant difference at the 0.05 level between the amount of carbon dioxide around the trees and the amount of carbon storage. Both palm trees (*Arecaceae* sp.) and cassia trees (*Senna siamea*) are now included in the list of trees eligible for carbon credit generation. Replanting these species provides additional options for farmers and other interested parties.

Keywords

Tree diversity, Environmental factors, Carbon dioxide, Biomass, Carbon credits

INTRODUCTION

The world is currently experiencing global, a situation where the climate is rapidly and severely changing due to human activities, including greenhouse gas emissions, deforestation, reduced use of renewable energy, and natural climate change. The effects of global warming include extreme heat, flooding, loss of life, and food scarcity. One of the leading causes of greenhouse gases is the increasing concentration of atmospheric carbon dioxide, making it imperative for people to prioritize reducing greenhouse gas emissions and transitioning to a low-carbon society. This can be achieved through education, promoting renewable energy, and implementing carbon credit programs. Thus, the research team seeks to answer the following questions:

1. Does the variety of trees, temperature, and relative humidity in the air affect the amount of carbon dioxide around the trees?
2. Do the circumference length and height of the tree affect biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by the trees?
3. Are temperature and relative humidity in the air correlated with the amount of carbon dioxide around the trees, circumference length, height, biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by trees?

In addition, researchers aimed to investigate the impact of temperature, relative humidity, and carbon dioxide levels on trees' characteristics, such as length, circumference, height, biomass, and above-ground carbon storage. The study focused on trees along Road No. 4018 Mae Sai Yan Nad Canal road, spanning from Thaksin University Phatthalung Campus to Paphayompittayakhom School, covering a total distance of 4 kilometers. Data was collected from trees within a 5-meter radius of the road, and the researchers used this data to calculate carbon content. The study also explored tree species diversity using the PictureThis application.

Tree planting is one effective method as trees absorb carbon dioxide from the atmosphere and store it as biomass, thereby reducing carbon emissions and mitigating climate change severity. Selling carbon credits generated from tree planting can provide income for farmers and interested groups.

RESEARCH HYPOTHESIS

1. The variety of trees, temperature, and relative humidity in the air affect the amount of carbon dioxide around the trees.
2. Circumference length and height of the tree affects biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by trees.
3. Temperature and relative humidity in the air, along with the amount of carbon dioxide around the trees, are related to circumference length, height, biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by trees.

THE EXPERIMENTAL SITE

The experiment was conducted in Ban Phrao, Pa Phayom, Phatthalung, Thailand.

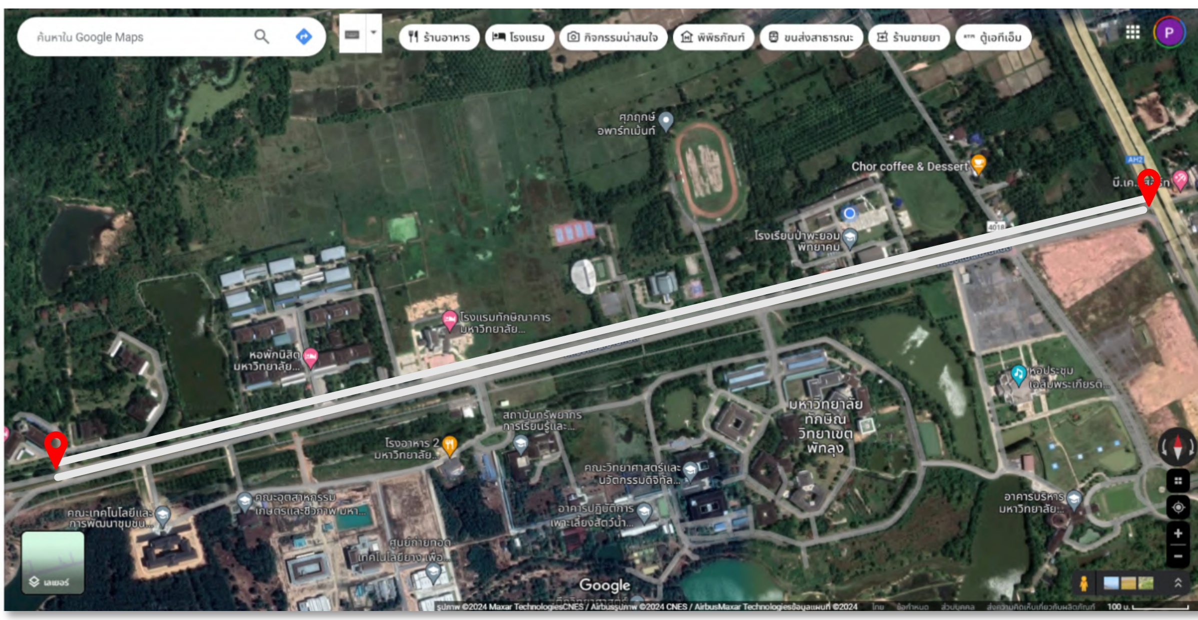

Figure 1: Map of the tree sampling area located at 7.48476° N, 99.56564° E to 7.48319° N 99.55521° E and elevation of 26.7 meters, in the area along Road No. 4018 Mae Sai Yan Nad Canal road, spanning from Thaksin University Phatthalung Campus to Paphayompittayakhom School, covering a total distance of 4 kilometers. Data was collected from trees within a 5-meter radius of the road.

MATERIALS AND EQUIPMENT

The following materials and equipment were used for the experiment:

- Measuring tape for measuring the circumference of the tree
- Clinometer for measuring tree height
- PictureThis application for identifying tree species.
- HT-2000 CO2 Meter for measuring carbon dioxide levels, temperature, and relative humidity in the air
- Google Maps for determining GPS coordinates
- Data recording equipment

METHODS

These steps were taken to conduct a study:

1. Study information regarding global problems and trees' capacity to store carbon dioxide. Measuring circumference length, height, and biomass of tree.
2. Determine the study area with coordinates ranging from 7.48476° N, 99.56564° E to 7.48319° N 99.55521° E by surveying along Road No. 4018, Mae Sai Yan Nad Canal Road. Between Thaksin University Phatthalung Campus and Paphayompittayakom School. The route covers a total distance of 4 kilometers.
3. 3 Conduct a survey and collect tree data according to the specified coordinates. Select trees with a height of 1.5 meters or more. Use a measuring tape measure to determine the circumference of the tree at 1.30 meters above the ground. Measure the tree's height using a measuring tape. Determine the distance from the base of the tree to the observer, as well as the height from the ground to the observer's eye level. Calculate the tree's height using the formula :

Tree height (meters) = (distance (meters) x tangent angle BAC)
+ Height of the observer's eye level above the ground (meters)

B - Angle of Elevation
A - Height of Eye Above Ground
C - Distance to Tree

Figure 2: Measuring the circumference of the tree at 1.30 meters above the ground

Figure 3: Determine the distance from the base of the tree to the observer

Figure 4: Determine the tree's tangent angle

Figure 5: Measuring the temperature, relative humidity, and carbon dioxide level with the HT-2000 CO2 Meter

Using PictureThis application to identify the tree species' name, then calculate the diversity index of the 219 trees.

Diversity Index (Shannon -Wiener index)	Diversity Index (Simpson's index)	Evenness index

4. Record the collected data in a results recording table, including air temperature (in Celsius), relative humidity (as a percentage), and carbon dioxide content (in ppm).
5. Analyze the data by utilizing the air temperature, relative humidity, and carbon dioxide levels. Incorporate height and tree circumference length to calculate the tree's biomass, using the allometry equation developed by Ogawa et al. (1965).

$$Ws = 0.0396 (D^2H)^{0.9326}$$
$$Wb = 0.003487 (D^2H)^{1.0270}$$
$$Wl = ((28.0/Ws+Wb)+0.025)-1$$

*Ws is the biomass of stem (kilograms)
Wb is the biomass of branch (kilograms)
Wl is the biomass of leave (kilograms)
D is the diameter at 1.30 meters (centimeters)
H = the height of tree (meters)

Next, the obtained tree biomass was used to calculate above-ground carbon storage using the IPCC (2006) equation.

Above-ground carbon storage = biomass x 0.47

The amount of carbon dioxide absorbed was calculated according to the equation proposed by Meepol (2010)

The amount of carbon dioxide absorbed = Carbon storage x 44/12

Similarly, the amount of oxygen released was determined using Somsak's equation (2016).

The amount of oxygen released = Carbon storage x 32/12

6. Analyze the statistical measures including average and variance (ANOVA) of temperature, relative humidity in the air, the amount of carbon dioxide around the tree, circumference length, height, biomass, above-ground carbon storage, as well as the amount of carbon dioxide absorbed, and the amount of oxygen released by trees. Perform correlation statistical analysis to examine the relationships between temperature, relative humidity in the air, the amount of carbon dioxide around trees, circumference length, height, biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by trees.

RESULTS

Table 1: Diversity of Trees and Environmental Factors

No.	Tree	Quantity	Environmental Factors		
			Average Air Temperature (Celsius)	Average Relative Humidity (percentage)	Average Carbon dioxide content (ppm)
1	*Acacia auriculiformis*	1	30.40	71.00	468.00
2	*Acnistus arborescens*	1	30.70	70.30	474.00
3	*Alstoniascholaris* sp.	1	32.00	68.00	472.00
4	*Anacardium* sp.	5	33.02	68.44	463.60
5	*Antidesma ghaesmbilla*	4	31.28	69.03	471.25
6	*Arecaceae* sp.	30	28.79	75.63	447.53
7	*Azadirachta indica*	1	30.50	71.20	453.00
8	*Baringtonia* sp.	3	32.80	67.20	449.00
9	*Borasas flabellifer*	3	31.87	66.67	468.67
10	*Cassia fistula*	25	31.26	93.61	472.12
11	*Eucalyptas robusta*	1	30.00	71.20	477.00
12	*Illigera rhodanthe*	1	33.00	65.20	480.00
13	*Lagerstroemia floribunda*	5	32.12	69.00	473.60
14	*Lannea coromandelica*	1	31.00	70.20	491.00
15	*Mangifera indica*	28	29.06	75.34	447.04
16	*Millingtonia hortensis*	1	30.40	69.50	472.00
17	*Pterocarpus indicus*	38	28.28	77.99	448.61
18	*Rhedantha* sp.	1	33.40	67.90	462.00
19	*Schefflera actinopohhylla*	2	32.30	64.50	462.00
20	*Senna siamea*	39	29.33	74.63	473.18
21	*Syzygium cumini*	1	31.20	68.90	464.00
22	*Tectona grandis*	25	31.66	67.30	454.08
23	*Terminalia neotaliala*	2	31.05	69.05	474.50
Total		219	31.11	70.95	466.01

This shows that a total of 219 trees were surveyed, all classified into 23 species. The study area exhibited an average air temperature of 31.11 degrees Celsius, an average relative humidity in the air of 70.95 percent, and an average carbon dioxide amount was 466.01 ppm.

Table 2: Tree Diversity Index Values.

Diversity Index Shannon -Wiener index	Diversity Index Simpson's index	Evenness index
2.33705147	0.878891	0.74535346

The Shannon index is an information statistic index, which means it assumes all species are represented in a sample that they randomly sampled. The value of H ranges from 0 to Hmax. Hmax is different for each community and depends on species richness. (Note: Shannon-Weiner is often denoted H').

The Simpson Index is a dominance index because it gives more weight to common or more dominant species. In this case, a few rare species with only a few representatives will not affect the diversity. The value of Simpson's D ranges from 0 to 1, with 0 representing infinite diversity and 1 representing no diversity, so the larger the value of D, the lower the diversity.

Evenness is a measure of the relative abundance of the different species in the same area.

The value of Simpson's D ranges from 0 to 1, with 0 representing infinite diversity and 1 representing no diversity, so the larger the value of D, the lower the diversity. The value of Evenness Index (J) ranges from 0 to 1. Higher values indicate higher levels of evenness. At maximum evenness, J = 1. J and D can be used as measures of species dominance (the opposite of diversity) in a community. Low J indicates that 1 or few species dominate the community.

Table 3: Circumference Length, Height, Biomass Calculations, Above-Ground Carbon Storage, Carbon Dioxide Absorption, and Oxygen Released by Trees.

No.	Tree	Data Collection		Average Results Analysis			
		Average Circumference Length (meters)	Average Height (meters)	Biomass (kg)	Above-Ground Carbon Storage (kg)	Carbon Absorption (kg)	Amount of Oxygen Released (kg)
1	*Acacia auriculiformis*	1.85	16.74	1390.85	653.70	2396.89	1743.19
2	*Acnistus arborescens*	0.80	13.21	228.90	107.58	394.48	286.89
3	*Alstoniascholaris* sp.	2.25	16.20	1950.61	916.79	3361.55	2444.76
4	*Anacardium* sp.	0.43	4.03	24.19	11.37	41.70	30.32
5	*Antidesma ghaesmbilla*	1.02	8.72	249.43	117.23	429.84	312.61
6	*Arecaceae* sp.	2.72	11.79	2222.14	1044.40	3829.48	2785.08
7	*Azadirachta indica*	0.21	10.82	15.12	7.11	26.05	18.95
8	*Baringtonia* sp.	0.43	3.62	24.04	11.30	41.42	30.13
9	*Borasas flabellifer*	1.37	12.73	779.71	366.46	1343.70	977.23
10	*Cassia fistula*	0.77	13.39	397.32	186.74	684.71	497.97
11	*Eucalyptas robusta*	1.46	11.71	635.22	298.55	1094.70	796.14
12	*Illigera rhodanthe*	0.62	19.87	204.81	96.26	352.95	256.69
13	*Lagerstroemia floribunda*	1.70	14.89	1354.30	636.52	2333.90	1697.39
14	*Lannea coromandelica*	0.34	16.62	56.43	26.52	97.24	70.72
15	*Mangifera indica*	1.12	10.12	553.72	260.25	954.24	693.99
16	*Millingtonia hortensis*	0.20	18.22	22.56	10.60	38.88	28.28
17	*Pterocarpus indicus*	0.97	9.69	286.71	134.75	494.09	359.34
18	*Rhedantha* sp.	0.65	19.20	220.09	103.44	379.29	275.85
19	*Schefflera actinopohhylla*	1.32	14.92	1127.89	530.11	1943.72	1413.62
20	*Senna siamea*	0.74	10.49	202.06	94.97	348.21	253.24
21	*Syzygium cumini*	0.56	6.39	58.68	27.58	101.12	73.54
22	*Tectona grandis*	0.45	9.46	71.82	33.76	123.77	90.02
23	*Terminalia neotaliala*	1.85	16.74	63.24	29.72	108.99	79.26

This shows that *Arecaceae* sp., *Alstoniascholaris* sp., and *Acacia auriculiformis* had the highest biomass, measuring 2222.14, 1950.61, and 1390.85 kg, respectively. Similarly, the highest above-ground carbon storage, measuring 1044.40, 916.79, and 2396.89 kilograms, respectively. In terms of carbon dioxide absorption, the maximum amounts were found in *Arecaceae* sp. (3829.48 kg), *Alstoniascholaris* sp. (3361.55 kg), and *Acacia auriculiformis* (653.70 kg). Additionally, the amount of oxygen released was highest for *Arecaceae* sp. (2785.08 kg), *Alstoniascholaris* sp. (2444.76 kg), and *Acacia auriculiformis* (1743.19 kg).

Table 4: Analysis of Variance (ANOVA) for Air Temperature, Relative Humidity, Carbon Dioxide Levels, Circumference Length, Height, Biomass, Above-Ground Carbon Storage, Carbon Dioxide Absorption, and Oxygen Released by Trees.

Source of Variation		Sum of Squares	df	Mean Square	F	Sig.
Air Temperature	Between groups	372.764	22	16.944	4.493	.000
	Within the group	739.085	196	3.771		
	Total	1111.849	218			
Relative Humidity in the Air	Between groups	8515.608	22	387.073	.196	1.000
	Within the group	386365.85	196	1971.254		
	Total	394881.458	218			
Amount of carbon Dioxide around the Trees	Between groups	25602.571	22	1163.753	1.315	.165
	Within the group	173444.771	196	884.922		
	Total	199047.342	218			
Circumference Length of Tree	Between groups	55.004	22	2.500	4.034	.000
	Within the group	121.482	196	.620		
	Total	176.486	218			
Tree Height	Between groups	729.472	22	33.158	.457	0.983
	Within the group	14214.809	196	72.525		
	Total	14944.281	218			
Biomass	Between groups	60808401.2	22	2764018.24	3.29	.000
	Within the groups	164689497	196	840252.537		
	Total	225497898	218			
Above-ground carbon storage	Between groups	13403532.3	22	609251.467	3.283	.000
	Within the group	36367691.1	196	185549.445		
	Total	49771223.4	218			
Carbon Absorption	Between groups	180203020	22	8191046.38	3.284	.000
	Within groups	488942482	196	2494604.5		
	Total	669145502	218			
Amount of Oxygen Released	Between groups	95313991	22	4332454.14	3.284	.000
	Within the group	258614272	196	1319460.57		
	Total	353928263	218			

* Statistically significant at the .05 level (Sig ≤ .05)

The result shows that air temperature, tree circumference length, biomass, above-ground carbon storage, amount of carbon dioxide absorbed, and amount of oxygen released were significantly different at the 0.05 level.

Table 5: Correlation Coefficients Reflecting the Relationship Between Temperature, Relative Humidity, Carbon Dioxide Levels, Circumference Length, Height, Biomass, Above-Ground Storage, Carbon Dioxide, Absorption, and Oxygen Released by Trees.

Source of Variation		Temperature	Relative Humidity in the Air	Carbon Dioxide Levels Around the Trees	Circumference Length of Tree	Tree Height	Biomass	Above-Ground Carbon Storage	Carbon Dioxide Absorption
Temperature	Pearson Correlation	1	-.637**	.181**	-.224**	0.052	-.162*	-.082	-.162*
	Sig. (2-tailed)		.000	.007	.001	.446	.016	.228	.016
	N	219	219	219	219	219	219	219	219
Relative humidity in the air	Pearson Correlation	-.637**	1	-.212**	.270**	-.082	.145*	.099	.145*
	Sig. (2-tailed)	.000		.002	.000	.230	.032	.145	.032
	N	219	219	219	219	219	219	219	219
The amount of carbon dioxide around the trees	Pearson Correlation	.181**	-.212**	1	-.166*	.036	-.122	-.133*	-.122
	Sig. (2-tailed)	.007	.002		.014	.592	.072	.049	.072
	N	219	219	219	219	219	219	219	219
Circumference length of tree	Pearson Correlation	-.224**	.270**	-.166*	1	.167*	.915**	.001	.915**
	Sig. (2-tailed)	.001	.000	.014		.013	.000	.986	.000
	N	219	219	219	219	219	219	219	219
Tree Height	Pearson Correlation	.052	-.082	.036	.167*	1	.398**	.016	.398**
	Sig. (2-tailed)	.446	.230	.592	.013		.000	.816	.000
	N	219	219	219	219	219	219	219	219
Biomass	Pearson Correlation	-.162*	.145*	-0.122	.915**	.398**	1	-.037	1.000**
	Sig. (2-tailed)	.016	.032	.072	.000	.000		.584	.000
	N	219	219	219	219	219	219	219	219
Above-Ground Carbon Storage	Pearson Correlation	-.082	.099	-.133*	.001	.016	-.037	1	-.037
	Sig. (2-tailed)	.228	.145	.049	.986	.816	.584		.584
	N	219	219	219	219	219	219	219	219
Carbon Dioxide Absorption	Pearson Correlation	-.162*	.145*	-.122	.915**	.398**	1.000**	-.037	1

* Statistically significant at the .05 level (Sig ≤ .05)

This result shows that the correlation coefficient between temperature and the amount of carbon dioxide in the tree area was found to be significant at the 0.05 level. The direction of this relationship is positive (rtt = 0.181, Sig. = 0.007). Similarly, the relative humidity in the air was found to be significantly related to the amount of carbon dioxide around the trees at the 0.05 level. The direction of this relationship is negative (rtt = -0.212, Sig. = 0.002). Additionally, the circumference length of the tree was found to be significantly related to the amount of carbon dioxide in the tree area at the 0.05 level. The direction of this relationship is negative (rtt = -0.166, Sig. = 0.014). Moreover, above-ground carbon storage was found to be significantly related to the amount of carbon dioxide near trees at the 0.05 level. The direction of this relationship is negative (rtt = -0.133, Sig. = 0.049).

CONCLUSION

The study surveyed a total of 219 trees in the study area, classified into 23 species, with an average air temperature of 31.11 degrees Celsius, an average relative humidity of 70.95 percent, and an average carbon dioxide amount of 466.01 ppm.

The study obtained several significant findings, which are as follows:

1. The variety of trees, temperature, and relative humidity in the air affect the amount of carbon dioxide around the trees. When the temperature is high, the amount of carbon dioxide will increase. However, if the relative humidity is high, the amount of carbon dioxide will decrease.

2. The circumference length and height of the tree affect biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by the trees. When the circumference length and height increase, the biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by the trees will also increase.

3. The temperature and relative humidity in the air are correlated with the amount of carbon dioxide around the trees, circumference length, height, biomass, above-ground carbon storage, the amount of carbon dioxide absorbed, and the amount of oxygen released by trees. The direction of the temperature relationship is positive, but the direction of the relative humidity relationship is negative.

Furthermore, the analysis revealed that the amount of carbon dioxide around the trees and carbon storage did not significantly differ, falling within the normal CO_2 concentration threshold range of 447.04–491.00 ppm.

Trees such as Golden shower trees (*Cassia fistula*), Mango trees (*Mangifera Indica*), and Teak trees (*Tectona grandis*) are classified as carbon credit trees, while palm trees (*Arecaceae* sp.) and Cassia trees (*Senna siamea*) possess similar carbon storage capabilities and can be considered for carbon credit generation. Recommendations include planting palm trees (*Arecaceae* sp.) and Cassia trees (*Senna siamea*) to replace carbon credit trees, tailored to local environmental conditions. Additionally, studying the diversity of other trees is suggested to expand the database of potential carbon credit trees for farmers and stakeholders.

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