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Tree diversity and aboveground carbon stock assessment in Sitio Bokbokon, Las Nieves, Agusan del Norte, Philippines

Rowena A. Japitana[1*], Janelito F. Olor[1], Katrine Mae B. Mante[2]

[1]*Biology Department, College of Arts and Sciences, Caraga State University, Butuan City, Philippines*

[2]*Bohol Island State University Calape Campus, Calape, Bohol, Philippines*

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Abstract

Tropical forest has a valuable role concerning climate change, by sequestering a huge amount of CO_2 from the atmosphere. This study assessed the carbon stock and rate of sequestration of forest ecosystems in Sitio Bokbokon Las Nieves Agusan Del Norte. A total of 11 families and 88 individuals of plants were identified. The conservation status of trees that have been collected using IUCN Red List of Threatened Species revealed that there were six (6) Least Concern trees status, five (5) Vulnerable, five (5) Not Assessed, four (4) Critically and Endangered two (2) species of trees. Plant diversity in all stations resulted to moderate with Shannon diversity (H`) of 2.542. Carbon density ranges widely from 402.61 t/ha to 6088.15 t/ha in the following 3 stations with station 2 as the largest due to the presence of large trees such as *Shorea macrophylla, Ficus benjamina, Eucalyptus deglupta,* and *Shorea* contorta. Overall, the identified trees in selected areas in Sitio Bokbokon were capable of storing a high amount of carbon dioxide and thus it has a big factor in mitigating climate change.

* **Corresponding Author:** Rowena A. Japitana ✉ weejapitana@gmail.com

Introduction

Forest ecosystem plays a valuable role in the world as they served as the source and sink of carbon. It helps reduce greenhouse gas concentration by absorbing a huge amount of carbon from the atmosphere. A variety of human activities such as land conversion, cultivation and illegal logging have led to a decrease of forests worldwide and increase the emission of CO_2 and other greenhouse gases, which in turn affects the world's climate (Melillo *et al.,* 1996).

In 2000, the IPCC report concluded that there is substantial evidence that human activities have affected the world's climate. The global average surface temperature rose at a rate of 0.17°C per decade (Climate.Gov, 2018). The carbon dioxide emission in the Philippines increases mostly due to fossil fuel combustion and due to illegal logging (Malayao and Mendoza, 2013). Though several efforts have been taken worldwide to reduce carbon emissions, the rise in carbon dioxide gas concentration in the atmosphere is still alarming. The drastic change in climate will lead to enormous challenges for forest management with heavy socio-economic and biological problems (Demafelis, 2015).

In the last century, the forest was slowly prone to abuse and exploitation, where the human population consumed and altered forest landscape in favor of agriculture development and urbanization (Goetz *et al.,* 2009). Few studies about the quantification of forest carbon stock have been carried out worldwide and still, many forest ecosystems remained unexplored, especially here in Caraga Region. With that, this study aims to determine the species diversity of trees, identify the potential of some forest areas in Sitio Bokbokon, Las Nieves, Agusan del Norte as a valuable carbon pool.

Materials and methods

Site description

The municipality of Las Nieves, Agusan del Norte has a land area of 582.69 square kilometers (224.98 sq mi) constituting 21.34% of the 2,730.24 km^2(1,054.15 sq mi) total area of Agusan del Norte. It is situated at approximately 8°39'54.36"N, 125°27'22.68"E, on the island of Mindanao.

Las Nieves is divided into 21 barangays, of which, Brgy Casiklan is included in where the forest sites in Sitio Bokbokon is located (Fig.1).

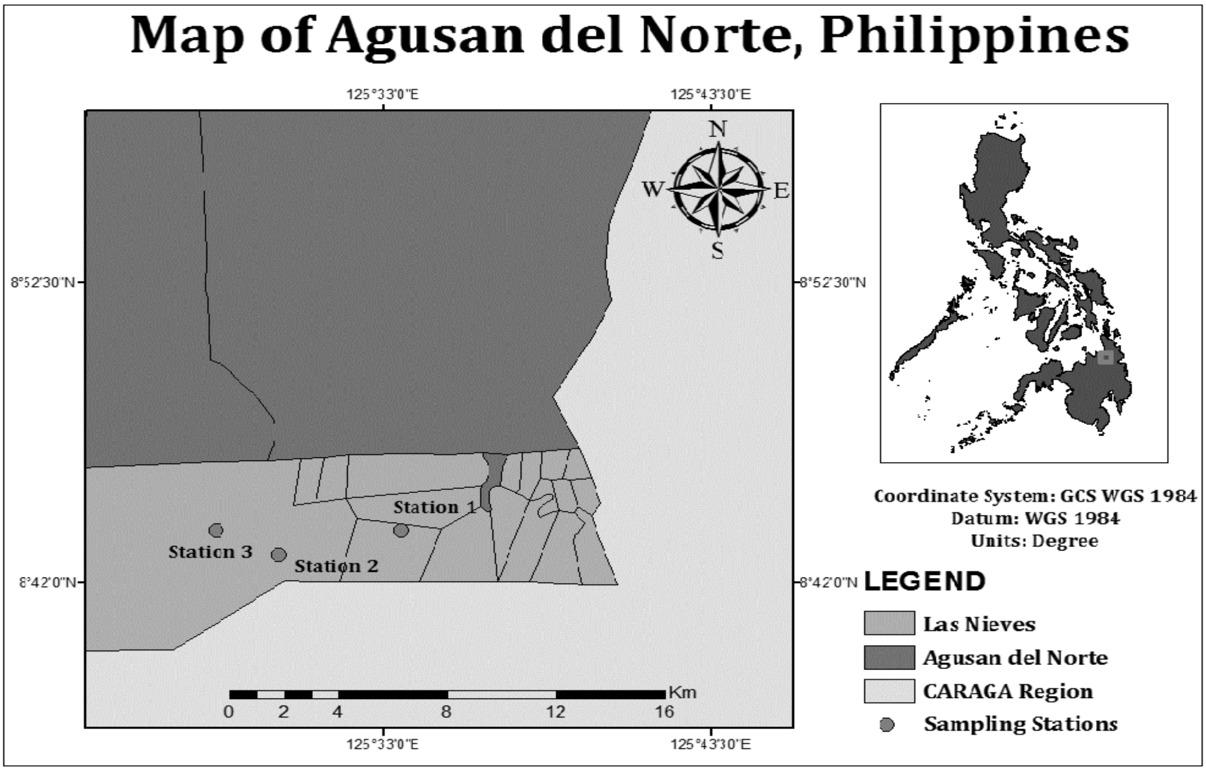

Fig. 1. Study area in Sitio Bokbon, Las Nieves, Agusan del Norte

The temperature could reach up to 34°C and could drop to 26°C at night. It is mostly dry with little or no precipitation and cloud covering 50% of the sky, the humidity will be around 74%. Its population as determined by the 2015 Census was 2,066. This represented 7.27% of the total population of Las Nieves (PSA).

Sampling method

To estimate the carbon stock in the forest sites of Sitio Bokbokon, (9) nine sample plots measuring 10m x 10m each were established at irregular intervals along with three different stations. Plots were distributed along the transect line to represent variations of conditions that influence the forest.

The location of the sampling plots was recorded using the Global Positioning System (GPS) device.

Only tree species that measures 1.4 meters above the ground were considered for measuring the diameter at breast height (DBH). The height of the identified trees was also measured using a measuring tape.

Conservation Status of Identified Trees

The conservation status of the trees was identified using the IUCN Redlist of 2019 and divided into different categories: Least Concern (LC), Endangered (EN), Critically Endangered (CR), Vulnerable (VU) and Not Assessed (NA).

Diversity index

Species diversity in each sample plots was assessed by using the Shannon Wiener index (H') (Maguran, 1998). The species diversity outcomes were interpreted using the description by Fernando (1998): Low (H' = 1 – 2.49), Moderate (H' = 2.5 – 2.90), High (H' = 3 – 4).

Shannon Weiner Index (H')

$$H' = -\sum_{i=l}^{s} Pi * \ln Pi$$

Where:

s = number of species

Pi = proportion of individuals in the population

ln = log base n

Biomass and carbon stock estimation

Tree biomass was computed using the following Allometric Equation: exp(-.289 + 2.649 x ln DBH – 0.021 x ln dbh2) which was derived and adapted from Brown (1997) updated by (Pearson, 2005) for the tropical forests with precipitation of 1500-4000 mm/yr. For the biomass density, the total biomass per plot was multiplied to 10,000 m^2 divided by the plot size in square meters which is 10m x 10m or 0.01ha.

On the other hand, tree carbon stock was computed by multiplying the tree biomass with the IPCC default carbon fraction value of 50% (0.50) (Houghton *et al.*, 1997).

Where:

DBH = diameter breast height expressed in centimeter

Tree data were converted into tree biomass per unit area (ha^{-1}).

Tree Carbon stock was computed using the Carbon Stock = Biomass x 0.50.

Statistical analysis

Analysis of Variance (ANOVA) was used to compare the means (DBH, and Carbon Stock) of the samples collected in different stations. Using of Paleontology Statistics Software (PAST) version 3.2.

Results and discussion

Species composition

A total of 90 tree individuals were identified in the area, with 22 species belonging to 11 families (Table 1). In terms of species richness, there were 15 species in station 1, while station 2 has 14 species, and station 3 has 12 species recorded, respectively. The family Dipterocarpacea takes 24% of the totality of the species identified namely; *Shorea contorta*, *Parashorea malaanonan (blanco)* Merr.,*Shorea negrosensis* and *Dipterocarpus grandifloras* and *Shorea palosapis*.

Table 1. Species composition of Tress in Sitio Bokbokon.

Family/SpeciesName	Common Name	Ecological Status
Annonaceae		
Cananga odorata	Ilang- ilang	NA
Araliaceae		
Polyscias nodosa	Malapapaya	LC
Burseraceae		
Canarium asperum	Pagsahangin	LC
Canarium luzonicum	Piling liitan	VU
Dipterocarpaceae		
Parashorea malaanonan (blanco)	Bagtikan	CR
Dipterocarpus grandiflorus	Apitong	EN
Shorea contorta	Lauan puti	CR
Shorea negrosensis	Lauan pula	CR
Shorea palosapis	Mayapis	CR
Fabaceae		
Leucaena leucocephala (Lam.) de Wit	Ipil-ipil	NA
Pterocarpus indicus	Narra	EN
Acacia mangium	Mangium	NA
Lamiaceae		
Gmelina arborea	Gmelina	LC
Vitex parviflora	Tugas	VU
Lecythidaceae		
Petersianthus quadrialatus Merr.	Toog	LC
Meliaceae		
Swietenia macrophylla	Mahogany	VU
Moraceae		
Artocarpus camansi	Kamansi	LC
Ficus bojeri	Ameson/ basikong	VU
Ficus benjamina	Balete	LC
Myrtaceae		
Eucalyptus pauciflora	Bagras	CR
Urticaceae		
Laportea brunnea Merr.	Alingatong	LC
Boehmeria nivea Linn	Ramie	NA

Legend: LC (Least Concern), EN (Endangered), NA (Not Assessed), CR (Critical Endanger) and VU (Vulnerable).

The family Fabaceae has 14% of the totality of the species identified namely; *Pterocarpus indicus, Leucaena leucocephala* (Lam.) de Wit, and *Acacia mangium.*

The family Urticaceae has 10% of the totality of the species identified namely;*Boehmeria nivea* Linn, *Laportea brunnea.* The family Moraceae, Burseraceae, and Lamiacea has 9% of the totality of the species identified namely; *Ficus bojeri, Artocarpus camansi* and *Ficus benjamina, Canarium asperum, Canarium luzonicum, Gmelina arborea*, and *Vitex parviflora.*

The families Myrtaceae, Meliaceae, Lecythidaceae, Annonaceae, Araliaceae each of has 5% of the totality of the species identified namely: *Eucalyptus pauciflora. Swietenia macrophylla, Petersianthus quadrialatus* Merr, *Polyscias nodosa,* and *Cananga odorata,* respectively (Fig. 2).

Table 2. Tree Diversity and Species Richness in Sitio Bokbokon.

Station	Shannon Diversity (H')	Species Richness
1	2.542	15
2	2.475	14
3	2.362	12

Table 3. Abundance and Mean Diameter of Trees indifferent Station.

Area	Trees	No. of trees	Mean DBH (cm)
Station 1	*Swietenia macrophylla*	3	34.47
	Vitex parviflora .	3	30.71
	Shorea negrosensis	5	45.54
	Laportea brunnea	1	29.24
	Ficus bojeri	1	14.08
	Petersianthus guardrialatus Merr.	3	30.9
	Parashorea malaanonan (blanco) Merr.	1	31.21
	Urtica nieva Linn	2	21.18
	Shorea palosapis	1	25.29
	Canarium asperum	1	47.77
	Shorea negrosensis	2	59.71
	Polyscias nodosa	4	22.29
	Pterocarpus indicus	1	48.08
	Leucaena leucocephala (Lam.) de Wit	1	17.19
	Gmelina aborea	2	22.07
Station 2	*Shorea contorta*	2	96.76
	Shorea negrosensis	3	40.05
	Artocarpus camansis	1	27.38
	Polyscias nodosa	5	94.52
	Dipterocarpus grandiflorus	3	42.13
	Laportea brunnea	1	38.21
	Vitex parviflora .	3	57.43
	Pterocarpus indicus	4	51.27
	Canarium luzonicum	1	70.06
	Ficus benjamina	1	120.7
	Swietenia macrophylla	4	82.44
	Cananga odorata	3	52.75
	Eucalyptus pauciflora	1	108.28
	Urtica nieva Linn	1	37.26
Station 3	*Artocarpus camansi*	2	31.20
	Swietenia macrophylla	5	46.59
	Dipterocarpus grandiflorus	2	42.83
	Ficus benjamina	1	116.87
	Ficus bojeri	2	54.77
	Laportea brunnea	1	32.16
	Vitex parviflora	4	29.56
	Pterocarpus indicus	1	34.07
	Polyscias nodosa	2	42.03
	Cananga odorata	2	43.47
	Shorea contorta	2	26.76
	Acacia mangium	2	28.18

Conservation status

The conservation status of trees that have been identified using IUCN Red List of Threatened Species revealed that there were six (6) Least Concern trees status, five (5) Vulnerable, five (5) Critically Endangered, four (4) Not Assessed and two (2) Endangered species of trees (Figure 3). The population of species with high ecological and economic importance such as *P. indicus, E .pauciflora, P. malaanonan (blanco), D.*

grandiflorus, S. contorta, S. negrosensis and *S. palosapis* are decreasing. Several factors such as climate change, land conversion, illegal logging and other anthropogenic activities might be caused for the status of the said tree species in the area (Rumana, 2009).

Table 4. Mean Aboveground Biomass Density and Carbon Stock along the different stations of Sitio Bokbokon, Las Nieves, Agusan del Norte.

Plot	Station 1		Station 2		Station 3	
	Biomass Density t/ha	Carbon Stock C t/ha	Biomass Density t/ha	Carbon Stock C t/ha	Biomass Density t/ha	Carbon Stock C t/ha
1	1067.7	533.85	6536.4	3268.2	4215.4	2107.7
2	805.22	402.61	12176.3	6088.15	869.6	434.8
3	2214.7	1107.35	3024.8	1512.4	688.7	344.35
Mean	1362.54	2043.81	7245.83	3622.92	1924.57	962.28

Species diversity

In terms of diversity, all stations have resulted in moderate diversity according to the biodiversity scale used by Fernando (1998). Station 1 had the largest diversity with 2.542 and 15 species found. Station 2 has a total of 2. 475 diversity index and 14 species. While station 3 was the lowest with a total of 2.362 diversity with 12 species recorded (Table 2). The absence of human settlers, animal grazing and cultivation in the area could attribute to the results of the diversity of the identified trees. Furthermore, natural disturbances such as fallen logs were also observed specifically in station 3. Nevertheless, conservation should be maintained since the area has moderate diversity and also the area has not been utilized by humans.

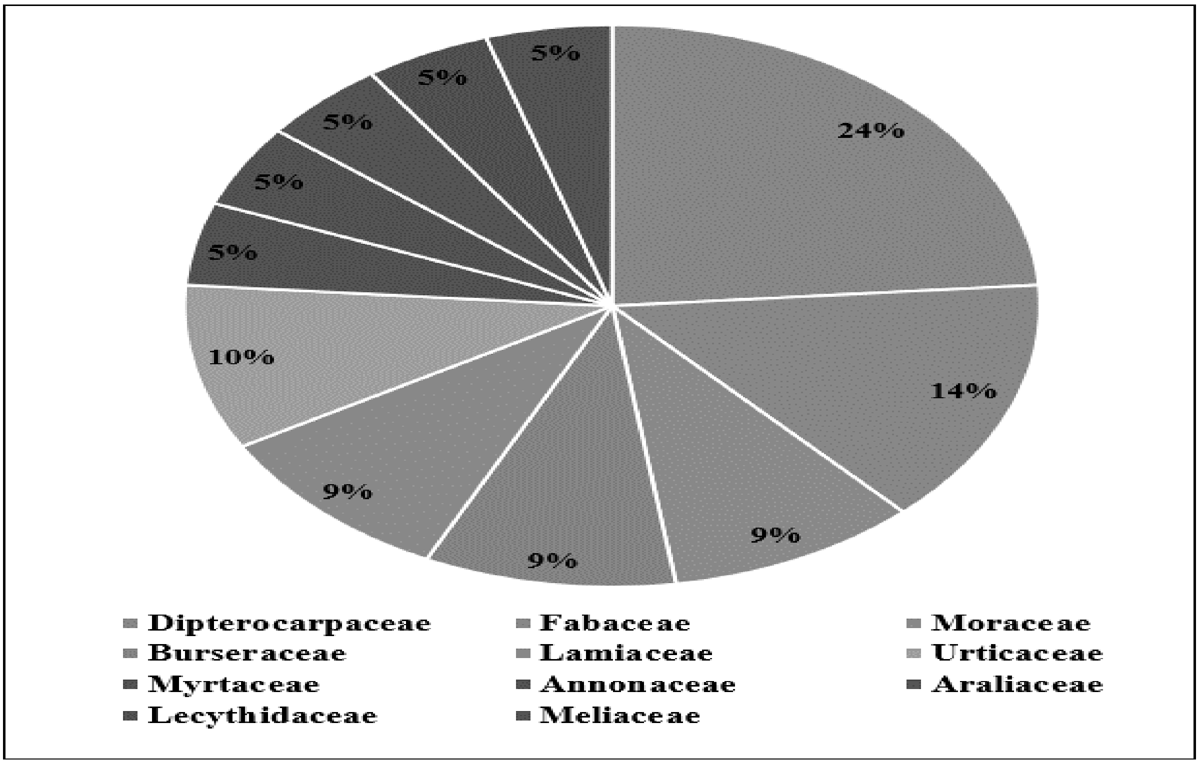

Fig. 2. Percentile distribution of plant families across sampling station.

Mean DBH

Among the 3 stations, the station 2 has the highest range of mean DBH with 919.24 cm, followed by the Station 3 and Station 1 having a mean DBH of 528.4 cm and 479.73 cm, respectively (Fig. 4). In terms of DBH, *F. benjamina* registered the largest that were found in both stations 2 and 3. Other trees that also predominated this range was *S. negrosensis, S. contorta, E. pauciflora, C. luzonicum, S. macrophylla* (Table 3). The branches of *F. benjamina* are usually expanded and wide-ranging from the side branches, an expansion of a system of tentacle-like, downward-growing. *S. negrosensis* and *S. contorta* produce valuable and strong bark, pulp timber and it grows upward. *E. pauciflora* has adaptable to a wide range of soil conditions and highly tolerant, it grows 8-20 meters long commonly found in thin, rocky soil (Snow *et al.*, 2013). *C. luzonicum* has a large tree about 30-meter height and can bole up to 100 cm diameter (PROSEA).

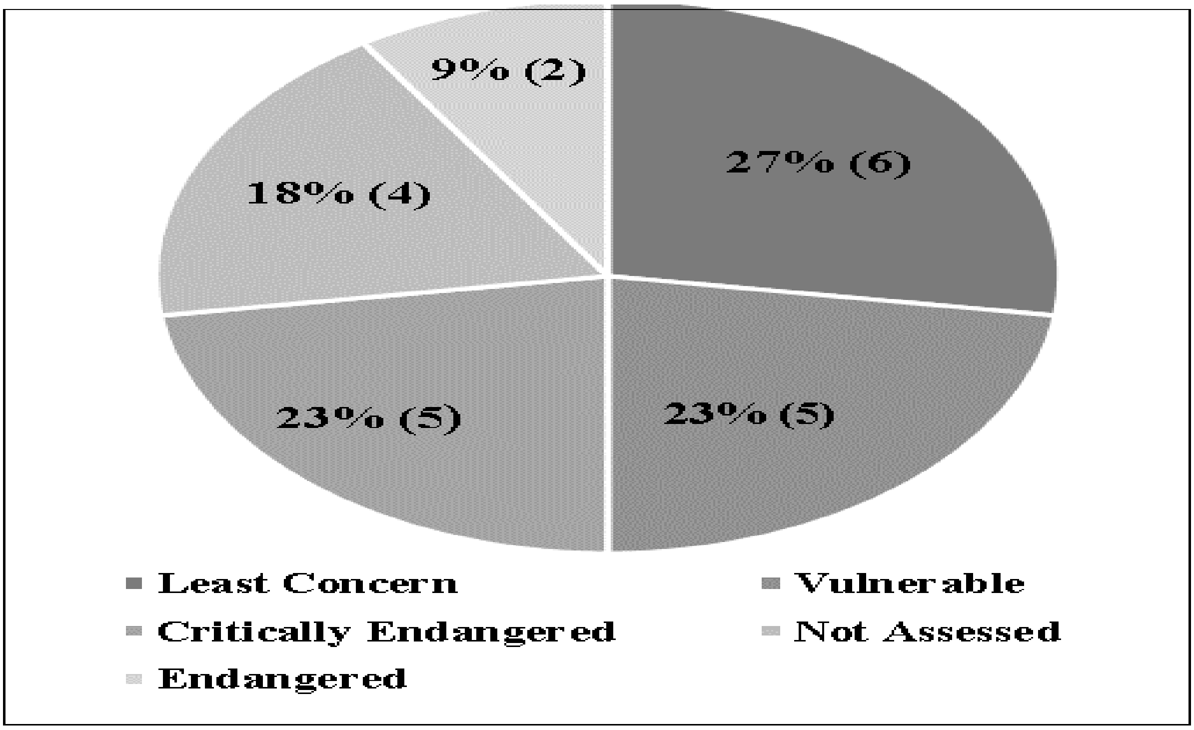

Fig. 3. Percentage of conservation status of trees in Sitio Bokbokon.

Total aboveground biomass density and carbon stock

Among the three stations, the highest aboveground biomass density and carbon stock mean was observed in station 2 with 7245.83 t/ha and 3622.92 t/ha respectively. In station 1, estimates in biomass and carbon stock were high in plot 3 with 2214.7 t/ha and 1107.35 t/ha, respectively. At this station, the presence of trees such as *S. contorta*, and *S. negrosensis* had highly contributed to the biomass and carbon stock in the area. The largest biomass and carbon stock was observed at station 2, plot 3 with 12176.3 t/ha and 6088.15 t/ha, respectively. This is also possible because of the presence of large trees such as *S. macrophylla, P. indicus, S. tripinnatum, P. nodosa, D. grandifloras, C. odorata, F. benjamina* with 14 individuals of trees. At station 3, the mean biomass and carbon stocks were 4215.4 t/ha and 2107.7 t/ha, respectively. Values were particularly highest in plot 1 were largest tress such as *P. nodosa, A. camansi, D. grandifloras, F. benjamina, L. brunnea, F. bojeri* contributed to aboveground biomass and carbon stock (Table 4).

The results of the study were high compared to the carbon stock studies in the Philippines of Gevaña, *et al.* (2013) in different elevations in where it obtained total biomass of 595.8tC/ha and 279.9 tC/ha carbon stock, Lasco *et al.* (2005) where it gained total biomass of 546.6Mg/ha and 251.6 MgC/ha carbon stock, respectively and Tulod, (2015) with a total carbon stock of 1229.46tC ha respectively.

All the mentioned studies have different habitat conditions, thus allowing it to have a different amount of estimated biomass and carbon stock.

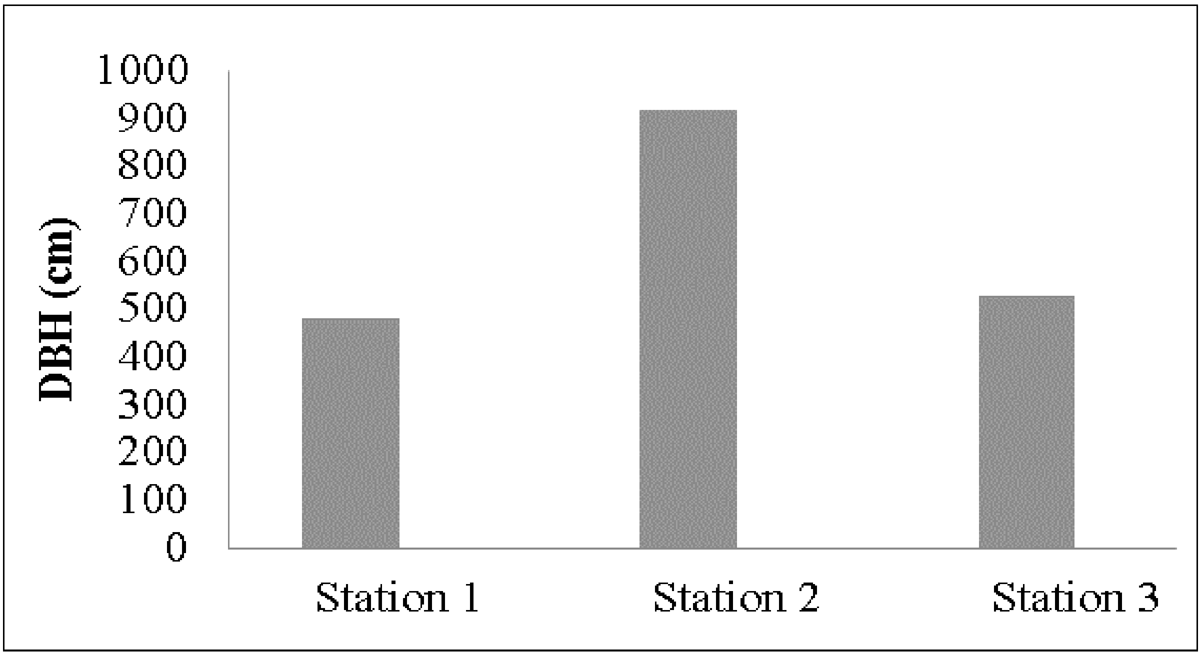

Fig. 4. Mean DBH of Trees in Three Stations.

Conclusion

Overall, the result of this study is particularly high and thus it has a big factor in mitigating climate change as the identified trees in the area were capable of storing a high amount of carbon dioxide.

Thus, forest management should be prioritized in the area especially that it has not been overly utilized by humans and more importantly it houses ecologically important tree species.

Future researchers should conducts studies that would gear up to recommendations on include creating policies and programs to help conserve the area. Furthermore, other carbon pools such as soil, roots, trunks, branches and foliage should also be considered.

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