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Research Article

Carbon Stock Assessment of Nueva Vizcaya State University (NVSU)-Agricultural Innovation Center (AIC), Singian Hills, Tuao South, Bagabag, Nueva Vizcaya

Camille Jade M. Polo*, Patricio A. Cosep II, Diana M. Lupaas, Norbert Abrias, Kathrina Mae M. Gandia, Shierel F. Vallesteros

College of Forestry, Environment and Resources Management, Nueva Vizcaya State University 3700, Philippines

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**Corresponding author:*
E-mail:
Polocamillejade@gmail.com

ABSTRACT

This study assessed the carbon stock at the Nueva Vizcaya State University Agricultural Innovation Center in Singian Hills, Tuao South, Bagabag, Nueva Vizcaya. The study covered a 100% inventory of trees with a diameter at breast height of at least 10 centimeters and above. Brown's formula was used to compute the carbon stock of the species. Trees with a diameter at breast height of less than 70 cm and greater than 70 cm were computed separately. A total of 383 trees with 39 tree species were found in the area. It was found that a total of 910,460.10 kilograms was being sequestered equivalent to 564, 485.26 kilogram of carbon stock. The most abundant and recorded as the largest in terms of diameter breast height in the area is the Rain tree (*Samanea saman*) followed by Gmelina (*Gmelina arborea*) and Mangga (*Mangifera indica*). The rain tree that has the largest diameter breast height has a record of 119 cm with an aboveground biomass of 16,107.45 kg and a carbon stock of 9,986.62 kg. The study concludes that increasing tree volume leads to greater carbon dioxide sequestration, emphasizing the importance of tree planting and forest conservation for climate change mitigation and addressing global warming.

Keywords: *Carbon Stock, Carbon Estimation, Carbon Sequestration, Above ground biomass*

Introduction

Climate change ranks among the most serious global challenges of our time, posing a profound threat to ecosystems and human societies alike. Its causes are multifaceted and stem from a wide range of anthropogenic activities and their cumulative impacts on the Earth's climate system. Rising levels of greenhouse gases like carbon dioxide and methane, driven by multiple factors including increased emissions

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and shifting weather patterns, are causing rising temperatures and impacting the environment in various ways, such as ocean acidification and more frequent extreme weather events (Lee et al., 2018).

Many environmental managers and climate scientists highlight the crucial role forests play in mitigating climate change. Forests act as the world's largest carbon sinks (Joshi et al., 2021), significantly influencing regional and global carbon fluxes through their soil and vegetation. Protecting forests enhances carbon storage in both aboveground and belowground biomass (Brown et al. 1996). Trees greatly contribute to carbon storage, the ecosystem, sustainability, and biodiversity. Trees are an important part of the ecosystem in carbon storage and sequestration through capturing carbon and using it in physiological processes like photosynthesis (Arasa-Gisbert et al., 2018).

Research indicates that forests in tropical Asia, including the Philippines, play a substantial role in mitigating climate change. Estimates suggest that Philippine forests alone could sequester approximately 109 million tons of carbon dioxide (Camacho et al., 2009), highlighting their importance in carbon sequestration (Racelis, 2008).

Unfortunately, the unsustainable exploitation of these forests through logging and urbanization over the past century has had devastating consequences. Deforestation is estimated to have released 3.7 gigatons of carbon into the atmosphere between the 1500s and the present (Lasco & Pulhin, 2003). With the ever-increasing human population and its constant attempts at destruction, forest ecosystems face a serious threat. Many provinces are required to establish climate action plans, which include forest carbon as a key component, and planners require up-to-date information on forest carbon stocks and rates of change at appropriate spatial scales. Planting trees can help with carbon storage and the forest ecosystem (Hoover and Smith, 2021).

Carbon stock assessment is essential for transparent carbon trading and marketing, requiring verifiable procedures and effective monitoring. This assessment is also crucial for developing sustainable land-use plans that minimize carbon emissions, as changes in land use directly impact carbon sequestration or release (Assefa et al., 2013).

Forests and trees are highly effective carbon sinks, making forest protection and conservation a valuable model for climate change mitigation. Therefore, quantifying the carbon sequestration potential of tree species at the Nueva Vizcaya State University Agricultural Innovation Center is crucial for effective tree protection, conservation, and raising awareness about the importance of dense tree cover for carbon sequestration. As a result, this study deals with the carbon stocks of Nueva Vizcaya State University (NVSU)- Agriculture Innovation Center (AIC), Singian Hills, Tuao South, Bagabag, Nueva Vizcaya using the Aboveground biomass allometric equations on trees having 10 cm and above DBH.

Objectives of the Study

The general objective of the study is to estimate tree carbon stock in the area of Nueva Vizcaya State University (NVSU)- Agriculture Innovation Center (AIC), Singian Hills, Tuao South, Bagabag, Nueva Vizcaya

Specifically, the study aimed to:

1. Map tree locations at the NVSU-Agriculture Innovation Center.
2. Estimate the aboveground biomass of trees in the built-up areas using an allometric equation.
3. Calculate the total carbon stock of trees in the built-up areas.
4. Identify the tree species with the highest carbon stock; and
5. Estimate the total carbon stock in the built-up areas of the NVSU-Agriculture Innovation Center.

Methodology

Study Area

The study area is located at Nueva Vizcaya State University (NVSU)- Agriculture Innovation Center (AIC), Singian Hills, Tuao South, Bagabag, Nueva Vizcaya

The municipality of Bagabag is located in the northeastern part of Nueva Vizcaya with a total land area of 260 square kilometers (26,000 ha). The Magat River, which runs parallel to the Pan-Philippine Highway (AH 26), is situated in the eastern part of the town proper.

Bagabag is politically subdivided into 17 barangays.

Nueva Vizcaya is located in Northern Luzon, 268 kilometers north of Manila and 118 kilometers south of Tuguegarao City. It is situated in the far south of Region 02 and is known as the gateway to the vast Cagayan Valley Region. It is bounded on the north by Ifugao, in the northeast by Isabela, east by Quirino, west by Benguet, and south by Nueva Ecija. Nueva Vizcaya now covers roughly 3,903.90 square kilometers, accounting for about 10.72 percent of the regional land area and 1.30 percent of the country's overall land area (Regional Development Council Cagayan Valley Region, n.d.).

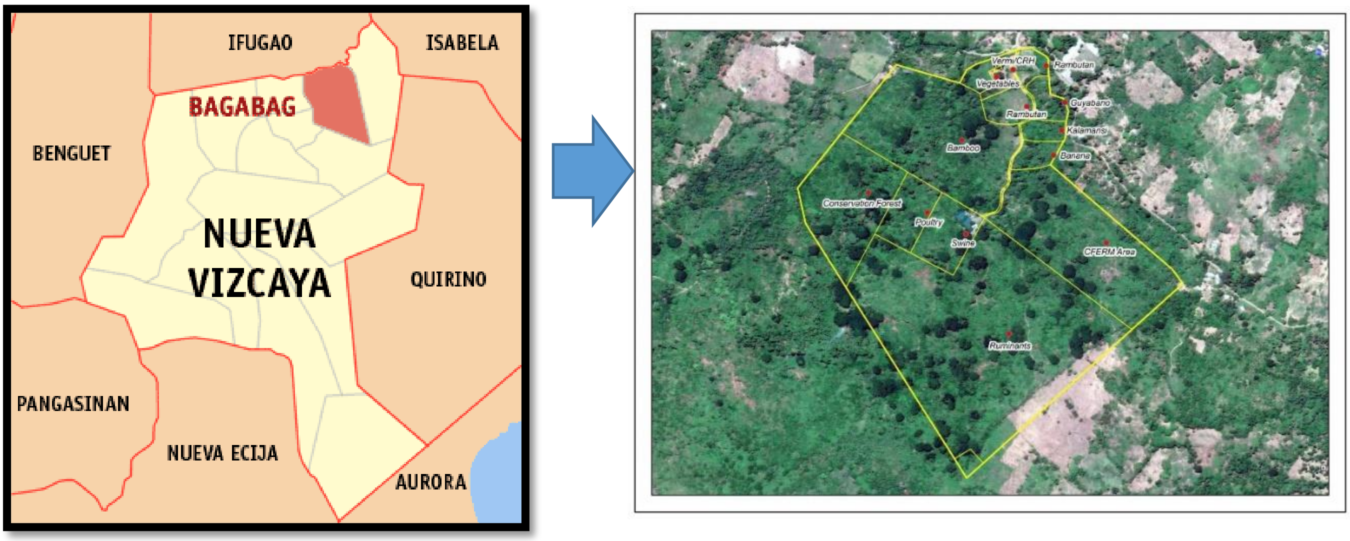

Figure 1. Location Map of the Study.

Field Measurements and Observations

The study focuses on estimating the carbon sequestered by tree species having a diameter at breast height (DBH) of 10 cm or greater at the Nueva Vizcaya State University (NVSU)- Agriculture Innovation Center (AIC), Singian Hills, Tuao South, Bagabag, Nueva Vizcaya. The data collection was done from September to December 2023. Trees were numbered, tree data, common names, and X and Y coordinates were taken. Tree measurement was taken using the diameter tape at DBH (diameter at breast height) which is 1.3 meters. For fork trees, the measurement of each fork was taken individually and computed for its average. While for stumped trees, the dbh was measured either above or below the stump.

Data Analysis

After data collection, data was encoded in Microsoft Excel. The AGB was computed using Brown's formula (Brown,1997).

The formula for < 70 cm DBH; Y (kg) = exp (2.134 + 2.530 * ln (D))

The formula for ≥ 70 cm DBH; Y (kg) = 42.69-12.800* D + 1.242* D2

Where:
Y = biomass per tree in kg
D = diameter at breast height (dbh) in centimeters
ln = natural logarithmic

The total biomass was computed by multiplying it by the R (root shoot ratio) which is 1.24. AGB (1 + 0.24). The IPCC formula (IPCC, 2006) was used to calculate the quantity of carbon stock.

Carbon stock = biomass x 0.50

This method was used for the analysis of quantitative data. Here, considering only the DBH of the identified tree species, the above-ground biomass and total carbon sequestered were computed. The tree location data from the locus map was also encoded through Excel and processed through an arc map.

Results and Discussion

The study quantified the carbon stock found within the Bamboo, CFERM Area, Vermi/CRH, Vegetables, Rambutan, Guyabano, Kalamansi and Banana areas at Nueva Vizcaya State University Agricultural Innovation Center at Barangay Tuao South, Bagabag, Nueva Vizcaya.

A tree inventory was conducted within the different areas of the Agricultural Innovation Center of the University. The diameter at the breast height of tree species at 10 cm was calculated using Brown's formula on carbon sequestration.

Table 1. Tree Carbon Stock of Nueva Vizcaya State University Agricultural Innovation Center, Tuao South, Bagabag, Nueva Vizcaya

No of Trees	AGB** (Kg)	CS (Kg)	AGB* (Kg)	CS (Kg)	Total AGB (Kg)	Total CS (Kg)
383	450,180.04	279,111.62	460,280.06	285,373.64	910,460.10	564,485.26

10-69 DBH-AGB** **70-Greater- AGB***

Table 1 displays the quantity of above-ground biomass and carbon stock in the area. It shows that trees with 70-diameter breast height quantify the higher above-ground biomass and carbon stock with a little difference on the trees with 10-60 diameter breast height. A total of 910,460.10 kilograms was sequestered equivalent to 564, 485.26 kilograms of carbon stock.

Based on the findings of the study, there was evidence of carbon sequestration in the area, with the greater volume of trees planted, the greater the amount of carbon dioxide sequestered. These findings demonstrated that large-diameter trees equate to a significant increase in additional carbon storage when compared to a small-diameter tree. Overall, each centimeter of stem diameter leads to a gradually higher increase in tree carbon storage. As a result, built-up areas should consider the value of trees in mitigating the effects of global warming and climate change.

Table 2. Tree Carbon Stock between 10 and 69 cm DBH and their Aboveground Biomass and Carbon Stock

Common Name	Scientific Name	No. of Trees	DBH (cm)	AGB (kg)	CS (kg)
African Tulip	*Spathodea campanulate*	2	28.7	200.03	124.02
Alim	*Melanolepis multiglandulosa*	1	11.6	58.38	36.20
Antsoan Dilao	*Cassia spectabilis*	1	15.2	115.69	71.73
Balete	*Ficus benjamina*	2	115.3	6,988.34	4,332.77
Banato	*Mallotus philippensis*	4	56.9	411.08	254.87
Bignay	*Antidesma bunius*	1	4	1,702.75	1,055.70
Bignay Kalabaw		1	66	4,749.65	2,944.78
Binunga	*Macaranga tanarius*	2	31.2	250.94	155.58
Bitnog		2	26.9	170.16	105.50
Caimito	*Chrysophyllum caimito*	3	73.8	2,326.14	1,442.21
Danglin	*Canavalia cathartica*	6	82.9	698.88	433.30

Common Name	Scientific Name	No. of Trees	DBH (cm)	AGB (kg)	CS (kg)
Dao	*Dracontomelon dao*	1	62.7	4,171.60	2,586.39
Dita	*Alstonia scholaris*	2	26.1	158.92	98.53
Gmelina	*Gmelina arborea*	86	3,431.5	143,679.44	89,081.25
Governors Plum	*Flacourtia indica*	5	74.8	694.08	430.33
Guijo	*Shorea guiso*	1	11	51.04	31.65
Himbabao	*Broussonetia luzonica*	7	109.3	1,004.99	623.09
Ipil-ipil	*Leucaena leucocephala*	4	74.1	823.85	510.79
Kalomata	*Clausena grandifolia Merr.*	3	49.2	514.32	318.88
Kalukoy	*Ficus callosa Willd.*	6	112.6	1,258.25	780.12
Kamiring	*Semecarpus philippinensis*	1	11	51.04	31.65
Katmon	*Dillenia philippinensis*	1	10.9	49.88	30.92
Lanete	*Wrightia arborea*	2	23.5	124.18	76.99
Mahogany	*Swietenia macrophylla*	12	512.7	21,591.74	13,386.88
Malasantan		2	39.4	457.67	283.75
Malapapaya	*Polyscias nodosa*	1	14	93.95	58.25
Manga	*Mangifera indica*	31	1,488.1	72,307.06	44,830.38
Mayapis	*Shorea squamata*	1	40	1,337.91	829.51
Narra	*Pterocarpus indicus*	1	11	51.04	31.65
Pagsahingin	*Canarium asperum subsp.asperum*	1	5	3,063.92	1,899.63
Philippine Teak	*Tectona philippinensis*	10	318.8	9,358.96	5,802.55
Rain Tree	*Samanea saman*	96	3,046.8	123,537.48	76,593.24
Sablot	*Litsea glutinosa*	1	21.6	281.44	174.49
Sampaloc	*Tamarindus indica*	2	53	960.45	595.48
Santol	*Sandoricum koetjape*	3	111.6	3,412.24	2,115.59
Taluto	*Pterocymbium tinctorium*	1	10.8	48.73	30.21
Tangisan Baya-wak	*Ficus variegate Blume*	1	10	40.11	24.87
Tibig	*Ficus nota*	8	111.8	767.58	457.90
White Lauan	*Shorea contorta*	14	760.3	42,616.16	26,422.02
TOTAL		**329**	**11,104.1**	**450,180.1**	**279,111.7**

The table above shows the accounted trees with diameter at breast height (DBH) of 10 cm to 69 cm and there are three hundred twenty-nine (329) tree individuals recorded belonging to thirty-nine (39) Floral species. From the table, the Rain tree (*Samanea saman*) has the most abundant number of trees with ninety- six (96) tree individuals, followed by the Gmelina *(Gmelina arborea)* species with eighty-six (86) tree individuals. Next to Gmelina is Mangga *(Mangifera indica)* accounting for thirty-one (31) tree individuals. Fourteen (14) tree individuals were observed from White lauan *(Shorea contora)* belonging to family Dipterocarpus. There are (12) tree individuals recorded in mahogany *(Swietenia macrophylla*). Other trees accounted for ten (10) and lesser tree individuals. In terms of the average diameter at breast height (DBH), Gmelina obtained the greatest diameter at breast height with an average diameter of 3,431.5 cm which is also observed to have the greatest AGB with 143,679.44 kg, and great Carbon stock with 89,081.25 kg eventually. Rain tree *(Samanea saman)* has 123, 537.48 kg AGB with an equivalent of 76,593.24 kg Carbon stock. Manga *(Mangifera indica)* was accounted to have 72,307.06 kg AGB and 44,830.38 kg of Carbon stock. White lauan (*Shorea contorta*) obtained 42,616.16 kg of AGB with an equivalent of 26,422.02 kg of Carbon stock. Mahogany with an AGB of 21,591.74 kg and with an equivalent of 13,386.88 kg Carbon stock. The study shows that the higher the diameter at breast height (DBH), the higher the estimation of the Above Ground Biomass (AGB) and Carbon Stock (CS) eventually, this is supported by the study of (Calders et al, 2015). Large-diameter trees frequently provide the most aboveground biomass (Kirby and Potvin, 2007; Baishya et al., 2009; Djuikouo et al., 2010). Additionally, the diameter and carbon stock are consistent with the idea that the carbon stock increases with larger trees' presence (Vanninen et al., 1996; Baraloto et al., 2011). In the study of Polo et al., (2020) their study demonstrated that large tree diameter trees equate to a significant increase in additional carbon storage when compared to a small. Overall, each centimeter of stem diameter leads to a gradually higher increase in tree carbon storage (Polo et al.,2020).

Table 3. Tree Carbon Stock between 70 or greater cm DBH and their Aboveground Biomass and-Carbon Stock

Common Name	Scientific Name	No. of Trees	DBH (cm)	AGB (kg)	CS (kg)
Caimito	*Chrysophyllum caimito*	1	81	7,154.65	4,435.88
Gmelina	*Gmelina arborea*	8	605.6	50,028.37	31,017.59
Manga	*Mangifera indica*	9	759.3	70,516.86	304,706.76
Rain Tree	*Samanea saman*	32	2,921.1	304,706.76	188,918.19
White Lauan	*Shorea contorta*	4	316.3	27,873.42	17,281.52
TOTAL		**54**	**4,683.3**	**460,280.1**	**285,373.6**

The table shows the recorded species having a DBH of 70 cm and greater. There are five (5) tree species with a total of fifty-four (54) tree individuals. Rain Tree (*Samanea saman)* has the most abundant number of trees with thirty-two (32) individuals. Manga (*Mangifera indica)* has nine (9) tree individuals and eight (8) tree individuals from Gmelina (*Gmelina arborea).* While four (4) tree individuals from White lauan (*Shorea contorta)* and only one tree were observed in Caimito (*Chrysophyllum caimito).* In terms of Above Ground Biomass (ABG), species from Rain trees have the greatest kg with 304,706.76 with an equivalent of 188,918.19 kg of Carbon stock. Mangga *(Mangifera indica)* with 304,706.76kg of AGB has an equivalent of 304,706.76 kg Carbon stock. It was also observed that Gmelina *(Gmelina arborea)* has 50,028.37 kg of AGB with a carbon stock of 31,017.59kg. White lauan *(Shorea contorta)* was observed to have 27,873.42kg of

AGB with an equivalent of 17,281.52 kg of Carbon stock. The least amount of AGB and Carbon stock was observed from Caimito *(Chrysophyllum caimito)* with 7,154.65 kg and 4,435.88 kg respectively, as expected because it was the only tree species with a single tree individual. This study reveals that a higher accumulated diameter results in higher biomass and eventually carbon stock. The same result was shown in the study of Origenes and Lapitan (2021) in Carbon stock assessment through aboveground biomass of trees at different forest composition in Mt. Malindawag, Lubilan, Naawan, Misamis Oriental.

Table 4. Largest Trees at Nueva Vizcaya State Agricultural Innovation Center

Common Name	**DBH (cm)**	**AGB (Kg)**	**CS (kg)**
Rain Tree	115	14,996.14	9,297.61
Rain Tree	118.9	16,079.18	9,969.09
Rain Tree	106.2	12,691.15	7,868.51
Rain Tree	110.3	13,741.13	8,519.50
Rain Tree	103	11,900.67	7,378.41
Rain Tree	101	11,419.53	7,080.11
Rain Tree	118	15,825.90	9,812.06
Rain Tree	119	16,107.45	9,986.62
Rain Tree	113	14,455.39	8,962.34
TOTAL	**1,004.4**	**127,216.5**	**78,874.25**

Table 4 shows that the Rain tree *(Samanea saman)* dominates the largest trees located in the area. The rain tree that has the largest diameter breast height has a record of 119 cm with an aboveground biomass of 16,107.45 kg and a carbon stock of 9,986.62 kg. It shows that the larger the tree the larger the above-ground biomass and carbon stock sequestered.

Based on the result of the study, rain trees can accumulate higher carbon biomass compared to other species. According to research by Bambalan et al., (2022) in their study of Tree diversity and carbon stock in North Poblacion and South Poblacion (Dipaculao, Aurora, Philippines), Rain trees had the highest carbon storage potential of 407.4 tons using and 342.2 tons using. This was possible due to the large diameter of individual trees of *Samanea saman*.

Table 5. Number of Trees per species

Common Name	**Scientific Name**	**Number**
African Tulip	*Spathodea campanulate*	2
Alim	*Melanolepis multiglandulosa*	1
Antsoan Dilao	*Cassia spectabilis*	1
Balete	*Ficus benjamina*	2
Banato	*Mallotus philippensis*	4
Bignay	*Antidesma bunius*	1
Bignay Kalabaw		1
Binunga	*Macaranga tanarius*	2
Bitnog		2
Caimito	*Chrysophyllum cainito*	4
Danglin	*Canavalia cathartica*	6
Dao	*Dracontomelon dao*	1
Dita	*Alstonia scholaris*	2

Common Name	Scientific Name	Number
Gmelina	*Gmelina arborea*	94
Governors Plum	*Flacourtia indica*	5
Guijo	*Shorea guiso*	1
Himbabao	*Broussonetia luzonica*	7
Ipil-ipil	*Leucaena leucocephala*	4
Kalomata	*Clausena grandifolia Merr.*	3
Kalukoy	*Ficus callosa Willd.*	6
Kamiring	*Semecarpus philippinensis*	1
Katmon	*Dillenia philippinensis*	1
Lanete	*Wrightia arborea*	2
Mahogany	*Swietenia macrophylla*	12
Malasantan		2
Malapapaya	*Polyscias nodosa*	1
Manga	*Mangifera indica*	40
Mayapis	*Shorea squamata*	1
Narra	*Pterocarpus indicus*	1
Pagsahingin	*Canarium asperum subspasperum*	1
Philippine Teak	*Tectona philippinensis*	10
Rain Tree	*Samanea saman*	128
Sablot	*Litsea glutinosa*	1
Sampaloc	*Tamarindus indica*	2
Santol	*Sandoricum koetjape*	3
Taluto	*Pterocymbium tinctorium*	1
Tangisan Bayawak	*Ficus variegate Blume*	1
Tibig	*Ficus nota*	8
White Lauan	*Shorea contorta*	18
TOTAL		383

Table 5 shows the number of trees per species with their common name and scientific name. In this study, it was found that most species were exotic. There are a total of 39 tree species found in the area. Rain tree is the most dominant species with a total of 128 trees, followed by gmelina with 94 trees and manga trees with 40 species.

Exotic species found includes Gmelina, Rain Trees. Fruit trees such as santol, manga, and Sampaloc are also present. Some of the species are already naturalized in the country such as mahogany which is an exotic and invasive plant species in the Philippines.

Tree Location

Figures 2 and 3 show where each tree was located. The method used to locate the trees is through the use of locus map and geo cam and processed through ArcMap. There are 383 trees in all. The study area has a total area of 38.4 hectares.

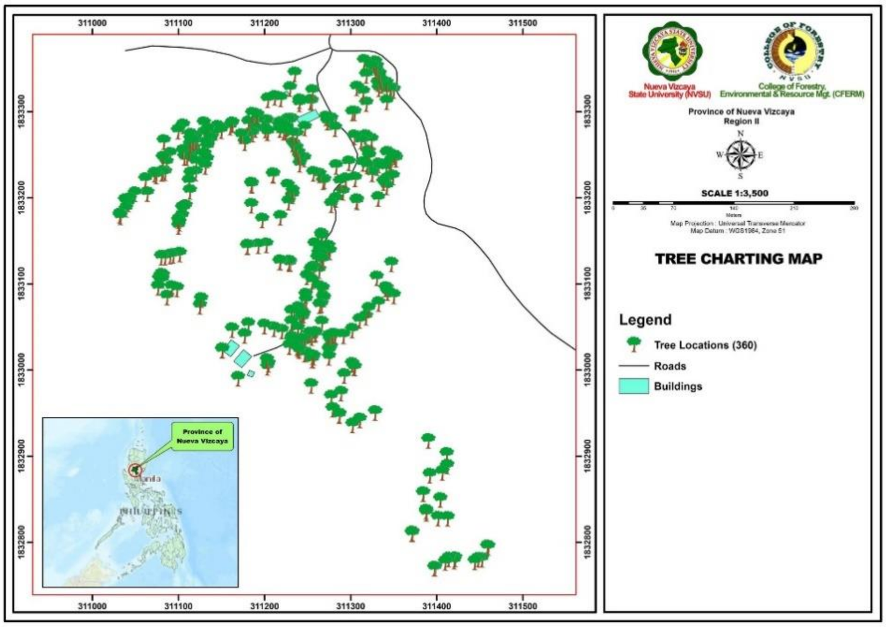

Figure 02. Location Map

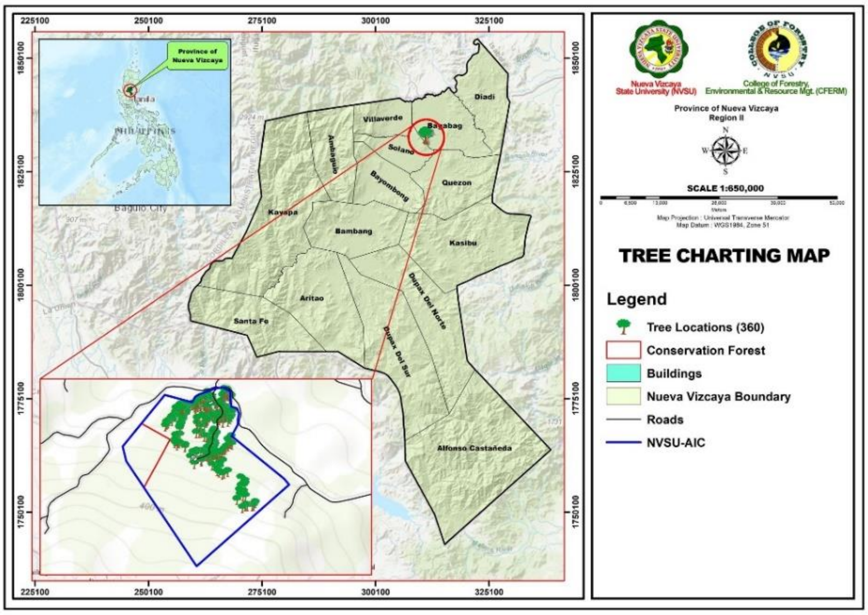

Figure 3. Tree Distribution

Conclusion and Recommendations

Trees are effective at capturing and storing carbon, and thus contribute to climate change mitigation and mitigating the consequences of global warming. The greater the volume of trees planted, the greater the amount of carbon dioxide sequestered. Carbon information is critical for understanding how trees in the forest act as carbon sinks.

In this study, the important role of trees in carbon sequestration was studied. This is important for tree protection and conservation, as well as for raising awareness of the value of dense tree cover for carbon sequestration. This is also a call for the administration to continue supporting and enhancing the area to improve the ecosystemecosystem capacity and to provide more ecological services. NVSU-

Agriculture Innovation Center must always have an updated inventory of trees planted and, if possible, every tree has a record of the dates of tree planting. Furthermore, after five (5) years, conduct a follow-up study to determine any developments or differences in the tree carbon stock

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