

## Carbon stock assessment of bamboo forest at Marangi, San Fernando, Camarines Sur

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### **Abstract**

Climate change mitigation increasingly relies on nature-based solutions, with bamboo recognized as a strategic resource due to its rapid growth, high biomass productivity, and regenerative capacity. This study assessed the carbon stock potential of the bamboo forest in Marangi, San Fernando, Camarines Sur, Philippines. The research aimed to identify bamboo species, evaluate ecological conditions through vegetation analysis and biometric measurements, and estimate carbon sequestration capacity. Standardized field guides, biometric characterization, and species-specific allometric equations were employed to quantify above-ground biomass pools, including culms, branches, leaves, roots, and forest floor litter. Results demonstrate bamboo's substantial capacity to store carbon, underscoring its ecological importance in climate mitigation and its socioeconomic relevance for rural livelihoods. Anchored on Carbon Sequestration Theory, the Sustainable Forest Management (SFM) Framework, and Ecological Succession Theory, the study highlights bamboo's dual role as a pioneer species in ecological restoration and as a sustainable livelihood resource. Findings provide localized, scientifically validated data that can inform national carbon accounting systems, policy development, and land-use planning. Furthermore, the study emphasizes bamboo's alignment with global sustainability goals, particularly SDG 13 (Climate Action) and SDG 15 (Life on Land). By integrating bamboo into climate strategies, restoration programs, and community-based management, the Philippines can enhance resilience to climate risks while promoting sustainable development. Ultimately, this research reinforces bamboo's potential as both a renewable carbon sink and a driver of ecological and socioeconomic resilience in climate-vulnerable regions.

**Keywords:** bamboo forest, carbon stock assessment, carbon sequestration, sustainable forest management, climate change mitigation

## Carbon stock assessment of bamboo forest at Marangi, San Fernando, Camarines Sur

### 1. Introduction

Global climate change is arguably the most dangerous crisis today, driven by man's activities that intensify the burning of GHGs (IPCC, 2021). Among these gases, carbon dioxide (CO<sub>2</sub>) is the most widespread and strongest contributor to atmospheric warming. Natural habitats, particularly forests, act as essential carbon sinks that absorb and store CO<sub>2</sub>, stabilizing the global climate system (FAO, 2020). Bamboo is increasingly recognized for climate-change mitigation because of its rapid growth, high biomass production, and strong regenerative capacity. Studies show that managed bamboo forests store carbon at rates comparable to fast-growing timber species and provide sustainable biomass through continuous harvest cycles due to rhizome-based regrowth. Bamboo's ability to store carbon both in biomass and in long-lasting phytolith-occluded (PhytOC) carbon further increases its sequestration potential (Song et al., 2017; Parr et al., 2023). Below-ground carbon accumulation is driven by dense rhizome systems that enhance soil organic carbon and improve soil structure, especially in degraded areas (Tong et al., 2016; Wang et al., 2020).

In the Philippines, bamboo is recognized as a potential contributor to national climate strategies, yet it remains underrepresented in carbon accounting systems and policy frameworks (DENR-FMB, 2022; Manalo et al., 2023). Bamboo initiatives across the Philippines and other tropical countries support forest restoration, improve livelihoods, and promote climate-smart agriculture, contributing to biodiversity conservation and community resilience (DENR-FMB, 2022; FAO, 2020). This aligns with global goals, particularly SDG 13 (Climate Action) and SDG 15 (Life on Land). Promoting bamboo strengthens watersheds, rehabilitates degraded lands, and reduces soil erosion, important for rural and disaster-prone areas (van der Lugt et al., 2018; United Nations, 2015). Given this context, assessing bamboo's carbon sequestration capacity is essential. This study aims to generate locally relevant, scientifically validated data that can inform environmental policy, land-use planning, and long-term climate mitigation and adaptation strategies. It further seeks to highlight bamboo's potential within carbon accounting systems and emphasize its role in both ecological restoration and community resilience.

**Objectives of the Study** - Generally, this study aims to determine the full measure of the carbon sequestered in the bamboo forest of Marangi, San Fernando Camarines Sur. Specifically, the objectives of the study are, 1.) Identify the different species of bamboo in the forest at Marangi, San Fernando Camarines Sur. 2.) To assess the ecological condition of the bamboo forest by conducting vegetation analysis and measuring biometric characteristics. 3.) Analyze the carbon sequestration potential of bamboo forest at Marangi, San Fernando Camarines Sur.

**Scope and Limitation of the Study** - The primary focus of this research is to estimate carbon stocks within bamboo forest to determine how much carbon exists in the bamboo crop. The study was conducted at Marangi, San Fernando Camarines Sur, a farming community in Camarines Sur, Philippines. The research scope involves determining the several species of bamboo found in the study area, estimating the ecological condition of the bamboo forest using vegetation analysis and biometric characterization, and determining the amount of carbon sequestered in the bamboo stand. Only the bamboo vegetation was treated by the study, and established methods like vegetation surveys, biometric measurement and standard allometric equations was used in the estimation of biomass and carbon content. Carbon was estimated only from above-ground biomass pools.

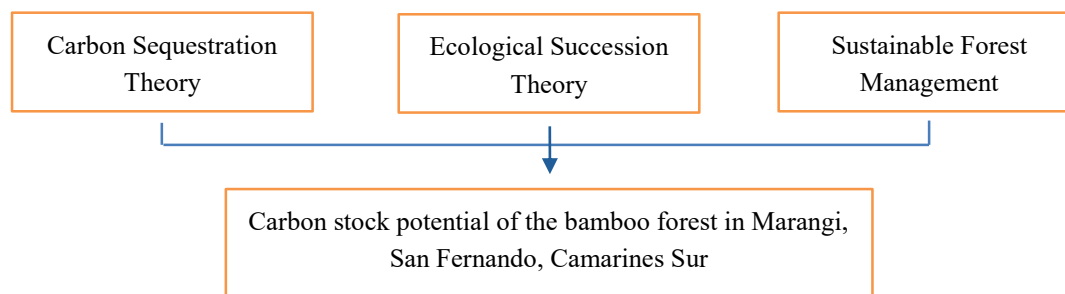
**Theoretical Framework** - This study is anchored on three main foundations, such as Carbon Sequestration Theory, the Sustainable Forest Management (SFM) Framework, and Ecological Succession Theory. Together, these theories explain both the scientific process of how bamboo stores carbon, the responsible way of managing bamboo forests, and bamboo's role in ecosystem recovery.

*Carbon Sequestration Theory* - Carbon sequestration theory talks about how plants absorb carbon dioxide

(CO<sub>2</sub>) from the air and keep it in their biomass and soil. Bamboo is very effective in this process because it grows fast, produces a lot of biomasses, and can regenerate quickly after harvesting. This means bamboo can continuously absorb and store carbon in both above ground and below ground parts (Pan et al., 2023). Studies also show that bamboo plantations can store large amounts of carbon even outside their native areas, which proves its potential as a renewable carbon sink (Chiti et al., 2024). To measure carbon stock, researchers often use allometric equations. These equations connect simple measurements like culm diameter and height to the total biomass of bamboo. This method is practical because it avoids destructive sampling and still gives reliable estimates of carbon storage (Devi et al., 2023).

*Sustainable Forest Management (SFM) Framework* - The SFM framework focuses on using forest resources wisely while keeping ecological balance and biodiversity intact. It reminds us that bamboo ecosystems should be managed in ways that consider not only the environment but also the needs of people and the economy (Boissière et al., 2019). Regional guidelines also highlight sustainable harvesting practices to protect bamboo regeneration and ensure that ecological health is not compromised (Guerrero & Varghese, 2020). Aside from carbon storage, bamboo forests provide other ecological benefits. They help stabilize soil, regulate water, and support biodiversity. Reviews of bamboo biodiversity show that bamboo has strong genetic resources and resilience, which makes it important for maintaining healthy ecosystems (Achugbu et al., 2025).

*Ecological Succession Theory* - Ecological Succession Theory explains how plant communities change and develop over time, leading to more stable ecosystems. Bamboo plays a unique role in succession because of its fast growth and ability to colonize degraded areas. As a pioneer species, bamboo can quickly establish itself, improve soil quality, and create favorable conditions for other plants and organisms. This accelerates the recovery of disturbed landscapes and enhances biodiversity. In the context of carbon sequestration, succession theory highlights how bamboo contributes to climate mitigation during the early stages of forest recovery. While mature forests store large amounts of carbon, pioneer species like bamboo play a critical role in initial carbon capture, especially in areas that have been cleared or degraded. Bamboo's rapid biomass accumulation allows it to absorb significant amounts of CO<sub>2</sub> even before other trees establish themselves, making it a valuable tool for nature-based climate solutions (Qin et al., 2021; Pan et al., 2023).



**Figure 1:** Theoretical Framework

## 2. Methodology

This section presents the overall framework and procedures used in conducting the study. It outlines the research design, methods of data collection, area of the study, species identification, vegetation analysis, carbon estimation, and statistical treatment employed to determine the carbon sequestration capacity of bamboo. Through systematic measurement and analysis, this section explains how the data were gathered and processed to ensure accurate and reliable results.

*Research Design* - This study uses a quantitative approach to measure the amount of carbon stored in bamboo above the ground. Quantitative research focuses on numbers and data, making it possible to calculate bamboo biomass and carbon stock using standard formulas. The data collected was analyzed to find patterns and relationships that show how bamboo helps store carbon in the environment (Pongon et al 2016).

**Research Method** - The research methods that were used were observation and vegetation analysis. A random sampling method was used for the vegetational analysis of the bamboo for forest test in the area. The research utilized random sampling to collect data on bamboo biomass, carbon content and environmental factors influencing carbon sequestration. Bamboo species were identified, and biometric characterization was conducted to determine ecological conditions (FAO, 2020).

**Area of the Study** - The study was conducted at Marangi, San Fernando, Camarines Sur, a farming community in Camarines Sur, Philippines. The area has a tropical climate that supports bamboo growth. It is located at 13° 30'21.60" N and 123° 4'41.17" E. The study site was selected because bamboo grows well in this region, making it a good place to study its carbon storage. Marangi was specifically selected as the research location since it boasts considerable bamboo stands and is located in an agricultural region

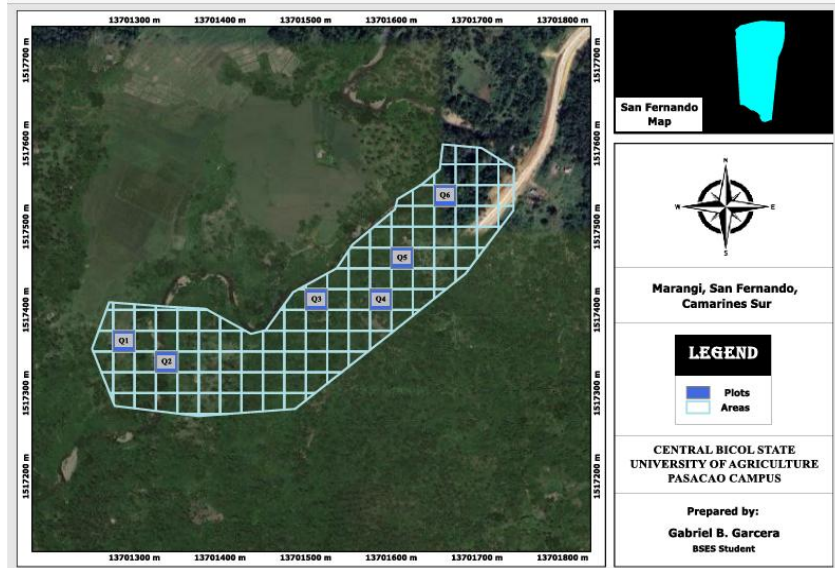


Figure 2: Sampling plot Map

where bamboo offers environmental as well as economic advantages. The climate and soil in Marangi are also extremely favorable for bamboo cultivation, and it presents itself as a suitable place for conducting such research. Moreover, Marangi is a representative rural community in San Fernando where bamboo is an integral component of the daily lives of the people and is a significant component of environmental protection. Its favorable climate for growth, abundance of species, and use by the community make it a strategic and appropriate location for determining the capacity of bamboo forests to store carbon. Generally, Marangi is a good place to investigate how bamboo helps to sequester carbon and reduce greenhouse gas emissions in rural regions.

**Species Identification** - To ensure correct identification, the researchers used the field guide, *The Handbook on Erect Bamboo Species* authored by Cristina A. Roxas (2012) of the Department of Environment & Natural Resources (DENR) and also the Ecosystems Research & Development Bureau (ERDB) was used.

**Data Gathering Procedure** - The data collection commences with the selection of sampling sites within the bamboo forest in Marangi, San Fernando, Camarines Sur. Random sampling was employed to ensure representation of different bamboo species and ecological conditions across the study area. Prior to data collection, the researcher secures the necessary permissions and coordinates with local stakeholders. The procedure begins with species identification and mapping. Using the GeoCam application and Google earth engine, the researcher document and geotag bamboo clumps across the study area. Photographs and GPS coordinates of each bamboo sample was recorded. Identification of species was verified using the “Handbook on Erect Bamboo Species” by Cristina A. Roxas (2012). Next, biometric measurements were collected. For each sampled bamboo culm, measurements of height and diameter at breast height (DBH) were taken using a measuring tape. These measurements are essential for estimating aboveground biomass using species allometric equations. Following this, a vegetation and ecological survey was conducted. Finally, all data collected in the field was recorded manually and later encoded into spreadsheets to ensure consistency and accuracy before analysis.

**Vegetation Analysis** - The research utilizes random sampling to collect data on bamboo biomass, carbon content, and environmental factors influencing carbon sequestration. Bamboo species were identified, and

biometric characterization was conducted to determine ecological conditions (FAO, 2020). The ecological condition of the bamboo forest was evaluated through the assessment of bamboo density, culm height, diameter, and other conditions. Vegetation investigation was conducted to observe how plants interact in the bamboo forest. The carbon stock of the field also be determined through an estimation of how much carbon was stored in the bamboo.

*Carbon Sequestration by the Bamboo Forest* - The researcher estimated the total carbon sequestration of the natural bamboo forest using developed allometric formulas for biomass conversion. The converted biomass was used to calculate the total above-ground biomass and natural bamboo forest carbon content in computing the estimated sequestered carbon. The parameter needed for the computations is the diameter at breast height, which is a biometric measurement of the bamboo species specifically for biomass computations.

*Total Carbon Content from Above Ground Biomass* - For total carbon content calculation, the data were categorized as carbon sequestration per species and total carbon sequestration by the entire area. The estimated carbon content is from above-ground biomass calculation, wherein the summation of above-ground biomass per species multiplied by the total number of culms over the area sampled by all individuals was multiplied by the conversion factor that reflects the proportion of carbon in the bamboo. The conversion factor is 0.5 based on the IPCC Guidelines for National Greenhouse Gas Inventories (2019).

*Statistical Treatment* - This study employed simple statistical methods, including vegetation analysis to examine the relationship between bamboo biomass and carbon sequestration. The researchers utilize simple statistical treatment particularly percentage cover, height, diameter, and total carbon content were analyzed to quantify carbon storage capacity. The results demonstrate a strong positive correlation between bamboo growth and carbon sequestration. The vegetational analysis was be examined using the following parameters: Density, it measures the thickness of the vegetation in the area by determining the number of plants in a unit area. Relative density, it determines the percentage of a particular species that occurs. It shows the dispersion of species within the sampling area. Frequency, it determines the percentage of a particular species that occurs. It shows the dispersion of species within the sampling area. Relative frequency, is defined as the probability of finding the species in any one plot and can only be compared between plots of equal size. Dominance, Basal area or volume of a species divided by the total area. Relative dominance, this is computed by the formula shown below, the dominance of a species divided by the total dominance of all species multiply by 100.

### 3. Results and discussion

The study's findings are presented in this chapter and were explained in accordance with to the goals, particularly biometric characterization, vegetation analysis, economic value and the computation of carbon reserves.

#### 3.1 Identified Bamboo Species in the Area

The identified bamboo species are shown in Table 1 as to their scientific name, common name, local name, area of sampling, and the number of populations for each species. There are three (3) different species identified in the bamboo vegetation analysis conducted in the study area, namely *Bambusa vulgaris* (Kawayang kiling or Butong), *Schizostachyum diffusum* (Bikal), and *Bambusa blumeana* (Kawayang tinik). The total number of identified bamboo individuals across all quadrats is six hundred forty-six (646). Among these, *Bambusa vulgaris* (Kawayang kiling) has the highest population count with four hundred fifty-eight (458) individuals, followed by *Bambusa blumeana* (Kawayang tinik) with one hundred thirteen (113) individuals, and seventy-five (75) individuals of the *Schizostachyum diffusum* (Bikal).

**Table 1***Identified Bamboo Species at Bamboo Forest in Marangi, San Fernando Camarines Sur.*

Family name	SPECIES			QUADRATS					
	Scientific name	Common name	Local name	1	2	3	4	5	6
Pocaceae	<i>Bambusa vulgaris</i>	Kawayang kiling	Butong	135	88	190	45		
Pocaceae	<i>Schizostachyum diffusum</i>	Bikal boboi	Bikal					75	
Pocaceae	<i>Bambusa blumeana</i>	Kawayang tinik	Kagingking						113

Note. Empty cells indicate no individuals recorded in that quadrat.

### ***Bambusa vulgaris* (Kawayang Kiling)**

*Bambusa vulgaris* (Figure 3) plays a crucial role in environmental sustainability due to its rapid growth and ability to adapt to different types of soil and climatic conditions. According to Velasco et al. (2019), this species is widely used in reforestation programs because of its strong root system that helps prevent soil erosion and improve soil structure. Similarly, research by Kumar et al. (2017) highlights that *Bambusa vulgaris* contributes significantly to biomass production and carbon sequestration, making it an important species for mitigating climate change and promoting sustainable land use. Its ecological versatility and economic potential further support its use in various environmental and industrial applications.

Growth characteristics include the striking regenerative ability of *Bambusa vulgaris* plays a crucial role in environmental sustainability due to its rapid growth characteristics include the striking regenerative ability of *Bambusa vulgaris*, it readily regenerates by vegetative means (rhizome offsets, nodal cuttings, and culm cuttings), which in many production systems reduces the need for replanting. (Suwal, 2020; Kaladhar, 2017). The culms typically reach harvestable maturity within about 3-5 years under managed plantation conditions and can then be repeatedly harvested to provide continued raw material supply. (Isukuru, 2023; DA Regional Field Office, 2021). Because of its rapid growth and favorable fibre and biomass properties, *B. vulgaris* continues to be used for construction and crafts, and is increasingly considered a feedstock for pulp/paper and bioenergy applications. (Adier et al., 2023; Gopanna, 2024).



**Figure 3:** *Bambusa vulgaris* (Kawayang Kiling)

Besides, the ecological condition of *Bambusa vulgaris* in the study area expresses a balance between environmental health and resource utilization. A healthy stand of bamboo would thus mean that the soils are fertile and water is readily available (Terefe et al., 2021). However, areas with poor growth may suggest anthropogenic disturbances, such as overharvesting or poor soil management. Hence, sustainable harvesting practices and continuous monitoring should be implemented to maintain the productivity and ecological functions of *Bambusa vulgaris* (Tesfamariam et al., 2019).

### ***Schizostachyum diffusum* (Bikal)**

*Schizostachyum diffusum* (Figure 4), commonly known as Bikal in the Philippines, is a tropical clumping bamboo in the grass family (Poaceae) that forms part of the diverse *Schizostachyum* genus found in humid forests and riparian zones of Southeast Asia and the Philippines. Members of this genus are typically characterized by



**Figure 4:** *Schizostachyum diffusum* (Bikal)

slender, woody culms and short, thick rhizomes, traits that support their adaptation to moist tropical habitats and utility in local ecosystems (*Schizostachyum* genus overview; et al., recent bamboo profiling).

In broader Philippine bamboo research, climbing and clumping species similar to *S. diffusum* have been studied for their mechanical properties and potential uses in handicrafts, construction, and ecological services such as soil stabilization, showing the socio-economic importance of native bamboo species in rural communities (Bondad et al., 2023; Opeña et al., 2023). Although species-specific scientific studies on *S. diffusum* are limited, bamboo research within the Philippines highlights the genus's role in biodiversity, sustainable livelihoods, and conservation strategies, suggesting that *S. diffusum* shares these broad ecological and cultural values (Opeña et al., 2023).

#### ***Bambusa blumeana* (Kawayan Tinik)**

*Bambusa blumeana*, (Figure 5) commonly known as Kawayan Tinik or Spiny Bamboo, is one of the most well-known bamboo species in the Philippines and across Southeast Asia. It belongs to the grass family Poaceae and is easily recognized by its tall, upright culms that can grow up to 25 meters high. Its green stems, prominent nodes, and spiny branches make it stand out in bamboo forests, giving it a thorny appearance hence the name “Kawayan Tinik.” The leaves are long and pointed, with a slightly rough surface that helps the plant adapt to hot and humid tropical environments (Garcia & Ramos, 2018; Santos et al., 2020).

Aside from its unique structure, its thick root system helps hold the soil together, preventing erosion along riverbanks and slopes. It also supports watershed protection and contributes to carbon storage, which helps mitigate climate change (Velasco et al., 2019). Because it grows quickly and thrives in different conditions, it is often used in reforestation and land rehabilitation projects to restore degraded areas (Del Rosario & Custodio, 2017; DENR-FMB, 2021).



**Figure 5:** *Bambusa Blumeana* (Kawayan Tinik)

Beyond its ecological benefits, it is also a valuable resource for local communities. Its strong and durable culms are widely used for house construction, furniture, fencing, and handicrafts, while its young shoots are cooked and eaten as a vegetable (Reyes & Manuel, 2016). Because of its environmental and economic value, sustainable harvesting and proper management are essential to ensure that Kawayan tinik continues to support both people and nature for future generations (Lopez & Hernandez, 2022)

### 3.2 Vegetation Analysis

Vegetation analysis involves studying the species composition and structural arrangement of plant communities. It helps reveal how environmental differences influence the conservation and sustainable management of plant resources. Through this method, researchers can measure ecological parameters such as species density, relative density, frequency, relative frequency, dominance, relative dominance, and overall abundance within a community (Majeed et al., 2022). The vegetation analysis for the bamboo forest in Marangi, San Fernando, Camarines Sur is presented in Table 2, based on the assessment conducted on October 10 & 24, 2025. The table provides data on species count, density, relative density, frequency, relative frequency, dominance, and relative dominance.

### 3.3 Biometrics Components

Biometrics directly influence biomass calculations, which are then converted into carbon stock values. Biometric measurements involve the direct collection of physical plant data such as diameter at breast height, total height, and species.

**Table 2**

*Vegetation analysis of Bamboo Forest in Marangi, San Fernando Camarines Sur.*

Plant Species	Local Name	N	Den	RDen(%)	Freq	RFreq(%)	Dom	RDom(%)
<i>Bambusa vulgaris</i>	Butong	458	4.58	70.90	0.67	66.67	1.78	80.64
<i>Schizostachyum diffusum</i>	Bikal	75	0.75	11.61	0.17	16.67	0.06	2.79
<i>Bambusa blumeana</i>	Kagingking	113	1.13	17.49	0.17	16.67	0.37	16.60
Total:		646	6.46	100	1.00	100	2.20	100

Note. N = number of individual species; Den = density; RDen = relative density; Freq = frequency; RFreq = relative frequency; Dom = dominance; RDom = relative dominance.

### 3.4 Density and Relative Density

The results of the vegetation analysis revealed that *Bambusa vulgaris* (locally known as Butong) has the highest population among the bamboo species recorded in the study area, with a total of four hundred fifty-eight (458) individuals. It has a density of 4.58 and a relative density of 70.90%. In comparison, *Bambusa blumeana* (locally called Kagingking) has one hundred thirteen (113) individuals, with a density of 1.13 and a relative density of 17.49%, while *Schizostachyum diffusum* (locally called Bikal) has seventy-five (75) individuals, a density of 0.75, and a relative density of 11.61%. The abundance of *Bambusa vulgaris* in the bamboo forest may be attributed to its fast growth, straight culms, and versatility in use. This species is commonly cultivated or naturally spread in the area due to its value in construction, handicrafts, and ornamental applications. Its abundance suggests a preference for this species in local utilization and possibly in ecological adaptability within the forest conditions of Marangi.

### 3.5 Frequency and Relative Frequency

The frequency of the bamboo species was determined by their presence across the sampling quadrats. The results show that *Bambusa vulgaris* (Butong) has the highest frequency value of 0.67, with a relative frequency of 66.67%. This indicates that *Bambusa vulgaris* was present in most of the sampling quadrats. In contrast, *Bambusa blumeana* (Kagingking) and *Schizostachyum diffusum* (Bikal) were each recorded with a frequency of 0.17 and a relative frequency of 16.67%, suggesting that these species were found in fewer quadrats. The frequent occurrence

of *Bambusa vulgaris* can be explained by its ability to grow well in many kinds of soil and weather, especially in tropical areas (Kiyangi, 2024). This species grows in clumps and can quickly produce new shoots, which makes it easy to spread naturally and also useful for managed plantations (Ananfack et al., 2022). Because it is strong and grows fast, people often use it for building, making crafts, and even for decoration. These uses may be the reason why *Bambusa vulgaris* is the most common bamboo found in the forest of Marangi. Although *Bambusa blumeana* was recorded less often, it remains important because of its economic uses and ability to survive in dry conditions. Its strong culms make it useful for fencing and controlling soil erosion, and its drought tolerance adds to its value (Saducos, 2022).

### 3.6 Dominance and Relative Dominance

In the bamboo forest of Marangi, San Fernando, Camarines Sur, *Bambusa vulgaris* exhibits the highest dominance value of 1.78 and a relative dominance (RDom) of 80.64%, as shown in Table 2. Dominance refers to the basal area or space occupied by a species, which reflects its physical size and ecological influence within the forest stand. The high dominance value of *Bambusa vulgaris* indicates that it covers the largest portion of the forest area and likely plays a major role in shaping the canopy and contributing to overall biomass. This aligns with research showing that bamboo species with greater diameter and height tend to build up more aboveground biomass, which helps enhance carbon storage, regulate light availability, and support habitat development in forest ecosystems (Lacerda & Kellermann, 2019). The dominance of *Bambusa vulgaris* can be attributed to its relatively large average DBH of 27.2 cm and height of 11.81 m, which give it a competitive edge in accessing sunlight, nutrients, and growing space. Studies have shown that bamboo species with thicker culms and greater height tend to build up more aboveground biomass, which plays a major role in carbon sequestration and the development of forest canopy in tropical ecosystems (Lacerda & Kellermann, 2019). Compared to *Bambusa vulgaris*, the *Schizostachyum diffusum* and *Bambusa blumeana* exhibit much lower dominance values of 0.37 and 0.06, with relative dominance percentages of 16.60% and 2.79%, respectively. Research on bamboo ecosystems supports this observation, showing that species with smaller culm diameters and lower dominance levels tend to store less carbon and play supporting roles in shaping forest dynamics when compared to more dominant species like *Bambusa vulgaris* (Islam, Alamgir, Akhter, & Rahman, 2015).

### 3.7 Diameter at Breast Height (DBH)

The DBH of the bamboo species in the forest ranges from 2.26 cm to 14.96. As shown in Table 3, *Bambusa vulgaris* recorded the highest DBH average of 8.66 while the *Schizostachyum diffusum* had the lowest average DBH of 3.69. The larger DBH of *Bambusa vulgaris* may be attributed to its fast growth rate and adaptability to the forest conditions in Marangi. This species is known for its vigorous growth and responsiveness to propagation treatments, especially in tropical environments (Tambong, 2024). Studies have shown that bamboo forest, particularly *Bambusa vulgaris*, can store significant amounts of carbon in both aboveground biomass, emphasize their role in ecological restoration and carbon offset strategies (Islam, Alamgir, Akhter, & Rahman, 2015). On the other hand, *Bambusa blumeana* had an average DBH of 7.01, which also reflects its maturity and utilization potential. The presence of the *Schizostachyum diffusum* with smaller DBH values suggests either younger growth stages or less competitive traits in the forest ecosystem.

**Table 3**

*Biometric Components of Bamboo Forest at Marangi, San Fernando, Camarines Sur.*

Plant Species	Biometrics Components					
	DBH (cm)			Total Height (m)		
	Range		Average	Range		Average
	Min	Max		Min	Max	
<i>Bambusa vulgaris</i>	2.36	14.96	8.66	5.2	18.41	11.81
<i>Schizostachyum diffusum</i>	2.26	5.12	3.69	3.4	15.8	9.6
<i>Bambusa blumeana</i>	4.14	9.87	7.01	4.14	18.3	11.22

Note. DBH = diameter at breast height; values are presented in centimeters. Total Height values are presented in meters.

### 3.8 Total Height

The total height of the bamboo species in the forest ranges from 3.4 m to 18.41 m. As shown in Table 3, *Bambusa vulgaris* recorded the highest average height of 11.81 m, followed closely by *Bambusa blumeana* with an average of 11.22 m, while the *Schizostachyum diffusum* had the lowest average height of 9.6 m. The variation in height among species may be influenced by their age, ecological adaptability, and planting history in the forest. According to local observations, *Bambusa vulgaris* is one of the most vigorous and fast-growing species in tropical regions, capable of reaching heights of up to 20 meters, with internodes ranging from 25–35 cm. Its ability to thrive in open areas such as riverbanks, roadsides, and wastelands contributes to its vertical growth and dominance in the Marangi forest (Mensah et al., 2021). Meanwhile, *Bambusa blumeana*, though slightly shorter in average height, is known for its durability and resilience, growing well in both wet and dry conditions. It is commonly found in hillsides, plains, and riverbanks, and can also reach 15–25 meters under optimal conditions (Useful Tropical Plants, 2020). The presence of the *Schizostachyum diffusum* with lower height values may suggest either younger culms or species with less competitive growth traits, possibly due to shade tolerance or limited access to nutrients.

### 3.9 Carbon Content of Above-Ground Biomass

The Table 4 shows the total of Above-ground Biomass and total carbon content of each identified bamboo at Bamboo Forest in Marangi, San Fernando, Camarines Sur. The result shows that above-ground biomass of bamboo across the six sampling plots is 2067.28 kg, which corresponds to a total carbon content of 220.28 ton/ha. Among the plots, Plot 3 recorded the highest biomass with 621.99 kg and carbon content of 68.11 ton/ha. In this plot the species identified was *Bambusa vulgaris*. This is mainly due to the large number of culms 190 present in the quadrat, showing how density strongly influences carbon storage. Following this, Plot 1 also exhibited a high biomass of 446.48 kg and carbon content of 54.10 ton/ha, supported by its 135 culms. The species identified in this plot was also *Bambusa vulgaris*. In contrast, Plot 5 had the lowest carbon content (6.14 ton/ha) despite having 75 culms. And the species identified inside this plot was *Schizostachyum diffusum*. This relatively low value may be attributed to smaller culm sizes or reduced growth performance, which limited its biomass accumulation. While other plots, which is 2, 4, and 6 showed moderate values, with carbon content ranging from 19.99 to 36.52 ton/ha. In plot 2 and 4 the identified species was *Bambusa vulgaris*, while in plot 6 the species identified was *Bambusa blumeana*. These variations highlight the role of biometric characteristics such as culm diameter and height in determining biomass and carbon stock. Generally, as the number of culms per quadrat increases, the biomass and carbon content also rise.

**Table 4**  
*Total of above-ground biomass, and carbon content.*

Number of Sampling Plots (10x10m)	Numbers of culms	Above-Ground Biomass (kg)	Carbon Content (kg)	Total Carbon content (ton/ha)
Plot 1	135	446.48	223.24	54.10
Plot 2	88	291.80	145.9	35.42
Plot 3	190	621.99	310.99	68.11
Plot 4	45	150.24	75.12	19.99
Plot 5	75	195.03	97.52	6.14
Plot 6	113	361.74	180.87	36.52
Total:	646	2067.28	1033.64	220.28

*Note. Biomass and carbon content values are expressed in kilograms, while total carbon content is expressed in tons per hectare.*

Overall, the findings confirm that culm density and biometric traits are significant factors in bamboo carbon sequestration, with Diameter at Breast Height (DBH) serving as a key indicator of biomass allocation. This agrees with earlier studies showing that bamboo's carbon storage is influenced by age, species, site conditions, and management practices, and that bamboo plantations can absorb an average of 17 tonnes of carbon annually while also contributing to ecological restoration and sustainable development (Fransen, 2019; Devi, 2021).

#### 4. Summary of findings, conclusion and recommendation

This section presents a summary of the findings and conclusions. This primarily encapsulates the results and provides valuable recommendations. This study focused on measuring the amount of carbon stored in the bamboo forest in Marangi, San Fernando, Camarines Sur. It also examined the species of bamboo and the condition of the forest. The results help show how bamboo forests can support environmental protection and climate change mitigation.

In the study area, bamboo species identified were: *Bambusa vulgaris* (Butong), *Bambusa blumeana* (Kagingking) and *Schizostachyum diffusum* (Bikal) which had 646 individuals in the sampling plots. Dominance expressed itself through *Bambusa vulgaris* at 458 individuals, then followed by *Bambusa blumeana* with 113 individuals, and lastly an *Schizostachyum diffusum* with 75 individuals. The table depicted a total density of 6.46 units/ha with dominance of bamboo species represented by *Bambusa vulgaris* having a density of 4.58, relative density of (70.90%), frequency of (0.67), relative frequency (66.67%), dominance (1.78), relative dominance (80.64%). The data on biometrics revealed that DBH ranged from a minimum value of 2.26-14.96 cm to a maximum average height of *Bambusa vulgaris* at 8.66 and overall height up to a maximum average height of *Bambusa vulgaris* at 18.41 m.

The forest received the highest rank on species adaptability, certain tropical climate conditions of the region, and soil fertility on its productivity for the ecological condition through vegetation analysis and biometrics. *Bambusa vulgaris* performed best in all parameters, mainly due to its vigorous clumping growth, which monopolizes the canopy and also outcompetes other species for sunlight and nutrients. The average height attained was 11.81 m for *Bambusa vulgaris*, 11.22 m for *Bambusa blumeana* (it showed its resilience in different moisture levels), 9.6 m for the *Schizostachyum diffusum* while the DBH averages were 8.66 cm, 7.01 cm and 3.69 cm respectively suggested mature culms that could support high dense crown cover and good stand health, pointing to an adequate number of seedlings that must exist within a healthy stand perimeter system.

In the assessment of carbon storage potential for above-ground biomass, over all the plots a value of 2067.28 kg was recorded performing a comprehensive cutting of all trees. These results were used to determine above-ground biomass using allometric equations, yielding an overall assessment of 220.28 tons/ha from destructive sampling. Similarly, below-ground estimate contributed to additional uptakes through the root crop exchange ratio of 0.27, and IPCC estimates. Regarding productivity Plot 3 (*Bambusa vulgaris*, 190 culms) reached the highest stock accumulation rate per hectare yielding 68.11 ton/ha due to its high number and large sizes of bamboos followed by Plot 2 at 65.84 ton/ha and Plot 1 at 60.35 ton/ha indicating that culm number circular section and height determine storage increment as main species like *Bambusa vulgaris* efficiently construct biomass into sequestration structures for climate change mitigation system.

**Conclusion** - The results of the study revealed that the bamboo forest in Marangi, San Fernando, Camarines Sur is primarily dominated by *Bambusa vulgaris*, which recorded the highest number of individuals, density, frequency, and dominance values among all species present. Out of 646 bamboo individuals identified in the six sampling plots, 458 belonged to *Bambusa vulgaris*, making it the most ecologically influential species in the area. Its wide distribution and strong presence across plots reflect its adaptability, fast growth, and importance both ecologically and economically. The findings confirm that the bamboo forest in Marangi has a strong carbon sequestration potential, particularly because of the dominance and growth performance of *Bambusa vulgaris*. Its high biomass production, fast regeneration, and efficient carbon storage make it a valuable natural asset for environmental management. The variations observed among plots and species also emphasize the need for sustainable management practices to ensure the continuous productivity and ecological health of the bamboo forest. Through proper monitoring and conservation, the bamboo resources in Marangi can continue to support climate action efforts, biodiversity conservation, and community-based development.

**Recommendations** - Based on the findings and conclusion, the following are hereby recommended:

- Future researchers should use soil and litter sampling to more precisely estimate the total ecosystem carbon (not just in bamboo culms and roots).
- Future researchers are encouraged to refine and validate allometric equations for each species of bamboo to improve the accuracy of biomass and carbon stock calculations.
- Future researchers should expand the number and size of sampling plots and, if possible, employ mapping or GIS tools to better represent the entire bamboo forest area.
- Future researchers may conduct long-term monitoring after harvesting, disturbances, or management interventions to track bamboo regeneration and changes in carbon storage over time.

**Implications for Teaching and Education** - This research on bamboo forests in Marangi, San Fernando, Camarines Sur shows how bamboo can play a big role in fighting climate change by storing carbon. For teaching and education, it provides a clear example of how local ecosystems contribute to global climate solutions. Teachers can use it to explain the carbon cycle, sustainable forestry, and the importance of biodiversity in simple, relatable terms. It also highlights practical skills for students, such as species identification, field measurements, and data analysis, which can be applied in environmental science classes. Beyond science, the study connects to community development and policy, making it useful for lessons in sustainability, agriculture, and social studies. In short, it turns bamboo into a powerful teaching tool that links classroom learning with real-world environmental and social challenges.

**Implications for Learners** - Learners can see from this research how bamboo plays a vital role in fighting climate change. It shows that bamboo grows quickly, stores large amounts of carbon, and helps restore degraded lands. This teaches students that local ecosystem, like bamboo forests, can make a global impact on reducing greenhouse gases. The study also gives learners practical skills in environmental science. By using vegetation analysis, biometric measurements, and allometric equations, students learn how to measure carbon storage in a scientific and systematic way. These methods can be applied in other ecological studies, making their training more hands-on and relevant. Finally, the research highlights the connection between science, community, and policy. Learners can understand how findings like these support climate action plans, sustainable development, and local livelihood programs. This encourages them to see science not just as theory, but as a tool for resilience and positive change in society.

**AI use disclosure:** We used ChatGPT, December 2025, for fact-checking sources and validating results, also Quillbot, December 2025, for language editing, and Grammarly, December 2025, for grammar checking/ correction. All outputs were reviewed, verified, and edited by the authors. The authors take full responsibility for the content.

**Author Contributions:** Gabriel B. Garcera served as the lead author and was primarily responsible for the overall conceptualization of the study, manuscript preparation, coordination of the research process, and finalization of the paper. Francine A. Traquiña contributed to the field data collection, species identification, and vegetation analysis. Desiree E. Belardo assisted in the biometric measurements, data encoding, and organization of field records. Melissa O. Milan contributed to the computation of above-ground biomass, carbon content, and preparation of tables. Rochelle C. Nieva assisted in the review of related literature, theoretical framework, and interpretation of ecological findings. Jane L. De la Rosa contributed to the methodology, results discussion, and proofreading of the manuscript. Jasper Ian U. Felezmiño served as the research adviser and provided academic supervision, technical guidance, methodological direction, and critical review throughout the development of the study. All authors agree to be accountable for the accuracy and integrity of the work. The authors further declare that there are no conflicts of interest related to this study. Any use of artificial intelligence and language-editing tools was limited to fact-checking, language refinement, grammar checking, and readability improvement. All AI-assisted outputs were reviewed, verified, and edited by the authors, who take full responsibility for the final content of the manuscript.

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