

Blue carbon assessment of mangrove forest at Camangi, Pasacao, Camarines Sur

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Abstract

The study of blue carbon assessment of mangrove forest at Camangi, Pasacao, Camarines Sur. Specifically, it aimed to: (a) Identify the different species of Mangrove in Sitio, Camangi, Sta. Rosa Del Sur Pasacao, Camarines Sur. (b) Determine the ecological status of the Mangrove forest through vegetation analysis and biometric characterization. (c) To calculate the Carbon stock of Mangrove in Camangi, Pasacao, Camarines Sur. Using a descriptive method and random nested plot sampling, the researcher collected mangroves species from the seven quadrants. A total of 79 mangroves individuals across three species: *Avicennia Marina* (*Apiapi*), *Aegiceras floridum* (*Saging-saging*), and *Sonneratia Alba* (*Pagatpat*). Physico-chemical analysis revealed that most parameters, such as color (clear) and odor (smell of gas) while salinity (0.01%), dissolved oxygen (5.44), total dissolved solids (28.56), Ph (7.57), and temperature (29.43). Vegetation analysis revealed that *Sonneratia Alba* (*Pagatpat*) most dominates the ecosystem with a relative density of 67.04%, followed by *Avicennia Marina* at 31.93%, and *Aegiceras Floridum* at just 1.02%. The carbon stock assessment used diameter at breast height (DBH) and total height measurements to determine results which showed that *Avicennia Marina* had a DBH range of 6.4 – 10.41cm and heights from 20.64 – 24.46m, *Aegiceras Floridum* had a BBH range of 10.19 cm and height of 3.25 m and while the *Sonneratia alba* exhibited a DBH range from 68.46 - 156.81 cm and height 22.61m. The total carbon storage capacity of mangroves through blue carbon accumulation can store up to 4303.86 kg of carbon. This study concludes that the blue carbon sequestration of mangrove forest can be affected by the age of the mangrove, species, and management practices of mangroves. Future studies are recommended to include policy and management integration.

Keywords: blue carbon assessment, mangrove forest, Pasacao, Camarines Sur

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1. Introduction

Blue carbon refers to carbon dioxide absorbed from the atmosphere and stored in the ocean. The term “blue” highlights the aquatic nature of this storage. Most blue carbon exists as carbon dioxide dissolved directly in seawater. Smaller amounts are stored in underwater sediments, coastal vegetation, soils, organic compounds like proteins and DNA, and marine organisms such as phytoplankton and whales (Zac Cannizzo et al., 2022). Mangroves are a type of plant that thrives in the intertidal zones of tropical and subtropical coastlines, particularly in low-latitude regions (Kusmana & Suknstijiono, 2016; Serosero et al., 2020). Despite the intertidal zone being prone to sudden physical and geological changes, mangrove ecosystems maintain strong ecological stability due to their high adaptability (Alongi, 2015). These ecosystems are vital coastal habitats that offer numerous ecosystem services and play essential ecological roles (Kauffman et al., 2017).

These ecosystem services include serving as natural defenses against storms, tsunamis, and coastal erosion (Asari et al., 2021, Nur & Hilmi, 2021), providing crucial habitats for fish to breed, feed, and develop (Vincentius et al., 2018), and offering ecotourism opportunities that can improve the livelihoods of coastal communities (Eddy et al., 2016; Sarhan, 2018). These plant-based ecosystems are increasingly recognized for their role in combating climate change due to their ability to absorb carbon dioxide from the atmosphere, making them significant net carbon sinks (IUCN Issues Brief, 2017). Once carbon is deposited in a blue carbon habitat, it can follow three potential pathways it may be broken down by microbes and incorporated into new biomass, respired back into CO₂ by microbial activity, or remain in a particulate or dissolved organic carbon (Corg) form that is unavailable to microbes, thereby contributing to long-term carbon storage (Trevathan-Tackett et al., 2015).

An important ecological service provided by mangroves is their capacity to sequester and store “blue carbon,” the carbon accumulated and stored in coastal and marine ecosystems (Hilmi et al., 2023; Howard et al., 2023). These habitats collectively act as vital carbon sinks, mitigating atmospheric CO₂ levels and contributing to global climate regulation (Chowdhury et al., 2018). Blue carbon systems are particularly efficient in carbon sequestration, as they combine high rates of primary production with the ability to store organic carbon in their anoxic, saline sediments. This efficiency positions them as a critical natural solution to combat climate change, aligning with global targets such as Sustainable Development Goal 13 (SDG-13), which emphasizes climate action for carbon capture, and SDG-14, which focuses on conserving marine and coastal ecosystems, for marine health, SDG 1 (No Poverty), SDG 2 (Zero Hunger) for food security and SDG 11 (Sustainable Cities and Communities) for coastal protection. (Chowdhury et al., 2023a). Chowdhury et al. These vegetative ecosystems are now acknowledged for their capacity to extract carbon dioxide from the atmosphere, making them substantial net carbon sinks (IUCN - Issues Brief, 2017)

Objectives - This study primarily aims to assess the Blue Carbon potential of the mangrove forests in Sitio Camangi, Caranan, Pasacao, Camarines Sur. (a) Identify the different species of mangroves in Sitio Camangi, Pasacao, Camarines Sur. (b) Determine the ecological status of the mangrove forest through vegetation analysis of the parameters. (c) Determine the Physico-Chemical characteristics in Camangi, Caranan, Pasacao, Camarines Sur. (d) Calculate the carbon stock of mangroves in Camangi, Pasacao, Camarines Sur.

Statement of the Problem - This research study would determine the amount of blue carbon of mangroves in Sitio Camangi, Sta Rosa Del Sur, Pasacao, Camarines Sur. Specifically, it would answer the following questions:

- What species of mangroves are found in Sitio Camangi Caranan, Pasacao, Camarines Sur?
- What is the level of species diversity of the mangroves in Camangi, Pasacao, in terms of vegetation of analysis of the parameters? Population Density, Relative Density, Dominance, Relative Dominance, and

Species Diversity Index?

- What are the physico-chemical characteristics of the mangrove ecosystem in terms of Physical Characteristics, Odor, Color, Chemical Characteristics, Salinity, Dissolved Oxygen, Total Dissolved Solids, Ph meter, and Temperature?
- How much blue carbon can the mangrove ecosystem at Camangi, Pasacao can sequester?
- What recommendations in consideration of CEPA may be prepared to the LGU of Pasacao?

Scope and Limitation - This study focuses on measuring the amount of above-ground carbon (AGC) sequestered by Mangrove in Sitio Camangi, Caranan, Pasacao, Camarines Sur the study include below-ground carbon (BGC) the results of this study should not be used as a measure of the area's absolute flora and fauna population. The ecological roles that mangroves play as carbon sinks and stores are very helpful in reducing global warming and climate change. However, there is a lack of knowledge about mangrove carbon pools. Which makes it difficult to conserve and manage these ecosystems and is acknowledged as a major barrier to national climate change mitigation strategies. In order to effectively conserve and manage mangrove species, efforts must be made to fill in these knowledge gaps.

Definition of Terms - For general understanding, the following terms are defined conceptually:

Blue Carbon Assessment - Blue carbon assessment involves analyzing the sequestration, storage, and emission of carbon within coastal ecosystems like mangroves, seagrasses, and salt marshes, with key terms including autochthonous carbon, carbon burial rates, and socioeconomic frameworks like PES. These studies typically employ techniques such as sediment core sampling, allometric equations for biomass, and remote sensing to evaluate ecosystem health and carbon stock. (Bhavesh Choudhary et. al June 2024)

Blue Carbon – refers to the carbon captured and stored by coastal and marine ecosystems such as mangroves, sea grass, and salt marches, with play a significant role in mitigating climate change (Duarte et. al 2019).

Mangrove forest - is a distinctive tropical/subtropical coastal ecosystem, mangrove forests are made up of salt-tolerant trees and shrubs (mangroves) that flourish in intertidal zones. They form dense thickets with complex root systems that stabilize shorelines, provide storm protection, and serve as an essential buffer between land and sea (Alongi, D. M. 2022).

Physico-chemical – is the scientific study of properties that involve both physical and chemical processes. It looks at how the composition, structure, and properties of matter are all connected (P. et al., 2016).

Vegetation Analysis – Vegetation analysis is a method for researching the structure of plant communities and species composition. (Julian Brown et. al 2021)

2. Methodology

This section presents the research method, research design, sampling method, data gathering procedure and data analysis used to interpret the information gathered.

Research Design - This study employs a descriptive quantitative research design. Quantitative research involves measurement, based on the assumption that all phenomena can be quantified. In this approach, data is analyzed to identify patterns and relationships, ensuring each piece of information is validated through statistical analysis (Watson, 2015).

Data Gathering Procedure - The researchers coordinated with the Barangay Local Government Unit (BLGU) of Pasacao, Camarines Sur. A request letter was submitted to the Barangay's Office to ask for permission about the study being conducted in Sitio Camangi, Caranan, Mangrove Area. The letter included the purpose of the study,

the location (Camangi, Caranan, Pasacao Camarines Sur), and the dates of data gathering. Upon informing them, the researchers prepared the equipment that were used in the field study. This study focused on measuring and identifying mangroves in all sampling plots and data collection activities are done with prior notice to the BLGU to ensure proper coordination and transparency.

Sampling Design - A random sampling technique from the Handbook for Participatory Coastal Resource Assessment by Walters et.al. 1998 was used for the sampling design and data collection of the Mangrove stands. This was used to identify the different types of Mangrove and determine the physicochemical and calculate the carbon sequestration potential of the mangrove stands at Sitio Camangi, Pasacao, Camarines Sur. The total number of nested plot sampling plot nested sampling plots is 7 with the measurement of 20x20 meters.

Research Method - This study utilized a quantitative method to gather data through 7(seven) quadrants, nested plot method was used for the vegetational analysis of mangrove ecosystem in the area. To determine physical parameters and observe the area and for the chemical parameters result equipment was used to obtained the results in Camangi, Pasacao, Camarines Sur.

Area of the Study - This study was conducted at Camangi, Pasacao, Camarines Sur (Figure 1) with the geographical coordinates of 13° 31" N and 123° 2 E. The area study measured 4,000 square meter is shown in Figure 1 (Google Earth Pro 7 3 2022). The coastal community of Barangay Caranan Camangi is located in the Camarines Sur Municipality of Pasacao with the total land area of 13,876 square meter. It is situated on the western coast of the province, along the Ragay Gulf and bordered to the north by the barangay Cuco and to the south/east by Santa Rosa.

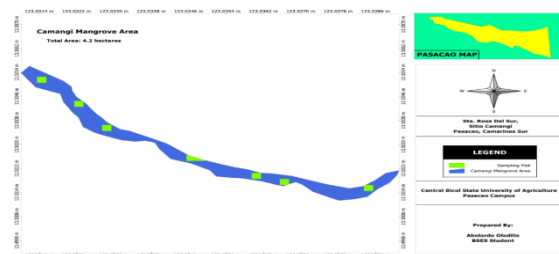


Figure 1. Map of Camangi, Pasacao, Camarines Sur

3. Results and Discussion

The result and discussion for this study include mangrove identification, physical and chemical characteristics, vegetational analysis, level of species diversity and total blue carbon sequester in Camangi, Pasacao, Camarines Sur.

3.1 Identification of Mangrove Species at Camangi, Pasacao, Camarines Sur

These mangrove species are found in Sitio Camangi, Pasacao, Camarines Sur, mangrove area with the total of 4.2 hectares *Sonneratia alba* (Pagatpat), *Avicennia marina* (Apiapi), and *Aegiceras florindum* (Sagingsaging) are mature trees.

Pagatpat *Sonneratia alba* commonly known as the White Mangrove or Mangrove Apple, is a widespread, evergreen mangrove tree belonging to the family Lythraceae. This species typically grows as a small to medium-sized tree, often reaching heights of 10-15 meters, though occasional specimens may reach up to 30 meters. Its bark is described as cream-colored to brownish, often showing slight vertical fissures. *Sonneratia alba* Sm. (Lythraceae), a mangrove species that is widely distributed across the tropical regions in Africa, Asia, and Australia. It is commonly known as “mangrove apple” and is assessed as “Least Concern” in the International Union for Conservation of Nature (IUCN) Red List due to its abundance. The tree is known for its edible fruit that plays an important role in local cuisines. Pagapat (*Sonneratia alba*) is a significant contributor to the carbon sequestration capacity of mangrove ecosystems, often exhibiting high biomass and carbon storage potential compared to other species. In specific studies, natural populations of *Sonneratia alba* have shown a total biomass of approximately 88.25 metric tons per hectare (t/ha), resulting in a carbon stock of 37.95 t/ha and a substantial carbon uptake potential of 139.27 t/ha (Bui et al., 2025).

These variations in carbon sequestration potential are often influenced by the tree's diameter at breast height (DBH) and the specific environmental conditions of the coastal site (Bui et al., 2025; Hadi et al., 2019). The leaves are simple, opposite, stalked, and leathery, with an elliptical to obovate shape, measuring around 5-12 cm long and 4-8 cm wide, with a rounded or notched apex (NParks; Jithu et al., 2015). The showy, nocturnal flowers are bisexual and are borne singly or in small clusters. It is highly tolerant of saline conditions, often in high salinity water, but requires a tidal range of at least one meter for optimal growth (PROTA4U; Jithu et al., 2015).

Sonneratia alba is classified as Least Concern (LC) on the IUCN Red List of Threatened Species due to its wide distribution and commonality throughout its range (Duke et al., 2025).



Figure 2. **Pagatpat** (*Sonneratia alba*)

Api Api (*Avicennia marina*), also known as Api-api Jambu, is a mangrove tree. The fruit is greyish green with a short beak at the tip (Rongione et al., 2025). *Avicennia marina* is a small evergreen tree that grows more than 10 m in height (Aljaghthmi et al., 2017). *A. marina*'s growth under varying light and intertidal conditions supports its potential in mixed mangrove forests, with Jiang et al. (2019). Due to the adaptive nature of the plant, it can grow within a wide range of latitude. They mostly grow from 30°N to 30°S in the Indo-Pacific region (Behbahani et al., 2016).

An *Avicennia marina* is highly resistant to environmental stresses and can flourish under inhospitable environmental conditions of extreme tides, high salinity, high temperature, strong winds and anaerobic soil (Das et al., 2016; Thatoi et al., 2016). *Avicennia marina* is a highly-salt tolerant mangrove that can tolerate twice the salinity of sea water (Moore et al., 2015). *Avicennia marina* may be the only species with such highly developed morphological, biological, ecological and physiological adaptation to variable environmental conditions (Das et al., 2016). Api-api (*Avicennia marina*) is widely recognized as a high-performing pioneer species with significant carbon sequestration and storage potential across diverse coastal environments. Mature trees have been found to store an average of 7.754 kg of carbon, which translates to a sequestration equivalent of roughly 28.431 tons of CO₂ when considering both above-ground and below-ground biomass (Nar et al., 2024).

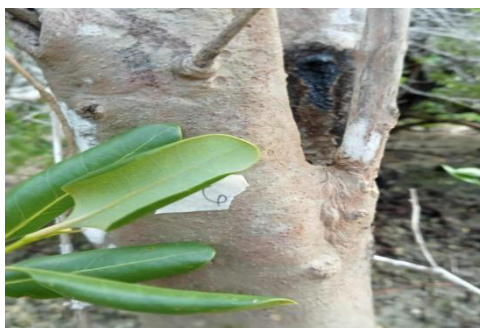


Figure 3. **Api Api** (*Avicennia Marina*)

Saging saging (*Aegiceras floridum*) - The mangrove species *Aegiceras floridum* (Saging-saging) is native to the Philippines, as it is naturally found across a wider geographical range that includes the country. The *Aegiceras floridum* occurs often as small trees on sandy or rocky shores that tolerate higher salinities. It is not considered

endemic, which would mean it is found only in the Philippines. (POWO, 2024). The conservation status of *Aegiceras floridum* is Near Threatened (NT) on the International Union for Conservation of Nature (IUCN) Red List. Saging-saging (*Aegiceras floridum*) is a mangrove species that plays a contributing role in the carbon dynamics of coastal ecosystems, though its individual carbon storage is typically lower than larger-stature mangroves (Bobon-Carnice et al., 2023; Hilmi et al., 2023). The carbon sequestration potential of these stands is highly dependent on structural properties, showing a positive correlation with tree height and diameter at breast height (DBH) (Purnamasari et al., 2020).



Figure 4. **Saging-saging** (*Aegiceras floridum*)

3.2 Vegetational analysis of Mangrove Forest

Frequency - The mangrove community is dominated by *Avicennia marina* and *Sonneratia alba*, both achieving 100% frequency across all study plots. Their widespread distribution identifies them as the forest's structural foundation, well-adapted to high salinity and tidal energy. In contrast, *Aegiceras floridum* is a rare species with only 14% frequency, likely limited by specific microhabitat needs or competition. Its “Near Threatened” IUCN status further highlights its ecological vulnerability within the community

Relative Frequency - The Mangrove forest is characterized by the two-dominant species of Pagatpat (*Sonneratia alba*) and Apiapi (*Avicennia marina*), which both exhibit a relative frequency of 46.67%. These two species act as the primary ecological pillars of the area, with Pagatpat typically serving as a seaward pioneer due to its high salt tolerance and large pneumatophores, while Apiapi adapts well to various salinity levels through specialized salt-secreting glands. Saging-Saging (*Aegiceras floridum*) remains a minor but essential part of the community at a relative frequency of 6.67%, often situated in less saline landward fringes. These three species form a complete ecological profile with a total relative frequency of 100%, highlighting a specialized habitat where two major species provide the bulk of the coastal protection and biomass.

Dominance - The dominance data shows that Pagatpat (*Sonneratia alba*) is the overwhelmingly dominant species with a value of 86.83%, indicating that it likely consists of the largest trees with the greatest basal area; despite appearing with the same frequency as other species, its structural contribution to the forest is far superior, followed by Apiapi (*Avicennia marina*) holds a secondary position at 16.06%; although it is widely distributed across all seven sampling plots, its significantly lower dominance suggests that the individual trees are likely much smaller in diameter or biomass than those of *S. alba*, while the Saging-saging (*Aegiceras floridum*) maintains a negligible presence with a dominance value of only 0.57%, which is consistent with its low frequency of occurring in only one out of seven plots, representing a minor component of the overall forest structure and canopy.

Relative Dominance - The mangrove forest at the study site is heavily dominated by *Sonneratia alba* (Pagatpat), which accounts for 80.56% of the relative dominance. This species acts as the forest's primary structural backbone and coastal defense against wave action. *Avicennia marina* (Api-api) plays a secondary role at 19.02%, contributing to shoreline stabilization, while *Aegiceras floridum* (Saging-saging) is a minor component at only 0.43%, likely due to competition and deep tidal waters. While this distribution forms a functional coastal barrier, the extreme dominance of a single species results in low species evenness, making the ecosystem more vulnerable

to pests, diseases, and climate-related threats.

Table 1

Vegetational analysis of Mangrove Forest

| Taxonomic Group | Mangrove species | Frequency | | | | | | | Relative Frequency (%) | Dominance (%) | Relative Dominance (%) | |
|-----------------|---------------------------|-----------|---|---|---|---|---|---|------------------------|---------------|------------------------|-------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | | | T |
| Acanthaceae | <i>Avicenna marina</i> | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 | 46.67 | 16.86 | 19.02 |
| Primulaceae | <i>Aegiceras floridum</i> | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 6.67 | 0.57 | 0.43 |
| Lythraceae | <i>Sonneratia alba</i> | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 | 46.67 | 86.83 | 80.56 |

3.3 Level of Species Diversity of the Mangrove in in Terms of Vegetational Analysis

Population Density - The data show different distribution patterns which follow the established population density distribution system. The ecological zone is dominated by *Sonneratia alba* because it achieves a density of 3.65 which shows its environmental preferences. The presence of *Avicennia marina* at a density of 2.48 functions as an essential resource competition element in its environment. The low density of *Aegiceras floridum* at 0.14 indicates that this species exists as a minor component which depends on specific habitat needs and encounters competition from dominant species. The research demonstrates that the mangrove community contains various species but only a few can thrive while most species remain uncommon

Relative Density - A vegetational analysis of the mangrove forest in Camangi, Pasacao, Camarines Sur, indicates a highly specialized ecosystem dominated by a few key species. Pagatpat (*Sonneratia alba*) is the primary species with a relative density of 67.04%, suggesting the forest is concentrated in seaward zones characterized by high salinity and regular tidal influence. Api-Api (*Avicennia marina*) the second most abundant species at 31.93%. Saging-Saging (*Aegiceras floridum*) accounts for only 1.02% of the population, which may point to a limited landward transition or high competition within the habitat. While these three species collectively account for the total relative density, the heavy concentration of just two species (98.97%) suggests low overall biodiversity, potentially signaling a need for conservation strategies or enrichment planting to increase the mangrove forest's ecological resilience.

Relative Dominance - The distribution of mangrove species highlights a distribution heavily centered on a single dominant tree. Pagatpat (*Sonneratia alba*) is the highest total average of relative dominance, with a relative dominance of 80.56%. This high percentage suggests it forms the structural backbone of the site, likely positioned in the seaward pioneer zone where its sturdy trunks and specialized roots provide critical defense against wave action and storm surges. Api-api (*Avicennia marina*) occupies a secondary yet important role at 19.02% relative dominance. Known for its high salt tolerance and widespread distribution, it typically co-exists with Pagatpat in high-salinity areas, contributing to the mangrove forest's ability to stabilize shorelines. Saging-saging (*Aegiceras florindum*) is a minor component at only 0.43%, indicating that environmental conditions such as deep tidal waters and competition for sunlight from larger canopy species are not ideal for its development in this specific area. The total average of relative dominance is 100% functional coastal barrier, the extreme dominance of Pagatpat reflects low species evenness. This lack of diversity can make the ecosystem more susceptible to species-specific threats, such as certain pests or diseases, which could compromise the Mangrove forest's long-term stability and its capacity for carbon sequestration.

3.4 Physical characteristics of the Mangrove Ecosystem at Camangi, Pasacao, Camarines Sur

Odor - The assessment of odor in the water samples from Sitio Camangi reveals a distinct contrast between the sampling sites. While Plots 1 through 5 were characterized by a "none" or odorless quality, Plots 6 and 7 exhibited a noticeable smell of gas. In water quality assessment, odor is a critical sensory parameter that serves as

an immediate indicator of potential chemical or biological contamination. The absence of odor in the first five plots suggests that these areas are relatively free from high concentrations of volatile organic compounds (VOCs) or anaerobic decomposition products. The “smell of gas” detected in Plots 6 and 7 is highly significant. According to World Health Organization (WHO) guidelines (2017), odors in water are often caused by foreign substances such as organic compounds, inorganic salts, or dissolved gases. A “gassy” or petroleum-like odor is frequently associated with the presence of hydrocarbons, which may enter water systems through fuel leaks, runoff from motorized boats, or improper disposal of petroleum-based products in coastal or riparian communities (Atkins, 2015).

Table 2

Level of species diversity of the Mangrove in in terms of Vegetational analysis

| Taxonomic Group | Mangrove species | Number of Species | Pop. Density | Relative Density (%) | Dominance | Relative Dominance (%) |
|-----------------|---------------------------|-------------------|--------------|----------------------|-----------|------------------------|
| Acanthaceae | <i>Avicenna marina</i> | 25 | 2.48 | 31.93 | 16.89 | 19.02 |
| Primulaceae | <i>Aegiceras floridum</i> | 1 | 0.14 | 1.02 | 0.57 | 0.43 |
| Lythraceae | <i>Sonneratia alba</i> | 53 | 3.65 | 67.04 | 86.83 | 80.56 |

Color - The assessment of water color in Sitio Camangi reveals a notable consistency at the boundaries of the sampling area, with both Plot 1 and Plot 7 recording a clear appearance. The physical appearance of water is often a direct reflection of its immediate surroundings and the localized terrestrial-aquatic interface. Differences in color between station such as those that might appear in the middle plots can be attributed to the specific geographic and human activities present at each site. The clear status of Plots 1 and 7 suggests these locations may benefit from better water exchange or a lack of immediate point-source pollution, such as domestic wastewater or industrial discharge, which are known to alter water transparency in the Bicol region (EMB-XI, 2025). According to DENR Administrative Order No. 2016-08, color is measured in True Color Units (TCU). For Class B (recreational) and Class D (agricultural/industrial) waters, the guidelines set specific limits (e.g., 50–150 TCU) to ensure the water remains suitable for its intended use. Clear water is ecologically significant because it allows for deeper light penetration, which is essential for the photosynthesis of submerged aquatic vegetation and the overall health of the food web (USGS, 2018). The clear readings at Plots 1 and 7 indicate that these specific zones currently maintain high aesthetic and ecological quality, likely supporting better visual conditions for aquatic life compared to any plots that might exhibit turbidity.

Table 3

Physical characteristics of the Mangrove Ecosystem

| Plot | Physical Characteristic | | | | | | | Average |
|-------|-------------------------|-------|-------|-------|-------|--------------|--------------|---------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Odor | None | None | None | None | None | Smell of gas | Smell of gas | Clear |
| Color | Clear | Clear | Clear | Clear | Clear | Clear | Clear | Clear |

3.5 Chemical Characteristics of the Mangrove Ecosystem

Temperature - Water temperatures in Sitio Camangi, Caranan, average 29.43°C, with peaks up to 31°C suggesting localized thermal influences, though remaining within typical Philippine coastal ranges (Archium Ateneo, 2020; Poole et al., 2021). These higher temperatures, particularly at 30°C–31°C, correlate with reduced dissolved oxygen levels and increased metabolic stress on aquatic organisms (Boyd, 2015; US EPA, 2025; PMC, 2022).

Salinity - The results showed the average in seven (7) plots is 0.01%. The low salinity of river water, averaging around 0.01%, is primarily due to the constant “flushing” of the water cycle. Rainwater is essentially distilled water; when it falls on land, it picks up small amounts of minerals and salts from rocks and soil as it flows toward

the sea. Because this water is constantly moving and being replenished by fresh precipitation, the concentration of dissolved salts remains extremely low most freshwater is defined as having a salinity of less than 0.1% (Schmitt et. al. 2015).

Dissolved Oxygen Meter (DOmeter) - The Dissolved Oxygen (DO) levels in Sitio Camangi, Pasacao, average 5.44 mg/L, generally meeting DENR standards but showing significant localized variation. While Plot 3 recorded a healthy high of 8.0 mg/L, indicating good aeration and photosynthesis, Plots 6 (3.9 mg/L) and 2 (4.1 mg/L) fell below the ideal 5.0 mg/L threshold. These lower levels suggest “oxygen demand” from the decomposition of organic matter, likely linked to agricultural or domestic waste. Since DO levels below 4.0 mg/L can cause physiological stress or migration in aquatic life, the data indicates that several plots (1, 2, 5, and 6) are vulnerable to hypoxia and may require monitoring for nutrient enrichment.

Total Dissolved Solids (TDS) - The Total Dissolved Solids (TDS) in Sitio Camangi average an exceptionally low 28.56 mg/L, indicating a high degree of water purity. The readings are remarkably stable, ranging only from 27.8 mg/L (Plot 1) to 29.6 mg/L (Plot 7), which suggests a freshwater-dominated system with minimal saltwater intrusion or mineral leaching. While these levels are far below the 500 mg/L threshold for concern, the slight increases in Plots 7 and 6 coincide with previously noted “gas smells” and higher temperatures, potentially signaling minor localized runoff. Overall, the low and consistent TDS levels support a healthy osmotic balance for the mangrove's specialized flora and fauna.

pH meter - The pH levels across the seven plots indicate a generally alkaline environment, with variation driven by localized biological and chemical activity. Plots 2 (8.28) and 1 (8.14) show the highest alkalinity, likely due to intense photosynthetic activity or carbonate-rich runoff from nearby agricultural areas. In contrast, Plot 3 (7.28) is the closest to neutral. This relatively lower pH suggests a higher rate of organic matter decomposition, which releases carbon dioxide and organic acids that naturally buffer the water's alkalinity.

Table 4
Chemical Characteristics of the Mangrove Ecosystem

| Plot | Chemical Characteristic | | | | | | | Average |
|-----------------------------|-------------------------|------|------|------|------|------|------|---------|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Temperature (°C) | 28 | 29 | 29 | 29 | 30 | 30 | 31 | 29.43 |
| Salinity (%) | 1 | 1.40 | 1 | 2 | 3 | 0 | 2 | 0.01 |
| Dissolve Oxygen (DO) | 4.7 | 4.1 | 8.0 | 7.4 | 4.7 | 3.9 | 5.3 | 5.44 |
| Total Dissolved Solid (TDS) | 28.1 | 27.8 | 28.6 | 28.6 | 28.4 | 28.8 | 29.6 | 28.56 |
| pH meter | 8.14 | 8.28 | 7.28 | 7.73 | 7.42 | 7.34 | 7.54 | 7.57 |

3.6 Blue Carbon content of Mangrove Ecosystem at Camangi, Pasacao, Camarines Sur

Pagatpat (*Sonneratia alba*) - This table presents data (table 5) on the carbon storage of the mangrove species *Sonneratia alba* across seven different study plots, measured in tonnes of carbon per hectare (tC/ha). The data is categorized into three main metrics Total Above-Ground Biomass (ABG), Total Below-Ground Carbon (BGC), and Total Carbon Content (TCC). Across all plots, there is a significant dominance of above-ground storage compared to below-ground systems for instance, the highest total carbon is found in Plot 4 (743.05 tC/ha), where the ABG (739.96) far outweighs the BGC (3.09). Conversely, Plot 6 shows the lowest overall carbon storage at 97.72 tC/ha. The wide variation in these figures ranging from roughly 98 to 743 tC/ha suggests that factors such as tree age, density, or environmental conditions significantly impact the carbon sequestration potential of *Sonneratia alba* in different locations.

Apiapi (*Avicennia marina*) - The Apiapi species shows a wide range of carbon storage capacity, with Plot 2 emerging as the most productive area, boasting a peak Total Carbon Content (TCC) of 528.32. This is followed by Plot 5, which also shows strong sequestration levels at 418.84, and Plot 6, which maintains a solid mid-range TCC of 258.04. In Plot 4 stands out as the least productive site with a TCC of only 80.52, while Plots 1, 3, and 7 fall into the lower-to-middle bracket with values ranging from 148.26 to 232.42. Across all locations, the Aboveground

Biomass (ABG) remains the primary driver of total carbon, significantly outweighing the Belowground Carbon (BGC) in every instance.

Table 5

Pagatpat (Sonneratia alba)

| Plot No. | Mangrove Species | Total ABG | Total BGC | TCC (tC/ha) |
|----------|-------------------------|-----------|-----------|--------------|
| 1 | <i>Sonneratia alaba</i> | 525.49 | 2.22 | 527.71 |
| 2 | <i>Sonneratia alaba</i> | 663.88 | 2.78 | 666.66 |
| 3 | <i>Sonneratia alaba</i> | 398.81 | 1.67 | 400.48 |
| 4 | <i>Sonneratia alaba</i> | 739.96 | 3.09 | 743.05 |
| 5 | <i>Sonneratia alaba</i> | 581.14 | 2.42 | 583.56 |
| 6 | <i>Sonneratia alaba</i> | 97.30 | 0.42 | 97.72 |
| 7 | <i>Sonneratia alaba</i> | 251.07 | 1.63 | 252.71 |

Table 6

Apiapi (Avicennia marina)

| Plot No. | Mangrove Species | Total ABG | Total BGC | TCC |
|----------|------------------|-----------|-----------|--------|
| 1 | Apiapi | 225.95 | 6.47 | 232.42 |
| 2 | Apiapi | 512.80 | 15.52 | 528.32 |
| 3 | Apiapi | 143.76 | 4.51 | 148.26 |
| 4 | Apiapi | 78.04 | 2.48 | 80.52 |
| 5 | Apiapi | 406.21 | 12.63 | 418.84 |
| 6 | Apiapi | 253.64 | 4.41 | 258.04 |
| 7 | Apiapi | 173.67 | 5.79 | 179.46 |

Saging-saging (*Aegiceras florindum*) - The provided table details biomass and carbon metrics for several plots, including Plot No, Mangrove Species, Total Above-Ground Biomass (ABG), Total Below-Ground Carbon (BGC), and Total Carbon Content (TCC). Most plots (1, 2, 3, 4, 6, and 7) currently show zero values across all measured parameters. However, Plot 5 records significant data for the Saging-Saging mangrove species. For this specific plot, the Total ABG is measured at 18.28, the Total BGC at 0.08, resulting in a Total Carbon Content (TCC) of 18.36. This suggests that among the sampled areas, Plot 5 is the primary contributor to the recorded biomass and carbon sequestration efforts.

Table 7

Aegiceras florindum (sagingsaging)

| Plot No. | Mangrove Species | Total ABG | Total BGC | TCC |
|----------|------------------|-----------|-----------|-------|
| 1 | N/A | 0 | 0 | 0 |
| 2 | N/A | 0 | 0 | 0 |
| 3 | N/A | 0 | 0 | 0 |
| 4 | N/A | 0 | 0 | 0 |
| 5 | Saging-Saging | 18.28 | 0.08 | 18.36 |
| 6 | N/A | 0 | 0 | 0 |
| 7 | N/A | 0 | 0 | 0 |

3.7 Communication Education, and Public Awareness (CEPA)

A letter was written to presents recommended strategies which effectively address three specific issues through the implementation of effective mangrove conservation methods. The Blue Carbon Assessment of Mangrove Forest at Sitio Camanggi, Caranan, Pasacao Camarines Sur needs two fundamental strategies which include Communication Education and Public Awareness to enhance mangrove management while fostering community involvement in conservation efforts. Through better communication the residents and school personnel together with all community members will gain knowledge about current mangrove species status and its conservation importance. The community should organize seminars and workshops and information campaigns to educate people about biodiversity, carbon sequestration, pollution reduction and mangrove habitat protection techniques. Schools and youth organizations can also be involved to raise awareness at an early age and encourage long-term stewardship. The program for public awareness about mangrove forests needs active community participation through educational programs and tree planting events and social media campaigns which demonstrate the benefits of mangroves for protecting coastlines and capturing carbon and sustaining biodiversity. A community becomes

more responsible through better communication and educational methods which help people understand their obligations. CEPA activities also encourage collaboration between local government units, environmental agencies, and community groups (DENR-RBCO, 2017).

4. Summary, Conclusions, and Recommendations

This section presents the summary, conclusions, and the recommendations of the Blue Carbon Assessment of Mangrove Forest in Camangi, Pasacao, Camarines Sur.

Summary - The blue carbon assessment of the mangrove forest in Sitio Camangi, Pasacao, reveals a specialized, freshwater-influenced ecosystem dominated by *Sonneratia alba* (80.5% dominance) and *Avicennia marina*. While the environment maintains high water purity and an average pH of 7.57, localized stressors are evident in Plots 6 and 7, where high temperatures (up to 31°C), low dissolved oxygen (3.9 mg/L), and a gaseous hydrogen sulfide odor indicate anaerobic decomposition and potential organic loading. Despite these localized variances, the ecosystem demonstrates immense ecological value, sequestering a total of 5,136.11 tC/ha of carbon. This significant carbon stock, primarily driven by the above-ground biomass of *Sonneratia alba*, underscores the forest's vital role in climate change mitigation and highlights the need for targeted monitoring of the stressed plots to ensure long-term stability.

Conclusions - The blue carbon assessment in Sitio Camangi, Pasacao, identifies a resilient and productive mangrove ecosystem composed of three species: *Sonneratia alba* (the dominant species), *Avicennia marina*, and *Aegiceras floridum*. Vegetation analysis and biometric data reveal a healthy ecological status with high canopy cover and active natural regeneration. Most significantly, the forest serves as a vital carbon sink, sequestering a total of 5,136.11 tC/ha, underscoring its essential role in climate change mitigation and coastal protection. These findings highlight the forest's functional importance and the need for immediate, community-based conservation strategies to maintain its carbon storage potential.

Recommendations - Based on the findings, conclusion, and methods employed in the study, the following recommendations are proposed.

- Implement Community-Based Monitoring and Local Stakeholder Engagement, Integrate local community knowledge by involving residents in the monitoring of mangrove health and carbon stocks. This ensures local ownership, improves management effectiveness, and aids in documenting historical changes in forest cover.
- The community should work together with schools and government agencies to create programs that protect the existing ecological health of the mangroves in Camangi Pasacao Camarines Sur.
- Create an accurate method for measuring carbon stock which is necessary to accurately quantify the carbon sequestration potential of mangrove forest.
- Socio-Economic Valuation Assess local community dependence on mangroves (livelihoods, fisheries) and the economic viability of integrating blue carbon projects (carbon credits).
- Policy & Management Integration Evaluate how existing local coastal management plans in Pasacao can incorporate blue carbon conservation and potential carbon financing.

Implication in Education of academe - Blue carbon assessments bridge the gap between rigorous scientific research and practical environmental management, transforming the academic landscape into a hub for climate action. For faculty and researchers, these studies provide a high-impact platform for interdisciplinary collaboration and policy-making, while the curriculum benefits from providing students with technical expertise in biometric sampling, carbon accounting, and remote sensing. By translating complex ecological data into actionable insights for local governance, academic institutions solidify their role as essential leaders in sustainable development and

coastal conservation.

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