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Status of Mangrove Forest in Selected Barangay of Pasacao, Camarines Sur

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Abstract

The study assessed the status, diversity, and ecological condition of mangrove forests in three selected barangays of Pasacao, Camarines Sur. Sitio Pongol (Balogo), Sitio Sarimao (Caranan), and Sta. Rosa Del Sur. Mangrove ecosystems provide essential ecological services, yet increasing anthropogenic pressures threaten their health and sustainability. This research aimed to identify existing mangrove species, determine diversity indices, evaluate the biometric and vegetation structure, and document human activities affecting the mangrove stands. A quantitative descriptive design was employed using nested quadrat sampling, species identification guided by Primavera (2014), and vegetation analysis following DENR–FMB, 2022 protocols. Diversity indices were computed using the Shannon–Wiener and Simpson formulas. Results revealed five mangrove species from four families across the study sites, with Sitio Sarimao exhibiting the highest species richness and diversity (Simpson D = 0.65; H' = 1.08). Balogo and Sta. Rosa Del Sur displayed low diversity and dominance by only one or two species. Biometric data indicated mature *Sonneratia alba* and *Avicennia marina* in several areas, while *Rhizophora* species showed small diameters and canopy sizes, suggesting young or regenerating individuals. Vegetation analysis showed that Sarimao had a more balanced and structurally complex mangrove community, while the other two barangays exhibited simplified structures dominated by a single species.

Keywords: mangrove forest, species diversity, vegetation structure, biometric assessment, anthropogenic activities

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1. Introduction

A mangrove is a woody tree or shrub that lives along shores, rivers, and estuaries in the tropics and subtropics (Feller, 2018). Mangroves are remarkably tough. Most live on muddy soil, but some also grow on sand, peat, and coral rock. They live in water up to 100 times saltier than most other plants can tolerate. They thrive despite twice-daily flooding by ocean tides; even if this water were fresh, the flooding alone would drown most trees. Growing where land and water meet, mangroves bear the brunt of ocean-borne storms and hurricanes. Mangrove forests are among the most unique and productive ecosystems in the coastal regions of tropical and subtropical countries. These ecosystems consist of salt-tolerant trees and shrubs that thrive in intertidal zones, where environmental conditions such as high salinity, fluctuating tides, and unstable substrates would be unsuitable for most terrestrial plants (Alongi, 2014). Despite these harsh conditions, mangroves have developed specialized adaptations, including aerial roots and salt-excreting mechanisms, enabling them to survive and function effectively in dynamic coastal environments (Hogarth, 2015). Their ecological importance extends beyond their biological uniqueness, as they provide critical ecosystem services that support both environmental stability and human well-being.

This ecosystem provides services, such as support for local livelihoods through the provision of fuel, food, and construction materials (Thomas, et al., 2017), ethno medicinal, clean air, and typhoon/flood protection (Goloran, et al., 2020). In addition, it also improve water quality by filtering pollutants and trapping sediments from rivers and streams before they reach the ocean. This helps maintain the health of adjacent coral reefs and seagrass beds. (Brian James Lu, 2024). In the tropical coastline, mangroves are prominent features with great ecological and economic value. Mangroves are one of the most exceptional floras in the world and grow in the coastlines of tropical and subtropical countries and are well adapted to extreme conditions such as high salinity and temperatures.

The Philippines, renowned for its exceptional biodiversity, process significant mangroves ecosystems that provide ecological service and support coastal communities (Dixon G. 2023). It is regarded as one of 17 mega biodiversity countries due to its geographical isolation, diverse habitats and High rates of endemism. It ranks fifth globally in terms of the number of plant species and maintains 5 % of the world’s flora. In mangroves alone, the country holds at least 50 % mangrove species of the world’s approximately 65 species. However, due to anthropogenic activities as well as natural disturbances, the country continues to lose its rich biodiversity resources including mangroves. (Garcia et al. 2013). Mangrove forests are among the most productive and ecologically important coastal ecosystems in the world. In the Philippines, they form an essential component of the country’s coastal defense and livelihood systems. The Philippines is known to harbor about 35 to 42 true mangrove species, making it one of the most diverse mangrove regions globally (Long et al., 2011; Primavera & Esteban, 2008). Major species found include Rhizophora apiculata, Avicennia marina, Sonneratia alba, and Bruguiera gymnorhiza, among others (Garcia et al., 2020). This richness in mangrove biodiversity highlights the critical role these ecosystems play in maintaining ecological balance and supporting coastal communities across the archipelago.

Despite their ecological and socioeconomic value, mangrove forests in the Philippines continue to decline due to human activities. Coastal development, aquaculture expansion, illegal cutting, and pollution have led to widespread degradation of mangrove habitats (Primavera, 2000; DENR, 2021). Pasacao, Camarines Sur, known for its fishing communities and coastal ecosystems, is not exempt from these threats. Conversion of mangrove areas for fishponds and settlements, as well as improper waste disposal, have altered the natural composition and structure of these ecosystems (DENR-BMB 2022). These issues pose serious environmental and socioeconomic problems, as the loss of mangroves heightens the vulnerability of communities to typhoons, flooding, and coastal erosion.

To address these issues, several national laws and global frameworks emphasize mangrove conservation. The Philippine Fisheries Code (Republic Act 8550) and the National Integrated Protected Areas System (Republic Act 7586) protect mangrove forests from exploitation. In line with international commitments, the Philippines also supports the United Nations Sustainable Development Goals (SDGs) particularly SDG 13 (Climate Action), Mangrove Forest is among the most carbon-rich ecosystems in the whole of the tropics. Therefore, mangroves are a nature-based solution to climate change, capable of taking carbon from the atmosphere and locking it away. SDG 14 (Life Below Water), and SDG 15 (Life on Land), is connected to mangroves as they protect biodiversity, prevent ecosystem loss, and maintain essential ecosystem services, which advocate for ecosystem restoration and sustainable management of coastal resources (United Nations, 2015). Strengthening mangrove protection aligns with these goals by enhancing climate resilience, sustaining marine life, and promoting biodiversity conservation.

In Pasacao, Camarines Sur, mangrove ecosystems are vital components of the coastal environment and local economy. However, similar to other coastal areas in the Philippines, these ecosystems are increasingly threatened by human activities, including illegal cutting, settlement expansion, and land-use conversion. The degradation of mangrove forests in the area has implications for biodiversity loss, reduced fisheries productivity, and increased coastal vulnerability. Despite these concerns, there remains a need for localized studies that assess the current status, species diversity, and ecological condition of mangrove forests in specific barangays. This study, therefore, aims to assess the status of mangrove forests in selected barangays of Pasacao, Camarines Sur by examining species composition, diversity indices, vegetation structure, and anthropogenic pressures. Through this assessment, the study seeks to provide baseline data that can support conservation planning, sustainable management strategies, and community-based interventions to restore and protect mangrove ecosystems.

Objectives of the Study - The study aims to provide a general assessment of the mangrove forests in selected barangays of Pasacao, Camarines Sur. Specifically, it seeks to identify the existing mangrove tree species and determine their corresponding diversity indices. It also aims to determine which barangay exhibits the highest level of mangrove diversity. Furthermore, the study intends to assess the biometric condition of the mangrove forests in each selected barangay, as well as conduct a vegetation analysis to better understand species composition and structure. In addition, it will identify the prevailing anthropogenic activities and evaluate the overall condition of the mangrove ecosystems in the study areas. Based on the findings, the study will propose a mangrove intervention program in Barangay Balogo aimed at improving mangrove species diversity and promoting sustainable management of the ecosystem.

Significance of the Study - The results of this study are expected to benefit several sectors and stakeholders. For Local Government Units (LGUs), particularly in Pasacao, Camarines Sur, the findings will serve as baseline data on the status of mangrove forests, which can support informed decision-making in identifying suitable sites for conservation, rehabilitation, and the establishment of protected areas for sustainable mangrove management. For students and educators, the study will serve as a valuable academic resource in the fields of environmental science, biology, and marine studies, providing relevant data and insights that can enhance learning and research activities.

Theoretical Framework - The study focus on several theories to understand the status of mangrove forest in the three selected barangay of Pasacao, Camarines Sur. The Ecological Drift Species Diversity Theory, Harpole, W. (2010). Supports mangrove ecosystem assessment and species diversity research by providing a framework to understand how different species coexist and how diversity influences ecosystem functioning. This theory explains that species diversity results from ecological processes such as competition, niche differentiation, environmental filtering, disturbance, and stochastic events, all of which shape community structure in mangrove ecosystems. In the context of mangrove ecosystem assessment, this theory helps explain patterns of species richness, composition, and distribution within mangrove forests, guiding researchers in evaluating the health and resilience of the ecosystem. Diverse mangrove species contribute to important ecological functions like habitat complexity, productivity, and resilience against environmental changes such as climate impacts or human disturbances.

Tremendous ecological and socio-economic benefits (Bandaranayake 1998; Primavera et al. 2004), Mangroves are coastal trees that provide many important benefits both for nature and people. Mangroves protect coastlines by stopping erosion and reducing damage from storms and floods. They provide homes for many fish and animals, helping maintain healthy ecosystems. Mangroves also capture a lot of carbon, which helps fight climate change, and keep the water clean by filtering pollutants. People living near mangroves depend on them for income and food. Mangroves provide wood for building and fuel, and they support fishing by giving young fish a safe place to grow. In some places, mangroves also help create jobs through products like charcoal and poles used in construction, boosting local economies. Ecological Drift and Neutral Theory of Species Diversity, Harpole, W. (2010). Ecological Drift and Neutral Theory of Species Diversity provide complementary insights by considering random fluctuations and the role of species equivalence, which can be important in understanding species abundance and turnover in mangrove communities Value-Belief-Norm (VBN). Stern et al., expanded by contemporary scholars in environmental psychology. Theory Extension in Pro-Environmental Youth Behavior (2020).

2. Methodology

This section contains the research design, research method, data gathering procedure, and statistical treatment of data.

Area of the Study - The study was conducted in Pasacao, Camarines Sur, which is located at about 13.31°N latitude and 123.30°E longitude. Pasacao is a coastal town in the Philippines known for its extensive mangrove ecosystems, estuarine environments, and varied coastal resources. The town has a tropical climate with distinct wet and dry seasons. These seasons significantly impact the ecological conditions of the mangrove forests and nearby aquatic habitats. This research specifically focused on three selected barangays, which were chosen for their unique ecological features, accessibility, and the presence of important mangrove stands that support biodiversity, protect shorelines, and contribute to local livelihoods. These areas include: Balogo, Caranan and Sta.Rosa Del Sur. Barangay Balogo is situated along the southern part of the town. It has well-established mangrove forests, primarily made up of species like Sonneratia alba and Rhizophora spicies. The area features fine muddy substrates impacted by tides, supporting a wide variety of aquatic and terrestrial life. Its closeness to local fishing communities makes it important for both ecological and socio-economic research. Barangay Caranan is located in the southern part of Pasacao and is home to a diverse mangrove ecosystem with both pioneer and mature species. Caranan is recognized for its relatively undisturbed mangrove stands, which act as a natural barrier against coastal erosion. The area's hydrological conditions, sediment makeup, and density of vegetation make it an excellent site for studying the size and structure of mangroves. Barangay Sta. Rosa Del Sur situated along the southwestern coast of Pasacao, Sta. Rosa Del Sur contains mixed mangrove forests alongside human settlements. The site shows varying levels of human impact, such as small-scale aquaculture and resource extraction, making it crucial for evaluating how human activities affect mangrove structure and health. The mangrove species here reflect both natural recovery and areas that have been influenced by environmental stressors.

Research Design - This study employed a quantitative descriptive research design to assess and describe the current condition and species diversity of mangrove forests in selected barangays in Pasacao, Camarines Sur. The quantitative descriptive design was appropriate because it aimed to obtain numerical data that represented the ecological status of mangroves through measurable parameters.

Research Method - The mangrove diversity assessment conducted using the protocol of the Biodiversity Assessment Monitoring System (DENR-FMB,2022). The sampling station were randomly selected. Pre-determining the sampling site is essential to avoid bias and to get an accurate result of the assessment. A nested quadrat sampling design was used to record the presence of mangrove species. A 20m x 20m quadrat for mature mangrove species, a 10m x 10m quadrat for sapling species, and the seedlings counted in a 5x5 m quadrat. The identification of mangrove species based on the field guide of Jurgenne Primavera (2014). Some parameters gathered were used to assess the vegetation analysis of mangrove species. The data analysis involved calculating the Species Importance Value (SIV) and diversity indices using the formula of Shannon-Wiener and Simpson Diversity Index.

Geographic Information System (GIS) software used to organize, evaluate, and present the geographic and spatial data gathered. With the use of GIS software, users can produce maps and other visual representations of geographic data for in-depth study and captivating presentations. Mobile apps like Locus Map, which functions as a digital toolbox for people working with maps and locations, are one practical application of GIS principles. Locus Map allows users to explore the outdoors with detailed offline maps and is especially useful for school projects involving data collection, like geography or environmental science field trips. The program is a flexible tool for research and projects because it enables users to locate locations, add notes, and immediately insert photographs onto a map. Geo cam one of the applications in the Google Play Store that provides GeoPictures and GeoVideos. The app can display a composite view of geographical Information with the use of augmented reality (AR). GeoCam measures and determines a precise compass orientation by choosing the magnetic or geographic North. GeoCam can also estimate and determine the distances and relative positions of points spread over an area with the use of the triangulation feature.

Data Gathering Procedure - To collect reliable data on the mangrove forest, various techniques and tools were used. Before the actual fieldwork, the researcher conducted a ground-truthing and preliminary field survey. This helped them get familiar with the study area, check site accessibility, and pinpoint key sampling locations. During this phase, tools like Geocam and Locus Map gathered raw geographic data and visually represented the study area in a Geographic Information System (GIS). This process helped create accurate maps and plan for data collection activities. Before starting fieldwork, the researcher sent formal request letters to local barangay authorities for permission to conduct the study. They also reached out to relevant institutions to borrow necessary laboratory equipment for assessing mangrove health and biometric conditions. These steps made sure they followed local regulations and provided smooth access to study sites and essential resources. The fieldwork involved a mix of specialized tools for measuring and identifying species. A steel tape measured distances, widths, and lengths within the mangrove ecosystem. Meter sticks provided accurate tree height measurements, while diameter tapes determined the trunk diameters of mangrove trees. The researcher recorded the data using field data sheet and pen, allowing for efficient note-taking of immediate observations. For systematic sampling, nylon ropes served as transect lines, and quadrats were set up to standardize data collection across the study site. Accurate species identification relied on a Mangrove Identification Guide approved by the Department of Environment and Natural Resources (DENR). Additionally, a camera documented the study process, field conditions, and notable findings, providing visual evidence to back up the recorded data.

Statistical Treatment of Data - The study utilized different statistical treatments to analyze the gathered data, including the Species Importance Value (IV), Shannon-Wiener Diversity Index. The Shannon-Wiener Diversity Index, developed by Claude Shannon in 1948, was used to measure biodiversity by considering both species richness and species evenness within the community. Vegetation analysis included the measurement of density, which determines the number of individuals of a species within a sampled area and indicates population abundance. Relative density was used to show the dominance of a species compared to the total density of all species. Frequency measured how often a species appeared across sampling plots, reflecting its distribution within the study area, while relative frequency expressed the proportional occurrence of each species. Dominance referred to the area occupied by a species, commonly measured through basal area or biomass, and relative dominance compared the dominance of one species to the total dominance of all species in the ecosystem. Finally, the Importance Value (IV) combined relative density, relative frequency, and relative dominance to determine the overall ecological importance and influence of each species within the community.

3. Results and Discussion

In this section, the results and discussions are presented aligned with the objectives.

3.1 The Existing Mangrove Tree Species, and the Diversity Indices

Table 1 shows the identified existing mangrove tree species in three selected barangays of Pasacao, Camarines Sur. Based on the data presented, a total of five (5) mangrove species belonging to four (4) families were recorded across the study sites. These families include Avicenniaceae, Sonneratiaceae, Myrsinaceae, and Rhizophoraceae. The identified species were Avicennia marina (Miapi) Sonneratia alba (Pagatpat), Aegiceras floridum (Saging-saging), Rhizophora mucronata (Bakhaw babae), and Rhizophora stylosa (Bakhaw bato). In Barangay Balogo, Pasacao, Camarines Sur, two mangrove species were recorded, namely Avicennia marina and Sonneratia alba. These belong to two different families, Avicenniaceae and Sonneratiaceae with a total of 91 individual mangrove trees identified in the area. Among these, Sonneratia alba recorded the highest number of individuals with 65. The findings may be attributed to its strong tolerance to sandy–muddy substrates, which are commonly found in the area. Studies show that Sonneratia alba is typically one of the first colonizers along seaward zones due to its large pneumatophores and ability to with stand dynamic tidal environments (Duke, 2006; Primavera et al., 2004). While Avicennia marina accounted for 26 individuals. Though fewer in number, thrives well in saline environments. Its presence suggests that portions of Balogo's mangrove area may support higher salinity. (Hogarth, 2015; Kathiresan & Bingham, 2001).

In Barangay Caranan, four mangrove species belonging to four families were identified. These include Avicennia marina (Avicenniaceae), Sonneratia alba (Sonneratiaceae), Aegiceras floridum (Myrsinaceae), and Rhizophora mucronata (Rhizophoraceae). The total number of individuals recorded in Sarimao was 143, distributed as follows: Avicennia marina with 63 individuals. The dominance of Avicennia marina in Caranan can be linked to the substrates of the study area, according to Hogarth, (2015) Aviccena Marina has the ability to tolerate high salinity, and soft muddy substrates, often found in sheltered, estuarine-type environments. On the other hand, Sonneratia alba has a total of 50 individuals. Sonneratia alba abundance is again associated with its adaptation to seaward zones and tolerance to wave exposure. The interaction of freshwater inputs and tidal flushing in Caranan enhances habitat suitability, which has been observed in various Sonneratia dominated shorelines across Southeast Asia (Duke, 2006; Primavera et al., 2004). Aegiceras floridum with a total of 29 individuals, it's generally prefers brackish waters and inner mangrove zones, benefiting from lower salinity, which may be present in certain areas of Sarimao influenced by freshwater outflows (Duke et al., 1998)., and Rhizophora mucronata with 1 individual. It is typically associated with soft muddy substrates in estuarine rivers and tidal creeks, often located behind the more seaward (Primavera et.al 2014).

In Barangay Sta. Rosa Del Sur, three species from three families were identified. Avicennia marina (Avicenniaceae), Sonneratia alba (Sonneratiaceae), and Rhizophora stylosa (Rhizophoraceae). A total of 117 individuals were recorded in this barangay. Avicennia marina was the most abundant with 90 individuals, the dominance of Avicennia marina suggests that environmental conditions in Sta. Rosa del Sur particularly its rocky substrate favor species adapted to more stressful and variable intertidal settings. According to Tomlinson (2016), Avicennia species exhibit high tolerance to salinity, wave exposure, and unstable substrates due to their extensive pneumatophore systems that allow effective anchorage and gas exchange. Sonneratia alba with 26 individuals. The moderate presence of Sonneratia alba is consistent with its ecological preference for open coastal shorelines with good water circulation and slightly firmer substrates (Duke, 2006). Sonneratia alba often occurs in pioneer zones but is less competitive in environments where the substrate becomes too rocky or where wave action is excessive. Rhizophora stylosa was represented by only 1 individual. The very low occurrence of Rhizophora stylosa may be attributed to its structural and ecological limitations. Rhizophora species generally prefer softer, muddy substrates that allow the penetration of stilt roots necessary for anchorage and nutrient uptake (Kathiresan & Bingham, 2001)..

The identified mangrove trees across the three selected barangay confirms the study of Primavera et. al (2014) where, it is the common mangrove trees found in the Philippines. Additionally, it also confirms the report of Nieva (2016) as stated on the Documentation of Common Mangroves Species in Pasacao Camarines Sur, Philippines where the following mangrove family as stated above found in the Municipality of Pasacao, Camarines Sur. The data also indicates that most of the identified mangrove tree species are typically found in the seaward zone (Primavera et.al, 2014).

Table 1

Mangroves Species identified in three selected barangay of Pasacao, Camarines Sur

BARANGAY	FAMILY NAME	SCIENTIFIC NAME	LOCAL NAME	NO. OF INDIVIDUALS
Balogo	Avicenniaceae	Avicennia marina	Miapi	25
	Sonneratiaceae	Sonnertia alba	Pagatpat	66
Caranan	Avicenniaceae	Avicennia marina	Miapi	63
	Sonneratiaceae	Sonnertia alba	Pagatpat	50
	Myrcinaceae	Aegiceras floridum	Saging - saging	29
	Rhizophoraceae	Rhizophora mucronata	Bakhaw babae	1
Sta. Rosa Del Sur	Avicenniaceae	Avicennia marina	Miapi	90
	Sonneratiaceae	Sonneratia alba	Pagatpat	26
	Rhizophoraceae	Rhizophora stylosa	Bakhaw bato	3

Table 2 presents the Shannon – Weiner Diversity Index (H') for the mangrove forests in the three selected barangays of Pasacao, Camarines Sur. These indices are widely used ecological metrics that provide insights into species richness and evenness within a given habitat (Magurran, 2004; Krebs, 1999).

Table 2

Shannon- Weiner Diversity in Three Selected Barangay of Pasacao, Camarines Sur (October 10-18, 2025)

BARANGAY	SHANNON- WINER DIVERSITY INDEX	INTERPRETATION	TOTAL HEIGHT
Balogo	0.58	Very low	2
Caranan	1.08	Very low	3
Sta. Rosa Del Sur	0.57	Very low	1

The classification scheme by Fernando et al. (1998) in Table 3. Provides a helpful way to interpret ecological conditions using H' values. According to this scheme, values above 3.50 indicate very high diversity. Values between 3.00 and 3.49 suggest high diversity, while values from 2.50 to 2.99 indicate moderate diversity. Values ranging from 2.00 to 2.49 show low diversity, and values of 1.99 and below correspond to very low diversity. Based on the calculated Shannon-Wiener Index values for the three areas, Caranan (H' = 1.08), Balogo (H' = 0.58), and Del Sur (H' = 0.57) all fall under the "Very Low" diversity category according to the classification by Fernando et al. (1998). Low H' values usually show that the biological communities in these areas are mainly made up of just a few species, with limited species richness and uneven species distribution (Pielou, 1977). This pattern might relate to environmental stress, habitat damage, human impact, or less ecological variety. Among the sites, Caranan has the highest diversity (H' = 1.08), but it is still classified as very low. This means that the site has a slightly more varied or evenly distributed community compared to Sitio Pongol Balogo and Del Sur. Balogo and Del Sur have almost the same H' values (0.58 and 0.57), suggesting similar ecological conditions and possibly alike environmental pressures. Such extremely low values could point to unstable or simplified ecosystems, which are often more sensitive to outside disturbances (Magurran, 2013).

Table 3

Classification scheme for the Shannon Diversity Index (Fernando et al.1998).

RELATIVE VALUES	SHANNON- WINER DIVERSITY INDEX(H)
Very high	3.50 and above
High	3.00 - 3.49
Moderate	2.50 – 2.99
Low	2.0 – 2.49
Very low	1.99 and below

3.2 Most Diverse Barangay

Based on the species composition and abundance recorded at the three study sites, Caranan had the highest mangrove diversity. Diversity in ecological communities depends on both species richness and species evenness (Magurran, 2013). Among the three barangays, Caranan had four species from four families, which was the highest richness noted in the study sites. These species included Avicennia marina, Sonneratia alba, Aegiceras floridum, and Rhizophora mucronata. The presence of various species from different families suggests a more complex and stable mangrove community. This supports the idea that greater richness leads to better community resilience and ecological functioning (Alongi, 2015).

3.3 Biometric Condition of Mangrove Tree Species in Three Selected Barangay of Pasacao, Camarines Sur

Table 4 shows The biometric condition of mangrove species in the selected barangays of Pasacao, Camarines Sur demonstrates substantial variation in diameter at breast height (DBH), total height, and canopy length, reflecting differences in species growth patterns and site-specific environmental conditions. The biometric condition of the mangrove forests in the selected barangays of Pasacao, Balogo,Caranan, and Sta. Rosa Del Sur demonstrates significant variation in tree size and structural development. These differences are evident when comparing the measured parameters of diameter at breast height (DBH), total height, and canopy length, which are widely recognized as as indicators of forest maturity, ecological stability, and site productivity (Alongi, 2009).

Table 4
Biometric Condition of Mangrove forest in Selected Barangay of Pasacao, Camarines Sur

BARANGAY	SCIENTIFIC NAME	DBH(cm)	TOTAL HEIGHT	CANPOY LENGTH
Balogo	Avicennia marina	148.7	25	111.2
	Sonnertia alba	479.9	66	883.2
Caranan	Avicennia marina	393.1	63	164.3
	Sonnertia alba	489.7	50	181.8
	Aegiceras floridum	150.6	29	73.4
	Rhizophora mucronata	3.8	1	3.3
Sta. Rosa Del Sur	Avicennia marina	490.7	90	215.2
	Sonneratia alba	176	26	73.8
	Rhizophora stylosa	2.3	3	2.1

Diameter Breast Height (DBH cm) - The highest value recorded among all barangays was observed in Caranan, where *Sonneratia alba* exhibited a DBH of 489.7 cm, indicating the presence of fully mature and well-established trees. The large diameter are characteritics of old growth Sonneratia species, which are known to develop massive trunks under favorable ecological conditions such as as stable hydrology, low anthropogenic disturbance, and nutrient rich alluvial substrates (Alongi, 2009; Tomlinson, 2016). This was followed closely by *Avicennia marina* in Sta. Rosa Del Sur, which measured 490.7 cm, also reflecting advanced growth stages. The lowest DBH values were found among the Rhizophora species, specifically *Rhizophora stylosa* in Sta. Rosa Del Sur (2.3 cm) and *Rhizophora mucronata* in Caranan (3.8 cm), suggesting the presence of young regenerating individuals. These small diameters align with the known slow early growth rates of Rhizophora spp., which often establish under shaded or less favorable conditions (Krauss et al., 2008).

Total Height (m) - The tallest mangrove recorded was *Sonneratia alba* in Balogo, reaching 499.4 m. The shortest trees were *Rhizophora stylosa* in Sta. Rosa Del Sur, measuring only 3.2 m. These results show the differences in site conditions and growth stages among the selected barangays. The remarkable height of *Sonneratia alba* in Balogo indicates favorable environmental conditions and the species' natural tendency for rapid vertical growth in untouched habitats (Duke, 2006). On the other hand, the limited height of *Rhizophora stylosa* in Sta. Rosa Del Sur suggests early growth stages or less ideal conditions. This is likely due to reduced light availability, poorer soil quality, or less favorable water factors (FAO, 2007). These differences emphasize the role of abiotic factors in shaping the vertical structure of mangrove forests.

Canopy Length(m) - The assessment revealed that *Sonneratia alba* in Balogo exhibited the highest canopy length at 883.2 m, indicating exceptionally wide crown development within the area. The smallest canopy lengths were recorded for *Rhizophora stylosa* in Sta. Rosa Del Sur (2.1 m) and *Rhizophora mucronata* in Caranan (3.3 m). Canopy length is a key indicator of habitat quality, shading capacity, and competitive ability among mangrove species. The notably large canopy spread of *Sonneratia alba* in Balogo reflects the species' inherent tendency to develop broad crowns, particularly in stable, well-flushed environments that support vigorous lateral growth (Primavera et al., 2004). This expansive canopy suggests favorable site conditions and the presence of fully mature individuals.

On the other hand, the relatively narrow canopy lengths observed in *Rhizophora stylosa* and *Rhizophora mucronata* particularly in Sta. Rosa Del Sur and Caranan are consistent with the structural characteristics of young Rhizophora species. These species typically allocate more energy toward vertical elongation rather than lateral crown expansion during their early growth stages, resulting in smaller canopy spreads (Koch et al., 2015). These limited canopy widths may indicate younger stand structures or environmental conditions that restrict lateral growth. Across all three barangays, Balogo and Sta. Rosa Del Sur are characterized by large, mature Avicennia and Sonneratia stands with consistently high biometric values, while Caranan presents a more mixed structural profile, comprising both fully mature trees and extremely young Rhizophora recruits. The presence of both mature and juvenile individuals suggests ongoing natural regeneration, though also indicates potential disturbances or differing site conditions. As emphasized by Alongi (2014), such variability is typical of mangrove ecosystems where hydrology, sedimentation, and human activities strongly influence forest structure.

3.4 Vegetation Analysis of Mangrove Species in Selected Barangay in Pasacao, Camarines Sur.

Density (D) and Relative Density (RD) - Density (D), which measures the number of individuals per unit area, reflects how populated a mangrove stand is and helps determine species distribution within each barangay. In Balogo, *Sonneratia alba* exhibited the highest density value, accounting for 71.4% RD, whereas *Avicennia marina* contributed only 28.6% RD. This shows that *Sonneratia alba* dominates the area in terms of population abundance, likely due to its high tolerance to sandy–muddy substrates and exposure to tidal fluctuations. According to FAO (2007), species with greater structural adaptability often emerge as dominant in disturbed coastal zones. Caranan displayed greater species richness and a more equitable distribution of densities. Four mangrove species were recorded, and among them, *Sonneratia alba* represented 34.9% RD, followed by *Aviccenia marina* at 44.1%. Although *Aegiceras floridium* and *Rhizophora mucronata* showed low RD values (20.2% and 0.67%), their presence still indicates a more diverse assemblage. A more evenly distributed stand, as shown in Sitio Sarimao, is typically associated with healthier and more resilient mangrove ecosystems (Kathiresan & Bingham, 2001). In Sta. Rosa del Sur, *Aviccenia marina* overwhelmingly dominated the mangrove community, with a relative density of 77.48%, while *Sonnertia alba* and *Rhizophora stylosa* accounted for 21.69% and 0.83%, respectively. The high RD of *Aviccena marina* suggests that this species thrives in the rocky substrate present in the area, consistent with earlier findings that *Aviccena marina* can tolerate a wide range of soil conditions (Duke, 2006). Overall, density and relative density across barangays demonstrate distinct species dominance patterns influenced by habitat characteristics and substrate composition.

Frequency (F) and Relative Frequency (RF) - In Balogo, both *Avicennia marina* and *Sonneratia alba* recorded a frequency (F) score of 1, resulting in equal relative frequency values of 50% each. In Caranan, *Aviccena marina*, *Sonneratia alba*, and *Aigeceras floridium* each obtained an RF of 30.3%, while *Rhizophora mucronata* showed the lowest RF at 9.1%. In Sta. Rosa del Sur, *Aviccena marina* and *Sonneratia alba* both exhibited an RF of 43.48%, whereas *Rhizophora stylosa* registered a considerably lower RF of 13.04%. Frequency (F) evaluates how uniformly species appear across sampling plots, reflecting their habitat preference and spatial occurrence. In Balogo, the equal frequencies of *Aviccena marina* and *Sonneratia alba* indicate that despite differences in abundance, both species are encountered uniformly across the area. This pattern is typical in homogenous tidal flats where environmental conditions allow for even species distribution (Hogarth, 2015). Caranan, however, exhibited more variability in frequency. The nearly equal distribution of *Aviccena marina*, *Sonneratia alba*, and *Aigeceras floridium* suggests that these species share similar ecological niches or microhabitat conditions, while the low RF of R. mucronata indicates a patchy occurrence. Such patchiness is often associated with variations in soil moisture, salinity, and sediment stability, which significantly influence mangrove seedling survival and establishment (Alongi, 2009). In Sta. Rosa del Sur, the consistently high frequency of *Aviccena marina* and *Sonneratia alba* suggests that these species dominate the area and are regularly encountered across plots, whereas the low RF of *Rhizophora stylosa* indicates sparse distribution. As noted by Spalding et al. (2010), species with lower frequency values in mixed mangrove stands tend to be either naturally rare or more sensitive to specific microhabitat conditions.

Dominance (Dom) and Relative Dominance (RDom) - Dominance (Dom) relates to the basal area occupied by each species, reflecting canopy structure and biomass contribution. In Balogo, *Sonnertia alba* accounted for the highest dominance with 0.032 m² basal area, corresponding to a relative dominance of 74.42%. *Aviccena marina* contributed only 25.58% RDom. This indicates that *Sonnertia alba*, aside from being numerically abundant, also contributes more to the overall biomass. Larger basal area values typically indicate older and more established individuals (Cintrón & Schaeffer-Novelli, 1984). Caranan exhibited a more complex dominance pattern. While *Aviccena marina* showed the highest RDom (73.47%), *Sonneratia alba* followed at 19.05%. Meanwhile, *Aegiceras floridium* and *Rhizophora mucronata* contributed small proportions (6.80% and 0.68%). These values show that *Aviccena marina* trees in Sarimao possess larger trunk diameters and greater structural representation despite *Sonneratia alba* having higher abundance. This scenario highlights the importance of considering both biomass and numerical composition in vegetation analysis. Sta. Rosa del Sur demonstrated an even more pronounced dominance by *Aviccena marina*, which accounted for 59.29% RDom, followed by *Sonnertia alba* (40.43%) and *Rhizophora stylosa* (0.27%). The high structural dominance of *Aviccena marina* corresponds with its ability to thrive in rocky substrates, developing thicker trunks and more robust structures. As reported by Duke et al. (1998), Avicennia species exhibit strong adaptability, enabling them to dominate structurally in challenging environments.

Species Importance Value (SIV) - Species Importance Value (SIV) integrates relative density, relative frequency, and relative dominance, representing the overall ecological significance of each species in the community. In Balogo, *Sonneratia alba* recorded the highest SIV at 195.82, while *Aviccena marina* obtained 104.18. This indicates that *Sonneratia alba* is the ecologically dominant species in Balogo, playing a central role in biomass, distribution, and abundance. In Caranan, the presence of four species produced varied SIV values. *Aviccena marina* obtained a significantly high SIV of 138.67, closely followed by *Sonneratia alba* at 93.45. Meanwhile, *Aegiceras floridium* and *Rhizophora mucronata* recorded SIVs of 57.30 and 10.45, respectively. The distribution of SIVs reflects a moderately diverse ecosystem where multiple species contribute to community structure, consistent with the barangay's higher Shannon diversity index (H' = 1.08). According to Nagelkerken et al. (2008), ecosystems with multiple moderately represented species tend to be more resilient to environmental fluctuations. Sta. Rosa del Sur's SIV results further highlight the dominance of *Aviccena marina*, which scored 180.25, followed by *Sonneratia alba* (105.60) and *Rhizophora stylosa* (14.14). This indicates a semi-mixed but highly uneven mangrove stands, where *Aviccena marina* plays a disproportionately large ecological role. High SIV values for one species typically indicate reduced species diversity and greater vulnerability to habitat disturbance (Primavera, 2000).

3.5 Anthropogenic Activity and Condition of Mangrove Forest in Each Selected Barangay.

The mangrove forests in Barangays Balogo, Caranan, and Sta. Rosa Del Sur are facing serious anthropogenic pressures that threaten their ecological stability and long-term sustainability. One of the major threats across all areas is the overharvesting of mangrove wood for fuelwood, charcoal production, construction materials, and other domestic uses. Continuous cutting of mature mangrove trees reduces tree density, weakens root systems, and decreases the forests' ability to stabilize sediments, reduce coastal erosion, and protect shorelines from storms and wave action. These practices reflect broader patterns of mangrove exploitation in many Philippine coastal communities due to economic limitations and dependence on natural resources.

Another major issue affecting the three barangays is the accumulation of plastic and tidal debris within mangrove ecosystems. Mangrove roots naturally trap floating waste, causing plastics and other debris to build up around pneumatophores and prop roots. This pollution restricts gas exchange, prevents seedling establishment, and reduces mangrove regeneration and survival rates. In Balogo, Caranan, and Sta. Rosa Del Sur, inadequate waste management and proximity to residential settlements worsen the problem, transforming healthy mangrove habitats into debris-laden environments that can no longer function effectively as productive ecosystems.

Land-use change and coastal development further intensify mangrove degradation in the study areas. Portions of the mangrove forests have been cleared or altered for aquaculture expansion, fishponds, settlement encroachment, salt beds, and other livelihood activities. These human-driven modifications disrupt natural hydrological flows, alter salinity and sedimentation patterns, fragment habitats, and reduce biodiversity. As a result, the mangroves' capacity to provide essential ecosystem services such as fisheries support, carbon sequestration, shoreline stabilization, and nursery grounds for marine organisms continues to decline. Overall, the combined effects of overharvesting, pollution, and land conversion significantly reduce the ecological resilience of mangrove forests in the three barangays, creating long-term environmental and socio-economic challenges for coastal communities.

3.6 *Mangrove Intervention Program in Barangay Balogo*

Barangay Balogo was identified as a priority area for mangrove restoration because of its low species diversity and reduced mangrove population, with only *Avicennia marina* and *Sonneratia alba* dominating the area. This limited diversity makes the mangrove ecosystem more vulnerable to environmental disturbances and human activities such as illegal cutting, tidal debris accumulation, and aquaculture expansion. Reduced species richness weakens ecosystem resilience and decreases the mangroves' ability to provide important ecological services such as shoreline protection, carbon storage, nutrient cycling, and fisheries support.

To address these issues, the study recommends implementing a mangrove intervention program in Barangay Balogo focused on increasing species diversity and improving ecosystem stability. The program may include planting ecologically suitable species such as *Rhizophora mucronata* and *Aegiceras floridum* to complement the existing mangrove species. Increasing species diversity can improve habitat complexity, support regeneration, and strengthen the forest's resistance to natural and human-induced disturbances.

The proposed intervention should also emphasize community participation, environmental education, and capacity building to encourage local involvement in mangrove planting, monitoring, and protection. Community-based management can improve the success and sustainability of restoration efforts while reducing destructive activities such as illegal cutting and improper waste disposal. Overall, the program can help restore ecological functions, enhance coastal resilience, and serve as a model for mangrove conservation in other coastal areas of Pasacao.

4. Summary, Findings, Conclusions and Recommendations

Summary - The study aims to provide a general assessment of the mangrove forests in selected barangays of Pasacao, Camarines Sur. Specifically, it seeks to identify the existing mangrove tree species and determine their corresponding diversity indices. It also aims to determine which barangay exhibits the highest level of mangrove diversity. Furthermore, the study intends to assess the biometric condition of the mangrove forests in each selected barangay, as well as conduct a vegetation analysis to better understand species composition and structure. In addition, it will identify the prevailing anthropogenic activities and evaluate the overall condition of the mangrove ecosystems in the study areas. Based on the findings, the study will propose a mangrove intervention program in Barangay Balogo aimed at improving mangrove species diversity and promoting sustainable management of the ecosystem.

Findings - The study documented five mangrove species across three barangays belonging to four families, with clear differences in species composition, diversity, and ecological condition. Barangay Caranan exhibited the highest species richness and diversity, with four species and a more balanced distribution, indicating a relatively stable and resilient ecosystem. In contrast, Barangay Balogo and Sta. Rosa Del Sur showed lower diversity, dominated by Sonneratia alba and Avicennia marina, respectively, reflecting their adaptation to specific environmental conditions such as substrate type and salinity. Overall, low Shannon–Wiener diversity index values across all sites suggest simplified habitats, largely influenced by human activities like illegal cutting, land conversion, and waste accumulation, which increase vulnerability to environmental disturbances.

Biometric and vegetation analyses further revealed variations in forest structure and health among the barangays. Balogo contained large, mature trees with favorable growing conditions, while Caranan showed a mix of mature and regenerating species, indicating recovery from past disturbances. Sta. Rosa Del Sur, however, exhibited structural degradation with smaller trees and limited canopy cover. Vegetation patterns highlighted dominance in low-diversity areas and a more even distribution in Caranan, which supports greater ecological functionality. These structural differences directly affect ecosystem services such as habitat provision, sediment stabilization, and coastal protection.

Anthropogenic pressures including illegal harvesting, charcoal production, plastic pollution, and land-use conversion were evident in all sites, hindering regeneration and weakening ecosystem integrity. Despite the presence of mature trees, continued disturbances threaten long-term sustainability, particularly in Sta. Rosa Del Sur, which showed the poorest condition. As a result, Barangay Balogo was identified as a priority for restoration, with recommendations to introduce additional native species to improve biodiversity and resilience. The study emphasizes that combining ecological restoration with community involvement is essential to enhance ecosystem services, support biodiversity, and mitigate ongoing environmental degradation.

Conclusions - The mangrove forests of Pasacao are generally characterized by low species diversity and uneven distribution across barangays. Among the study sites, Caranan emerged as the most diverse barangay, supporting a wider variety of mangrove species and more complex ecological interactions. In contrast, Balogo and Sta. Rosa del Sur are dominated by only one or two species, resulting in simplified ecosystems. This low diversity reduces overall ecosystem resilience and limits the capacity of mangrove forests to sustain essential services such as coastal protection, nursery habitats for marine organisms, and carbon sequestration. The ecological complexity observed in Caranan allows for greater stability and adaptability, whereas the simplified systems in Balogo and Sta. Rosa del Sur are more vulnerable to environmental stressors and anthropogenic disturbances, thereby diminishing their functional contribution to the coastal ecosystem. Furthermore, the mangrove forests exhibit variations in structural maturity, with Balogo and Sta. Rosa del Sur containing older stands, while Caranan shows signs of regenerating areas. These differences in biometric conditions influence key ecosystem services, including carbon storage, shoreline stabilization, and habitat provision. Vegetation analysis further supports these findings, revealing that Balogo and Sta. Rosa del Sur have less complex vegetation structures dominated by a few species, while Caranan demonstrates a more diverse and stable composition. The study also identifies anthropogenic pressures as the primary driver of mangrove degradation in Pasacao, with disturbed and simplified forests being particularly at risk. These findings highlight the need for site-specific management strategies. In particular, a targeted mangrove intervention program in Barangay Balogo is recommended to restore species diversity, enhance structural complexity, and improve ecosystem resilience. Implementing community-based approaches will be crucial in ensuring the sustainability and long-term success of these restoration efforts.

The findings of this study have important practical educational implications for teachers, students, schools, and community stakeholders, particularly in promoting environmental education and coastal resource conservation.

Implications for teachers - the study may serve as a basis for integrating mangrove ecology, biodiversity conservation, and climate change awareness into science and environmental education lessons. The data gathered from the mangrove assessment can be used as localized instructional materials, allowing educators to provide students with real-life examples from their own communities. This strengthens contextualized learning and encourages experiential teaching approaches such as field activities and environmental projects.

Implications for students - the study enhances environmental awareness and develops a deeper understanding of the ecological importance of mangrove ecosystems. By exposing students to actual environmental conditions in Barangay Balogo and nearby coastal areas, they become more conscious of human impacts on biodiversity and coastal sustainability. The findings may also encourage students to participate in environmental stewardship activities such as mangrove planting, coastal clean-up drives, and biodiversity monitoring programs.

Implications for schools - the study highlights the importance of strengthening school-community partnerships in environmental conservation initiatives. Schools may use the findings as a foundation for extension programs, research activities, and sustainability campaigns related to coastal resource management. The identified need for mangrove rehabilitation in Barangay Balogo provides opportunities for schools to organize long-term environmental programs involving students, teachers, local government units, and community members. The documentation of limited mangrove species diversity and anthropogenic threats emphasizes the need for continuous environmental education and community-based conservation efforts. Through collaborative educational programs, schools and practitioners can contribute to restoring mangrove ecosystems while simultaneously fostering environmental responsibility among future generations.

Recommendations - To enhance the resilience and ecological functions of mangrove forests in Pasacao, it is recommended that existing mature mangrove trees be strictly protected and disturbances within mangrove areas be minimized to preserve canopy structure, root stability, and overall forest integrity. Mature mangroves play a vital role in shoreline stabilization, carbon storage, habitat provision, and protection against coastal erosion and storm surges. In addition, continuous community education and awareness campaigns should be conducted to strengthen public understanding of the ecological importance of mangrove ecosystems and the value of biodiversity conservation. These programs should encourage local participation in mangrove protection, proper waste management, and sustainable coastal resource practices to ensure the long-term sustainability and resilience of mangrove forests in the municipality.

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