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Assessment of mangrove conservation in Balogo, Pasacao for coastal protection

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Abstract

This study assessed the mangrove conservation status in Balogo, Pasacao, Camarines Sur, to evaluate its effectiveness as a natural "bio-shield" for coastal protection. Using a mixed-methods research design, ecological health was appraised across two stations (sitio mainit and sitio poñgol) through quadrat sampling to identify species diversity, density, and structural height. Additionally, structured interviews were conducted with the local government unit (LGU), the MangRASS organization, and the Municipal Agriculture Office to evaluate current management strategies. The inventory identified five primary species: *Avicennia marina*, *Sonneratia alba*, *Avicennia rumphiana*, *Rhizophora mucronata*, and *Nypa fruticans*. Results indicated that while station 2 exhibited higher tree density, it showed stunted growth due to wind exposure and high salinity. Station 1 faced significant ecological stress from natural sandbar formations that disrupted local hydrology. Anthropogenic pressures, specifically the accumulation of plastic waste damaging pneumatophores, were also identified as critical threats. The study concludes that the mangrove forest requires immediate hydrological restoration and formalized community-led protection. A strategic mangrove conservation and protection plan (2026–2030) was formulated, focusing on sustainable waste mitigation and hydrological management to enhance the forest's long-term capacity for coastal resilience.

Keywords: mangrove assessment, coastal protection, belt-transect, hydrological restoration, bio-shield

Assessment of mangrove conservation in Balogo, Pasacao for coastal protection

1. Introduction

Mangrove ecosystems are globally recognized for their critical role in coastal protection, acting as natural barriers that decrease wave energy, minimize erosion, and buffer communities against storms and sea-level rise (Menéndez et al., 2023). Studies have shown that mangroves can significantly reduce the impact of extreme weather events, with their dense root systems stabilizing shorelines and their canopies reducing wave force (Doughty et al., 2017). This protective capacity is enhanced when root densities exceed 2,000 roots/m², reducing wave heights by 50-75% over 100m—key structural metrics this study will assess to evaluate Balogo's coastal defense potential, supporting SDG 13.1 (climate disaster resilience) and SDG 11.b (resilient communities) (Narayan et al., 2017).

Globally, mangroves provide over $65 billion annually in flood protection benefits, preventing flooding for millions of people worldwide (Earth.Org, 2020). Mangroves reduce wave heights and storm surges, which lowers the risk of damage to coastal infrastructure and communities (The Nature Conservancy, 2023). Studies have shown that mangroves provide substantial economic value through flood protection worldwide, estimated at around $855 billion, with countries like Vietnam, Bangladesh, and India notably benefiting as mangroves safeguard hundreds of thousands of people each year (Menéndez et al., 2020). Additional research underscores their role in carbon sequestration, trapping up to four times more carbon per equivalent area than tropical rainforests, further amplifying their value in climate regulation (Alongi, 2018). Healthy mangroves sequester ~988 gC/m² annually, providing valuation benchmarks (protection: $12,660/ha/yr; fisheries: $5,275/ha/yr) that this study will contextualize for Balogo's economic justification, advancing SDG 13.2 (climate policy integration), SDG 14.2 (ocean health), and SDG 15.1 (forest conservation) (Donato et al., 2022; Brander et al., 2021).

In the Philippines, mangrove restoration and conservation have been promoted as effective nature-based solutions to enhance coastal resilience, with simulation studies demonstrating that well-managed restoration can reduce inland flooding from storm surges, yielding ecological and socioeconomic gains (Juanico D.E.O, 2022). National mangrove inventories establish health baselines—10 dominant species (*Rhizophora apiculata* 35%), density 2,800 trees/ha, DBH 12.5cm, height 8.2m—that this study will compare against Balogo's forest structure, establishing SDG 14.4 (fisheries sustainability) monitoring (Primavera et al., 2016). Successful restorations achieve 75% survival after 3 years through hydrological management, providing technical guidance for CBSUA's CBMRC efforts in Pasacao (SDG 13.3 climate education/action; Long et al., 2018). However, despite their importance, mangrove forests are declining globally due to deforestation, climate change, and human activities such as harvesting and land conversion, threatening their essential coastal protection services (Xie et al., 2024; PubMed, 2024). Primary threats—aquaculture conversion (35%), logging (25%), causing 1.5% annual loss—underscore the urgency of Balogo's conservation planning (SDG 15.2 sustainable forest management; Richards & Friess, 2016).

Objective of the study – Generally, the study assessed mangrove conservation in Balogo, Pasacao, for coastal protection. This study aimed to address the following:

- assess the current health status of the mangrove forest at Balogo, Pasacao, in terms of species composition, density, diameter at breast height (DBH), and tree height.
- determine the mangrove conservation efforts at Balogo, Pasacao, Camarines Sur.
- draft and formulate mangrove conservation and coastal protection plan.

2. Methodology

This section presents the systematic approach and procedural framework used to assess the mangrove forest health, evaluate existing conservation efforts, and formulate a strategic protection plan for Balogo, Pasacao. By employing a mixed-methods research design, the study integrates quantitative ecological data—gathered through belt-transect surveys and GIS mapping with qualitative insights obtained from semi-structured interviews with key institutional stakeholders. The following sections detail the research design, sampling techniques, data gathering procedures, and the statistical treatments applied to ensure a rigorous and scientifically sound assessment of Balogo's mangrove ecosystem as a vital coastal defense.

Research Design - This study utilized a mixed-methods research design to evaluate mangrove health and conservation efforts in Balogo, Pasacao. The quantitative component focused on gathering objective ecological data—such as species composition, density, diameter at breast height (DBH), and tree height—to establish a baseline for forest vitality. Simultaneously, the qualitative component employed purposive sampling to conduct semi-structured interviews and document reviews with key institutional stakeholders, including the MangRASS Organization, LGU-Balogo, and the Municipal Agriculture Office. This dual approach integrated statistical data with thematic insights to provide a comprehensive basis for formulating a strategic mangrove protection plan.

Research Method - The study implemented the belt-transect method following the standardized DENR-PAWB (2019) guidelines to assess the ecological status of the forest. A 100-meter baseline transect was laid parallel to the shoreline, with perpendicular transects established at 100-meter intervals extending inland toward the landward zone. Within these transects, 10 m × 10 m plots were systematically placed at 50-meter intervals to record structural data. Field measurements were executed using diameter tape for DBH, meter sticks and metal tape for height estimation, and visual assessments for canopy cover, while three 2 m × 2 m subplots were nested within each larger plot to quantify seedling and sapling density for regeneration analysis. To complement the physical survey, qualitative data were gathered through semi-structured interviews with representatives from the MangRASS Organization and the Municipal Agriculture Office. These sessions were guided by a research instrument validated by a subject matter expert to ensure the questions accurately addressed conservation challenges and governance. Additionally, the study area was mapped using Geographic Information System (GIS) tools and Google Earth to precisely document sampling locations and visualize forest cover. This systematic execution of both field techniques and stakeholder engagement provided the technical data necessary to identify specific ecological gaps and management needs.

Data Gathering Procedure - This study assessed mangrove conservation in Balogo, Pasacao using the belt transect method as outlined in the DENR-PAWB (2019) manual. The researchers first measured the total mangrove forest cover to determine the appropriate length of the transect lines and the number of quadrats to be established. Plastic straw ropes or nylon ropes were used to construct the transect lines and quadrats according to the specified intervals. The researchers then identified, measured, and counted the mangroves within the established 10 m × 10 m quadrats and 2 m × 2 m subplots. Species identification followed the *Field Guide to Philippine Mangroves* by J.H. Primavera, Ph.D. Secondary data were collected and visualized using Geographic Information System (GIS) tools to locate and map the geographic area of the study. Google Earth and Geo-Camera were used to accurately determine and document the specific sampling locations.

Qualitative data to determine the mangrove conservation efforts among LGU-Balogo, the Municipal Agricultural Office (MAO) of Pasacao, and the MANGRASS Organization were gathered using standard environmental study methods, including semi-structured interviews, focus group discussions, and perception surveys. To ensure the reliability and academic rigor of the qualitative phase, the research questionnaire was formally validated by Ms. Rosechel C. Labilles, an expert in the mangrove field and the Adviser of the Bachelor of Science in Marine Biology organization. Her technical expertise ensured that the survey instruments accurately captured the nuances of mangrove ecology and community-led conservation. These approaches captured subjective views by allowing participants to express their opinions, attitudes, and experiences in depth—interviews for individual insights, focus groups for collective dynamics, and surveys for structured responses. Data were systematically recorded through note-taking and audio transcription, then analyzed thematically to identify patterns. Cross-validation was achieved via triangulation across stakeholder groups to enhance reliability and align with DENR-PAWB (2019) ethical protocols for responsible coastal management.

Statistical Treatment of Data - This study assesses the current health status of mangrove forests in Balogo, Pasacao, for coastal protection, while evaluating local conservation efforts and formulating a protection plan. Mangrove vegetation health is quantified through species composition, density, diameter at breast height (DBH), and tree height, using tailored formulas for key attributes: Density, Relative Density, Frequency, Relative Frequency, Dominance (based on basal area from DBH), Relative Dominance, and Species Importance Value (SIV).

- **Density** refers to the number of individual plants of a particular species per unit area (Mueller-Dombois & Ellenberg, 1974). It helps in understanding the abundance of a species in a given ecosystem.
- **Relative Density (RD)** refers to the proportion of a specific plant species in a given area compared to the total number of all plant species present (Curtis & McIntosh, 1951). It helps measure the dominance of a species in a plant community.
- **Frequency** refers to how often a particular plant species appears in a given number of sample plots within a study area (Mueller-Dombois & Ellenberg, 1974). It helps measure the distribution pattern of a species in a plant community.
- ***Relative Frequency (RF)*** is the percentage of occurrence of a particular plant species compared to the total occurrences of all species in a study area (Curtis & McIntosh, 1951). It shows how evenly a species is distributed within a plant community.
- ***Basal area*** refers to the cross-sectional area of a tree trunk at breast height (DBH), calculated by converting the diameter from centimeters to square meters with division by 10,000—since $1m^2 = 10{,}000cm^2$. This standard conversion ensures basal area values are consistent for ecological and management studies. (Forestry Challenge, 2025; FAO, 2015)
- ***Dominance*** refers to the degree to which a particular plant species dominates a community based on factors like size, coverage, or biomass. It is usually measured by basal area (for trees) or cover percentage (for grasses and herbs) (Mueller-Dombois & Ellenberg, 1974).
- ***Relative Dominance (RDo)*** is the proportion of a species' dominance (based on basal area or cover) compared to the total dominance of all species in a plant community (Curtis & McIntosh, 1951). It helps determine which species has the most influence in an ecosystem.
- ***Species Importance Value (SIV),*** also known as the Importance Value Index (IVI), is a measure of the overall ecological dominance of a species in a plant community. It combines Relative Density (RD), Relative Frequency (RF), and Relative Dominance (RDo) to assess a species' significance (Curtis & McIntosh, 1951).

Sampling Station - The study was conducted in the mangrove forests of Barangay Balogo, Pasacao, Camarines Sur, Philippines. Two distinct stations were established for ecological assessment: In *Figure 1*, the area located in Sitio Mainit, Balogo, Pasacao, Camarines Sur, is illustrated with geographic coordinates of 13°29'44.65”N and 123° 4'18.61”E. Belt transects were systematically established parallel to the shoreline to accurately capture the mangrove forest coverage. The total mangrove forest coverage within the study area measures 115 meters, encompassing two transect lines. The mangrove forest assessment was conducted within these designated plots to ensure comprehensive data collection. In *Figure 2*, the area located in Sitio Poñgol, Balogo, Pasacao, Camarines Sur, is illustrated with geographic coordinates of 13°30'7.24”N and 123°3'30.94”E.

Belt transects were systematically established parallel to the shoreline to accurately capture the mangrove forest coverage. The total mangrove forest coverage within the study area measures 240 meters, encompassing three transect lines. The mangrove forest assessment was conducted within these designated plots to ensure comprehensive data collection.

Figure 1

Sampling station 1 in Sitio Mainit, Balogo

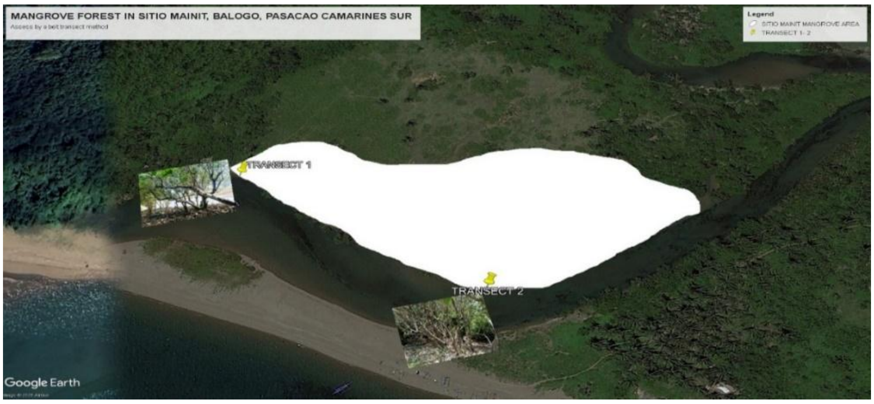

Figure 2

Sampling station 2 in Sitio Poñgol, Balogo

3. Results and Discussion

This section presents the comprehensive findings from the field assessment conducted to evaluate mangrove conservation in Balogo, Pasacao, for coastal protection. The data is organized into key components assessing the current health status of the mangrove forests through species composition, density, diameter at breast height (DBH), and tree height derived from inventories at Station 1 (Sitio Mainit) and Station 2 (Sitio Poñgol). These results inform the determination of ongoing conservation efforts and the formulation of a targeted mangrove protection plan.

3.1 Health Status of mangrove forest in terms of Species composition

Table 1 shows the species composition of mangroves in Sitio Mainit Balogo Pasacao (Station 1) and Sitio Poñgol Balogo Pasacao, Camarines Sur (Station 2). The table includes the parameters such as area, scientific name, species number, frequency that represents the probability of finding a species within the study area, while relative frequency indicates how widely distributed a specific species is compared to others, classified by health status using the Morano (n.d.) legend (Moderately Healthy: 41-60%, Slightly Healthy: 21-40%, etc.), serving as a key metric for landscape-scale spread.

Table 1
Species composition of station 1 & station 2 through frequency and relative frequency (%).

AREA	MANGROVE SPECIES	SPECIES NO.	FREQUENCY	RELATIVE FREQUENCY (RF) %
Station 1	*Nypa fruticans*	9	0.67	40%
	Rhizophora mucronata	7	0.33	20%
	Sonneratia alba	3	0.33	20%
	Avicenia rumphiana	1	0.33	20%
Station 2	*Avicennia marina*	12	0.66	57%
	Sonneratia alba	10	0.5	43%

Percentage (%)	Category	Interpretation
0 – 20%	Not healthy	Rare occurrence; degraded species
21 – 40%	Slightly healthy	Limited evenness; early stress
41 – 60%	Moderately healthy	Balanced distribution; adequate function
61 – 80%	Very healthy	Strong coverage; stable structure
81 – 100%	Extremely heathy	Dominant species; excellent, resilient

The analysis of species composition and spatial distribution in Balogo highlights how topographical features and environmental stressors dictate the diversity and physical form of mangrove forests. In Station 1 (Sitio Mainit), the community displays higher species richness, featuring a varied mix of *Nypa fruticans* (RF: 40%), *Rhizophora mucronata* (RF: 20%), *Sonneratia alba* (RF: 20%), and *Avicennia rumphiana* (RF: 20%). The dominance of *Nypa fruticans* is attributed to a sandbar blockage that restricts tidal flushing and traps freshwater runoff, creating a brackish, low-energy environment where this "Moderately Healthy" species thrives while preventing seaward pioneers from colonizing the area. In contrast, Station 2 (Sitio Poñgol) exhibits a specialized and restricted composition dominated by *Avicennia marina* (RF: 57%) and *Sonneratia alba* (RF: 43%). While these species maintain a "Moderately Healthy" status across the landscape, the *Avicennia marina* species were notably stunted. This physical structure suggests a "scrub" or "dwarf" formation, where the trees prioritize horizontal spread and root development over vertical growth to survive stressors like high-wind exposure and hypersaline conditions. These structural patterns are supported by ecological literature, which notes that physical barriers like sandbars significantly shift composition by altering tidal inundation and drainage patterns. Furthermore, research by Lugo and Snedaker (1974) confirms that mangroves often exhibit reduced height while maintaining high frequency under conditions of high evaporation or salinity. Despite their short stature, these dense formations serve as a vital "bio-shield," as the density and widespread landscape distribution are the most critical factors for breaking wave surges and providing coastal protection.

3.2 Health status of mangrove forests in terms of Density

In table 2, shows the result of mangrove conservation inventory in Sitio Mainit Balogo Pasacao (Station 1), and Sitio Poñgol Balogo Pasacao Camarines Sur (Station 2). The table includes the parameters such as Area, Scientific name, species number, density and relative density classified by health status using the Bengen (1999) legend (Moderately Healthy: 15-29%, Slightly Healthy: 5-14%, etc.) to evaluate the "numerical strength" and "crowdedness" of the forest, providing a quantitative basis for its health and coastal protection capacity.

Table 2
Mangrove Density found in station 1 & station 2.

AREA	SCIENTIFIC NAME	SPECIES NO.	DENSITY	RELATIVE DENSITY %
Station 1	*Nypa fruticans*	9	0.03	29.04%
	Rhizophora mucronata	7	0.0233	22.56%
	Sonneratia alba	3	0.01	9.68%
	Avicenia rumphiana	1	0.0033	3.19%
Station 2	*Avicenia marina*	12	0.02	19.36%
	Sonneratia alba	10	0.017	16.46%

Percentage (%)	Heath Category	Interpretation
0 - 4%	Not healthy	Sparse, degraded forest
5– 14%	Slightly healthy	Low density, stress indicators
15 – 29%	Moderately healthy	Adequate density for function
30 – 49%	Very healthy	Dense, good structural integrity
50 – 100 %	Extremely heathy	Very dense, excellent regeneration

The ecological assessment of Station 1 (Sitio Mainit) and Station 2 (Sitio Poñgol) demonstrates how site-specific environmental pressures and human-induced stressors shape the numerical strength and structural health of these mangrove communities. In Station 1, the forest exhibits a total of 20 individuals with *Nypa fruticans* maintaining the highest density (RD: 29.04%), though the site suffers from a sandbar blockage that traps residential waste and smothers the substrate. This physical barrier contributes to low regeneration rates—recorded at only 15 *Rhizophora mucronata* seedlings—by preventing seeds from reaching the soil and inhibiting vital gas exchange. In contrast, Station 2 displays a higher degree of "crowdedness" with 22 total individuals, dominated by pioneer species like *Avicennia marina* and *Sonneratia alba* that maintain a consistent "Moderately Healthy" relative density status. While this station possesses a more robust regeneration pool of 22 seedlings, the *Avicennia marina* are notably stunted in height, likely a physiological survival response to chemical pollutants from waste runoff and high salinity. This "scrub" formation occurs because mangroves under combined stress often prioritize numerical density over vertical growth, as documented in ecological literature. The dense stands in both areas act as physical filters that trap non-biodegradable debris, creating a "bio-shield" that protects the inner coast but simultaneously stresses the trees by burying their pneumatophores, or breathing roots. Research supports these findings, noting that solid waste accumulation in Philippine mangroves significantly reduces seedling survival and leads to "die-back" even in areas with seemingly stable structural integrity. While the current density of these stands is vital for wave attenuation, persistent pollution threatens to degrade the long-term health and resilience of the individual trees providing this protection.

3.3 Health status of mangrove forests in terms of Diameter at breast height (DBH).

Table 3 shows the result of the mangrove conservation inventory in Sitio Mainit Balogo Pasacao (Station 1), and Sitio Poñgol Balogo Pasacao, Camarines Sur (Station 2). The table utilizes metrics such as Diameter at Breast Height (DBH) classified by health status using the FAO (1994) legend (Very Healthy: 20-30 cm, Moderately Healthy: 10-19 cm, etc.), dominance and relative dominance to evaluate the physical maturity and biomass distribution of the conservation area.

Table 3
Mangrove diameter at breast height (DBH) in station 1 & station 2

AREA	SCIENTIFIC NAME	SPECIES NO.	DBH range (cm)	BASAL AREA (m^2)	DOMINANCE	RELATIVE DOMINANCE %
Station 1	*Nypa fruticans*	9	-	-	-	-
	Rhizophora mucronata	7	3.5- 7	0.12826m^2	0.00043	0.45097
	Sonneratia alba	3	11-20	0.06100m^2	0.000203	0.2129
	Avicennia rumphiana	1	43	0.003317m^2	0.000011	0.01154
Station 2	*Avicennia marina*	12	6-11.5	0.06362m^2	0.0000212	0.02223
	Sonneratia alba	10	7-15.49	0.08650m^2	0.0002883	0.30236

DBH range (cm)	Heath Category	Interpretation
<5	Not healthy	Stunted seedlings; stress/ degradation
5 – 9	Slightly healthy	Sapling stage; regeneration phase
10 – 19	Moderately healthy	Juvenile-mature transition; functional
20 – 30	Very healthy	Good development; structural maturity
>30	Extremely heathy	Matured trees; excellent growth vigor

The analysis of table 3 quantifies the physical dimensions and structural dominance across the sampling stations, revealing a disparity driven by topographical barriers and anthropogenic impacts. In Station 1 (Sitio Mainit), the forest is characterized by a mix of "Slightly Healthy" *Rhizophora mucronata* (DBH: 3.5–7 cm), which holds the highest relative dominance at 0.45097%, alongside a single "Extremely Healthy" *Avicennia rumphiana* with a DBH of 43 cm. In contrast, Station 2 (Sitio Poñgol) exhibits a more uniform "Slightly Healthy" status, where *Sonneratia alba* leads in relative dominance at 0.30236% and the more numerous *Avicennia marina* maintains a smaller diameter range of 6–11.5 cm. These structural values suggest that while Station 1 relies on a few dominant individuals, Station 2 prioritizes numerical density over large diameters as an adaptive response to high-stress seaward conditions, high salinity, and wave energy. This structural degradation is further exacerbated by the heavy accumulation of plastic and residential waste, which acts as a physical tether that smothers breathing roots and restricts biomass accumulation. In Sitio Mainit, the sandbar blockage creates a low-energy trap for such pollution, limiting trees to "Slightly Healthy" DBH ranges and preventing the expansion of basal areas. Ecological literature supports these findings, noting that plastic pollution significantly compromises mechanical stability and nutrient uptake, often leading to "climax" communities that fail to reach mature diameters. While individual dominance is reduced by these environmental stressors, research emphasizes that preserving the remaining structural density is paramount for the continued provision of coastal protection services.

3.4 Health status of mangrove forests in terms of tree height

In Table 4, results of the mangrove conservation inventory show tree height measurements from Sitio Mainit Balogo Pasacao (Station 1) and Sitio Poñgol, Balogo Pasacao Camarines Sur (Station 2). The table utilizes tree height classified by health status using the FAO (1994) species-specific mature tree legend to evaluate vertical growth and canopy development of the conservation area.

Table 4

Mangrove tree height in station 1 & station 2

AREA	SCIENTIFIC NAME	SPECIES NO.	TREE HEIGHT (m)
Station 1	*Nypa fruticans*	9	2-4
	Rhizophora mucronata	7	3.5-7
	Sonneratia alba	3	1,6,6
	Avicennia rumphiana	1	6.5
Station 2	*Avicennia marina*	12	3.5-7
	Sonneratia alba	10	4-7.5

Species name	Height range	Heath category
Nypa fruticans	<2	Not healthy
	2 – 5.9	Slightly healthy
	6 – 9.9	Moderately healthy
	10 – 15	Very healthy
	>15	Extremely heathy
Rhizophora mucronata	<3	Not healthy
	3 – 6.6.9	Slightly healthy
	7 – 11.9	Moderately healthy
	12 – 20	Very healthy
	>20	Extremely heathy
Sonneratia alba	<2	Not healthy
	2 – 4.9	Slightly healthy
	5 – 7.9	Moderately healthy
	8 – 12	Very healthy
	>12	Extremely heathy
Avicennia marina	<2	Not healthy
	2 – 3.9	Slightly healthy
	4 – 6.9	Moderately healthy
	7 – 10	Very healthy
	>10	Extremely heathy
Avicennia rumphiana	<2	Not healthy
	2 – 4.9	Slightly healthy
	5 – 7.9	Moderately healthy
	8 – 12	Very healthy
	>12	Extremely heathy

The vertical structural data from table 4 identifies a mangrove community characterized by immature and stunted canopy development across both sampling stations. In Station 1 (Sitio Mainit), *Rhizophora mucronata* reaches "Moderately Healthy" heights of 7 meters and *Nypa fruticans* shows "Slightly Healthy" heights of 2–4 meters, both of which fall significantly short of optimal mature benchmarks that range from 10 to 30 meters. Station 2 (Sitio Poñgol) exhibits a similar profile wherein *Sonneratia alba* achieves a "Moderately Healthy" height of 7.5 meters, while *Avicennia marina* is limited to "Slightly Healthy" heights of 3.5–7 meters. This overall lack of mature canopy development is attributed to cumulative environmental stressors; specifically, sandbar blockages in Station 1 create stagnant, low-energy conditions, while seaward pioneers in Station 2 prioritize survival over vertical development due to hypersaline stress. These findings are strongly supported by established ecological literature, which indicates that mature *Rhizophora* should exceed 15 meters under optimal conditions, confirming the "Moderately Healthy" status of the 7-meter specimens in Station 1. Research by Primavera et al. (2004) indicates that physical barriers like sandbars suppress canopy heights to "Slightly Healthy" ranges by altering tidal flushing and shifting zonation patterns. Alongi (2002) further confirms that seaward pioneers like *Avicennia marina* exhibit reduced height profiles under salinity stress, while Gevaña et al. (2018) link plastic waste accumulation directly to stunted vertical growth, preventing the transition to "Very Healthy" or "Extremely Healthy" mature statures in Philippine mangroves.

3.5 Mangrove's Species Importance Value (SIV%)

Table 5 shows the result of the mangrove conservation inventory in Sitio Mainit Balogo Pasacao (Station 1), and Sitio Poñgol Balogo Pasacao, Camarines Sur (Station 2). The Species Importance Value (SIV %) classified by health status using the Bengen (1999) legend (Very Healthy: 60-100, Moderately Healthy: 30-59, etc.) serves as a comprehensive indicator of the ecological "standing" and functional contribution of each species to the coastal ecosystem. This metric, which integrates relative frequency, relative density, and relative dominance, identifies which species are the most critical to the structural integrity and protection of the shoreline.

Table 5
Mangrove Species Importance Value

AREA	SCIENTIFIC NAME	SPECIES NO.	SIV %
Station 1	*Nypa fruticans*	9	69.04%
	Rhizophora mucronata	7	43.011%
	Sonneratia alba	3	29.89%
	Avicennia rumphiana	1	23.20%
Station 2	*Avicennia marina*	12	73.38%
	Sonneratia alba	10	59.76%

Percentage (%)	Health category	Interpretation
<10	Not healthy	Negligible presence; degraded status
10 – 29	Slightly healthy	Minor role; limited influence
30 – 59	Moderately healthy	Important associate: functional participation
60 – 100	Very healthy	Major contributor; strong forest structure
>100	Extremely healthy	Keystone/ dominant species excellent ecological role

The analysis of table 5 reveals a distinct distribution of ecological significance across the two sampling stations, where site-specific topographical barriers and anthropogenic pressures dictate the "Importance Value" of each species. In Station 1 (Sitio Mainit), the forest exhibits a more diverse distribution of importance, led by *Nypa fruticans* with a "Very Healthy" Species Importance Value (SIV) of 69.04%, followed by *Rhizophora mucronata* (SIV: 43.011%) and *Sonneratia alba* (SIV: 29.89%). The high dominance of *Nypa fruticans* is a direct response to the sandbar blockage, which creates a low-energy, brackish environment ideal for its proliferation. However, the heavy accumulation of residential waste in this area likely hinders the regeneration of other species, keeping their importance values within the "Moderately Healthy" to "Slightly Healthy" range.

In contrast, the ecological "work" in Station 2 (Sitio Poñgol) is heavily concentrated in just two "Very Healthy" pioneer species: *Avicennia marina* (SIV: 73.38%) and *Sonneratia alba* (SIV: 59.76%). The exceptionally high SIV of *Avicennia marina* reflects its resilience in high-stress seaward zones; despite being stunted by high salinity and wind exposure, its high numerical strength and crowdedness make it the most significant functional component of the local coastal defense. These findings align with ecological literature which emphasizes that "Very Healthy" importance values in pioneer species are essential for a functional "bio-shield". Research further supports that in stressed environments, mangroves maintain their ecological importance through numerical density rather than vertical height, ensuring the stand can still attenuate wave energy despite persistent pollution and stunted growth.

3.6 Mangrove conservation efforts at Balogo Pasacao

To determine the mangrove conservation efforts in Balogo, Pasacao, Camarines Sur, this study determines the integrated contributions of the MangRASS Organization, Municipal Agriculture Office (MAO), and Balogo Local Government Units (LGUs), as ascertained through key informant interviews with MangRASS personnel Mr.

Archangel Chaves Bermundo Jr., MAO representative Ma'am Eden Mortega, and Balogo LGU Captain Hon. Rodel O. Delos Santos. These entities address pressing threats like habitat degradation, pollution, illegal harvesting, and climate-induced vulnerabilities, restoring mangrove forests that deliver vital ecosystem services like coastal erosion control, storm surge protection, biodiversity support, and enhanced fisheries in high-risk zones, including Sitio Mainit and Sitio Poñgol. MangRASS personnel, as articulated by Mr. Archangel Chaves Bermundo Jr. during the key informant interview, reported that the organization functions as the frontline grassroots implementer, cultivating and selling propagules at 25 pesos each to corporate partners like Shell Foundation, Concentrix, and Petron, as well as institutions such as PAWADI water district, LTO, and academic groups including CBSUA students, with revenue directly funding propagule planting events—the most recent on December 20, 2025, planting 500 *miapi, bakhaw, pagatpat, saging-saging,* and other mangrove propagules ordered by PAWADI at a designated coastal site in Barangay Balogo.

This includes Information, Education, and Communication (IEC) campaigns emphasizing 1-2 meter spacing for optimal growth and survival, coastal clean-ups (e.g., in Barangay Sta. Rosa Del Sur) to remove smothering debris, on-site orientations before seedling distribution and for rehabilitation projects, recruitment of nearby residents and volunteers for training/seminars on mangrove ecology/conservation, regular monitoring after planting (checked at every gathering, with daily checks across barangays) and mapping of mangrove extent/health depending on soil conditions and clustering, and community-based enforcement patrols that file community blotters under Republic Act 7161 to protect the MangRASS Mangrove Nursery from illegal theft of propagules or vetiver grass.

Collaborators, including other LGUs, national agencies, Shell Foundation (which helped build the nursery), PAWADI, Daruanak Eagles Club, Concentrix, Petron, CBSUA students, and Sangguniang Kabataan Councils of Balogo contribute funds/donations, equipment, and nursery organization, supported by formal MOAs with BFAR, DOLE registration, and complete agency documentation, though challenges like bad weather, high waves, typhoons, and waste pollution persist. The MAO representative, Ma'am Eden Mortega, highlighted in the interview that the office has spearheaded conservation efforts, including active contributions of propagules and seedlings to planting events most recently on June 2, 2025, at Sitio Poñgol in Barangay Balogo, Pasacao, where 300 propagules were planted involving 100 participants, while leading IEC campaigns, conducting training and seminars on mangrove ecology and conservation, organizing coastal clean-ups targeting mangrove areas, spearheading rehabilitation and restoration projects, establishing marine protection zones or sanctuaries, and performing regular monitoring and mapping of mangrove extent.

These efforts are bolstered by robust multi-stakeholder collaborations in Balogo, involving LGU Balogo, BFAR, Daruanak Eagle Club, Microfinance, Concentrix Naga, Bantay Dagat, MangRASS Organization, and Camsur Cooperative, where LGU Balogo leads maintenance of conserved areas and mobilizes volunteer personnel for planting; BFAR provides technology transfer for mangrove seedling production; Daruanak Eagle Club, Microfinance, and Camsur Cooperative supply dedicated volunteer personnel; Concentrix Naga participates in planting activities; Bantay Dagat handles monitoring; and MangRASS conducts pre-planting orientations, planting, and post-planting monitoring. Since July 2018, these partnerships have restored and conserved an estimated 0.60 hectares, with 16,830 mangroves planted and ongoing monitoring to track survival rates and progress, despite challenges including natural calamities like typhoons, where boats are inserted into mangrove forests to avoid sea washout, causing major destruction and damage to pneumatophores, though coordinated roles suggest strong formal and informal agreements supporting targeted interventions.

Balogo LGU Captain Hon. Rodel O. Delos Santos emphasized in the interview that the LGU is responsible for leading execution and long-term stewardship of mangrove conservation, conducting regular clean-ups (e.g., the December 15, 2024, coastal clean-up led by the Land Transportation Office [LTO] in partnership with the Shell Foundation) to maintain site cleanliness post-planting, enforcing strict no-cutting policies through community patrols under RA 7161, and monitoring overall coastal and mangrove health via volunteer mobilization and policy enforcement. This effort is bolstered by a multi-stakeholder three-way framework where MangRASS handles propagule production and education; the Municipal Agriculture Office (MAO) provides technical coordination and direct action; and LGUs ensure overarching governance, with key partners extending this model including national agencies like LTO and the Department of Agriculture (DA) the latter via a formal MOA with Balogo LGU for adaptive conservation activities social programs such as Pantawid Pamilyang Pilipino Program (4Ps), community groups like BAWADI Organization (providing funding for mangrove propagule events, e.g., December 27, 2024), and academic institutions like Central Bicol State University of Agriculture (CBSUA), which led training, seminars, restoration, and planting in 2023 with community participation.

Together, these collaborations have restored 1 hectare of mangroves in Sitio Pongol and Sitio Mainit (e.g., alongside CBSUA and Pasacao LGU in Sitio Mainit), though progress monitoring reveals challenges from waste accumulation and natural calamities like typhoons, which damage mangrove volume and species, fostering a resilient, cyclical partnership model—sustained by joint events, awareness campaigns, and adaptive agreements—that enables recovery from disturbances and enduring coastal resilience in Pasacao.

3.7 Mangrove Conservation and Coastal Protection Plan

The formulation of this four-year Strategic Mangrove Conservation and Protection Plan is a direct response to the critical ecological stressors identified during the field assessment in Balogo, Pasacao. The study's findings revealed that while the mangrove ecosystem remains functional, it is currently reaching its threshold of resilience due to significant hydrological disruptions at Station 1 caused by sandbar formations and the prevalence of "stunted" scrub growth at Station 2. Furthermore, the pervasive accumulation of plastic waste across both sites poses an immediate threat to pneumatophore respiration and seedling survival. Without a structured, long-term intervention, these stressors will lead to a permanent decline in forest density, leaving the Balogo coastline increasingly vulnerable to storm surges and erosion. This plan, therefore, serves as a vital roadmap to transition the forest from a state of environmental stress into a robust and self-sustaining "bio-shield" through science-based restoration and community-led governance.

The four-year mangrove conservation and protection plan for Balogo, Pasacao, Camarines Sur presents a structured and systematic framework aimed at ecological restoration, community empowerment, and long-term sustainability. Mangrove ecosystems provide multiple ecological and socio-economic services including coastal protection, biodiversity support, carbon sequestration, and livelihoods for adjacent coastal populations (see systematic review by Gerona-Daga & Salmo, 2022; Mangroves provide breeding grounds and habitat). In the Philippine context, mangroves have historically declined due to conversion to aquaculture, urban development, and other anthropogenic pressures, which underscores the need for thoughtful rehabilitation and protection programs (Primavera & Esteban, 2008)

The decision to implement the plan over four years is grounded in the biological and socio-institutional dynamics of mangrove ecosystems. Mangrove restoration is not an instantaneous process; seedlings require prolonged establishment periods to develop structural integrity and resilience against tidal inundation, salinity gradients, and storm events. Indeed, the gap between restoration activities and measurable ecological outcomes (e.g., coastal protection) can span several years, making a prolonged timeframe essential for meaningful assessment and adjustment (Juanico, 2022). A shorter project timeframe might not allow sufficient monitoring to capture survival rates and ecosystem service delivery, while an excessively extended timeframe risks strained financing and community fatigue.

Year 1 activities focus on baseline assessment and planning. Establishing the current ecological condition of mangrove stands through inventories and mapping ensures that interventions are evidence-based. Effective planning also includes community mobilization and local policy development, which enhances local ownership and compliance (Pulhin, Gevaña, & Pulhin, 2017). This phase is foundational; inaccuracies in site assessment can lead to failed restoration efforts and wasted resources.

Year 2 centers on rehabilitation and initial protection measures. The larger budget allocation during this phase reflects typical costs associated with nursery establishment, seedling production, and labor-intensive planting (Primavera & Esteban, 2008). Rehabilitation must be paired with protective measures such as signage, fencing, and law enforcement to safeguard against illegal harvest and environmental disturbances. This dual focus ensures that newly planted mangroves are given the best chance to survive and mature.

Year 3 shifts emphasis toward monitoring and community engagement. Longitudinal monitoring is crucial to evaluate survival rates and growth trajectories of replanted areas, thereby enabling adaptive management (Primavera & Esteban, 2008). Trainings and environmental education empower coastal residents to act as stewards of their resources, which is recognized as a best practice in community-based conservation (Pulhin et al., 2017). Introducing alternative livelihoods such as eco-tourism or sustainable aquaculture helps reduce dependency on mangrove exploitation while enhancing household incomes.

Year 4 targets sustainability, expansion, and institutionalization. Evaluations conducted in this phase determine the overall success of the project, facilitate refinement of strategies, and highlight areas for future growth. Expanding reforested areas and strengthening local policies solidify the conservation gains achieved. Institutionally, forming or strengthening a mangrove management council embeds protection practices into local governance structures, increasing the likelihood that gains will endure beyond the project period.

Overall, the plan offers a balanced integration of scientific principles, community participation, and financial planning. Distributing the ₱1,900,000 budget across the four years aligns resources with the ecological and social needs of each phase, from data gathering to long-term maintenance. In conclusion, the four-year timeframe allows for comprehensive planning, effective implementation, consistent monitoring, and sustained community engagement, which together are critical to realizing long-term conservation outcomes for mangrove ecosystems in Balogo, Pasacao.

4. Conclusion

The ecological assessment of the mangrove forests in Barangay Balogo, Pasacao, reveals a resilient but physically compromised ecosystem that serves as a vital natural "bio-shield" for the community. The study identified two distinct forest structures: Station 1 (Sitio Mainit), which hosts a more diverse but hydrologically restricted community dominated by *Nypa fruticans*, and Station 2 (Sitio Poñgol), a specialized pioneer stand characterized by high numerical density and stunted *Avicennia marina*. Across both stations, the mangrove health status ranges from "Slightly Healthy" to "Moderately Healthy," with a notable absence of "Very Healthy" or "Extremely Healthy" mature canopy development due to environmental and anthropogenic stressors. The primary factors inhibiting the forest's full ecological potential are topographical barriers and plastic pollution. In Sitio Mainit, a sandbar blockage restricts tidal flushing, creating a low-energy environment that traps residential waste and hinders natural regeneration. In Sitio Poñgol, mangroves have adapted to high-stress seaward conditions and waste accumulation by prioritizing numerical density over vertical growth—a physiological response known as "scrub" formation—to maintain their protective functions.

Despite these challenges, the high Species Importance Value (SIV) of pioneer species and the robust "crowdedness" of the stands provide essential coastal protection benefits, which are valued at over $65 billion globally and estimated at millions of pesos locally. However, the persistent accumulation of non-biodegradable debris threatens to degrade this natural infrastructure over time. To ensure long-term resilience and alignment with Sustainable Development Goals 13 (Climate Action) and 14 (Life Below Water), the study emphasizes the urgent need for the Mangrove Conservation and Protection Plan (2026–2030). This plan focuses on hydrological restoration, intensified waste management, and community-led monitoring to transition these vital ecosystems from their current "stunted" state to a fully functional and resilient coastal defense system.

***Implication for Learners* -** The ecological study of Balogo's mangroves serves as a living laboratory where students can observe how nature adapts to human-induced challenges. By examining the "scrub" or stunted growth of *Avicennia marina* in Sitio Poñgol, learners gain firsthand insight into how high salinity and pollution force plants to prioritize survival density over height. Participation in community-led initiatives like the MangRASS seedling programs and coastal clean-ups transforms abstract concepts of biology and environmental science into tangible actions for climate resilience. Furthermore, exposure to technical tools such as GIS mapping and the calculation of Species Importance Values (SIV) equips students with practical, career-ready skills in environmental management and data analysis.

Implication for Teachers and Academe - For educators and academic institutions, this research provides a rich, localized dataset to contextualize instruction in environmental science, mathematics, and social governance. Teachers can utilize specific health metrics, such as the DBH and height disparities between the two stations, to create interdisciplinary lessons that link botanical physiology with real-world anthropogenic stressors like plastic accumulation. At the institutional level, the academe is positioned as a vital technical partner through the proposed Strategic Mangrove Conservation and Protection Plan (2026–2030), which bridges the gap between scientific monitoring and local government policy. By leading "Trainers Training" programs and providing quarterly GIS evaluations, academic institutions like CBSUA-Pasacao can ensure that conservation efforts remain evidence-based while fostering long-term sustainable development within the region.

AI declaration: Grammarly April 2026 – used for grammar checking, Perplexity AI, April 2026 – used for brainstorming and constructing paragraph.

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