

Species Composition and Rhizophora Dominance in a Rehabilitated Mangrove Area at Panatao Port, Claver, Surigao del Norte, Philippines

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ABSTRACT: Quantifying community structure and species diversity in rehabilitated coastal ecosystems is essential for evaluating restoration success and supporting evidence-based coastal management. This study assessed mangrove species composition, relative abundance, dominance, and diversity at Panatao Port, Barangay Panatao, Claver, Surigao del Norte, Philippines, a rehabilitated coastal greenbelt adjacent to port infrastructure. Field sampling was conducted during low tide from March 15–17, 2025, using line transects and quadrat sampling across three permanent transects (T1–T3), comprising nine 10 m × 10 m plots with a total sampled area of 900 m². All true mangrove trees were identified and enumerated. Species richness (S), Simpson dominance (D), Shannon–Wiener diversity (H'), and Pielou's evenness (J) were calculated using PAST software (v4.03). Only two true mangrove species were recorded, *Rhizophora apiculata* and *Rhizophora mucronata*, indicating low species richness. A total of 490 individuals were recorded, with *R. apiculata* strongly dominating the community (476 individuals; 97.14% relative abundance), whereas *R. mucronata* accounted for only 14 individuals (2.86%) and was absent from T2. Accordingly, Shannon–Wiener diversity was very low across the transects (T1: H' = 0.1914; T2: H' = 0.0000; T3: H' = 0.1095; overall: H' = 0.1297), accompanied by high Simpson dominance (D = 0.9445) and low overall evenness (J = 0.1872). Comparison with natural and rehabilitated mangrove forests in Surigao del Norte indicated that the Panatao Port stand exhibited a highly simplified community structure dominated by a single species, potentially reflecting historical species-selection bias during planting, localized intertidal conditions, and port-related disturbance. These findings highlight the need to shift coastal rehabilitation from single-species revegetation toward multi-species ecological mangrove restoration through targeted enrichment planting of suitable native species, including *Avicennia marina* and *Sonneratia alba*. This study provides baseline information for coastal resource management, long-term ecological monitoring, and future habitat enrichment at Panatao Port.

KEYWORDS: Castal baseline; species composition; *Rhizophora apiculata*; species diversity; community structure

1. Introduction

Mangroves are critical coastal ecosystems that support ecological stability, community resilience, and marine biodiversity. They provide a wide range of ecosystem services, including shoreline protection, carbon sequestration (“blue carbon”), wave-energy dissipation, nursery and feeding habitats for marine organisms, and livelihood opportunities for coastal communities [1, 2]. Despite these important functions, tropical mangrove ecosystems have experienced substantial historical losses due to aquaculture expansion, coastal urbanization, timber extraction, and port development [3, 4]. In response to this degradation, extensive mangrove rehabilitation and ecological restoration programs have been implemented across Southeast Asia [2, 4]. However, many early rehabilitation initiatives experienced high mortality or resulted in structurally simplified stands because of their reliance on fast-growing *Rhizophora* species planted in monospecific configurations, often without adequate consideration of hydrological conditions and natural mangrove zonation [4]. Consequently, evaluating species composition, stand structure, abundance, and community diversity in rehabilitated mangroves is essential for assessing their ecological development and long-term restoration success [4, 5].

The Philippines supports considerable mangrove diversity, with approximately 39 mangrove species reported nationwide [6]. Nevertheless, mangrove forests have declined substantially over the past several decades as a result of land conversion and other anthropogenic pressures [3, 6]. The Department of Environment and Natural Resources–Forest Management Bureau (DENR-FMB) estimated the country’s remaining mangrove cover at approximately 311,400 ha in 2020 [7]. Surigao del Norte contains extensive mangrove habitats, but their ecological condition varies considerably between relatively protected island environments and more heavily disturbed mainland coastal areas. Recent assessments have documented comparatively diverse mangrove communities at Mahaba Island ($S = 5$) [8], Bagakay Trail Lagoon ($S = 7$) [9], and the broader Hinatuan Passage ($S > 20$) [10]. In contrast, coastal areas exposed to intensive industrial activities, mining, maritime transportation, and other anthropogenic pressures may exhibit reduced structural complexity and species diversity [5, 11]. These contrasting conditions highlight the importance of site-specific assessments for understanding the ecological status of rehabilitated mangrove communities.

In the Municipality of Claver, Surigao del Norte, coastal communities, including Barangay Panatao, depend on mangrove ecosystems for shoreline protection, fisheries support, habitat provision, and broader coastal stability. However, increasing anthropogenic pressures and climate-related disturbances may compromise the ecological integrity of these habitats. This concern is particularly relevant to mangrove stands located adjacent to active maritime infrastructure, where vessel-generated waves, altered coastal hydrology, sedimentation, and localized pollution may interact with historical planting practices to influence community structure and regeneration [5, 11]. Although mangrove rehabilitation has been undertaken across Surigao del Norte, quantitative information on the ecological condition of rehabilitated stands associated with active port environments remains limited.

Panatao Port represents an important coastal transport site where mangrove rehabilitation has previously been undertaken. However, the species composition, relative abundance, dominance, and diversity of the rehabilitated mangrove stand have not been quantitatively characterized. This knowledge gap limits the ability to determine whether previous rehabilitation efforts have developed into a diverse and ecologically resilient mangrove

community or remain dominated by a limited number of planted species. Establishing such baseline information is also important for identifying appropriate management interventions, including enrichment planting and long-term ecological monitoring.

Therefore, this study aimed to assess the community structure and species diversity of the rehabilitated mangrove stand at Panatao Port, Barangay Panatao, Claver, Surigao del Norte. Specifically, the study quantified (1) mangrove species composition and richness, (2) species abundance and relative abundance, (3) species dominance, and (4) community diversity and evenness across the sampled transects. The findings provide baseline ecological information for evaluating the current condition of the rehabilitated mangrove stand and supporting future coastal management, monitoring, and ecological restoration strategies.

2. Materials and Methods

2.1. Study Site Characteristics

The study was conducted in a rehabilitated coastal mangrove stand adjacent to Panatao Port, Barangay Panatao, Claver, Surigao del Norte, Philippines (9.5624° N, 125.7466° E). The site consists of an intertidal mangrove strip bordering active port infrastructure and is regularly exposed to tidal inundation and maritime activities [5, 11]. The location of the study area and the three permanent sampling transects (T1–T3) are shown in Figure 1. Environmental variables, including water quality, sediment heavy-metal concentrations, sediment grain size, and detailed hydrodynamic characteristics, were not measured because the present study focused specifically on mangrove species composition and community diversity.

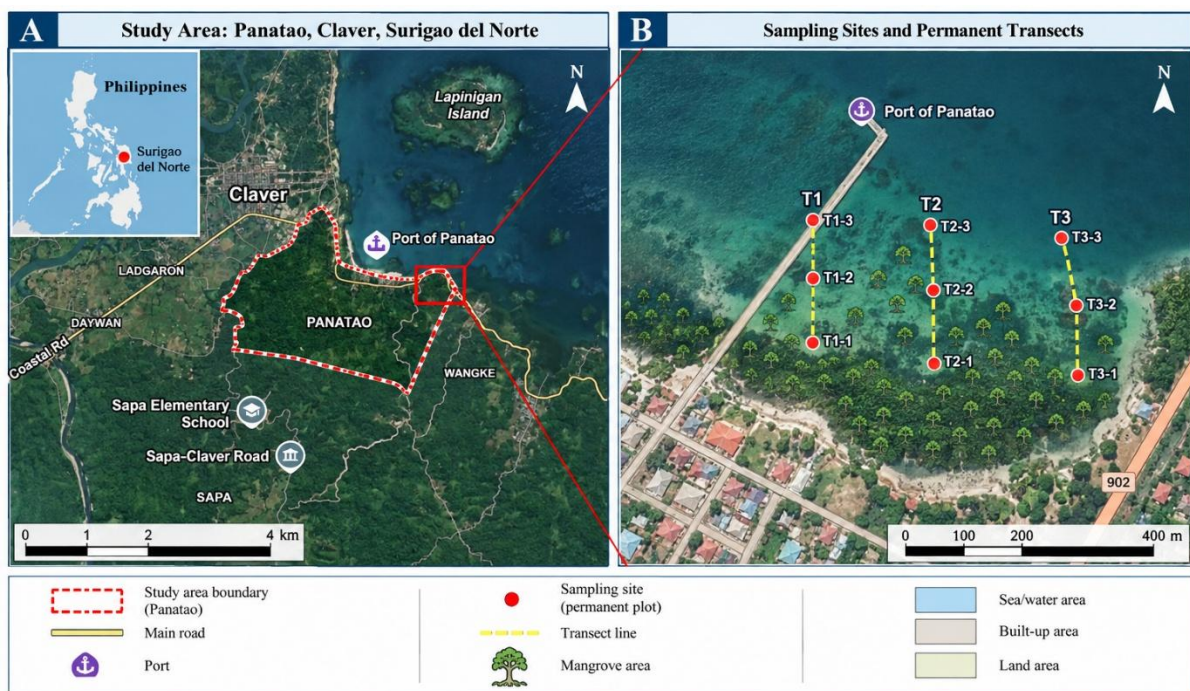


Figure 1: Map of the study area and sampling sites: (A) location of Panatao, Claver, Surigao del Norte, and (B) sampling sites and permanent transects (T1–T3) used for mangrove assessment.

2.2. Rehabilitation History.

Detailed historical records of the rehabilitation program, including the year of establishment, initial species composition, planting density, and subsequent management interventions, were

unavailable from local administrative records. Therefore, these characteristics could not be independently verified in the present study. Based on existing site information and field observations, the surveyed area was treated as a previously rehabilitated coastal greenbelt for the purpose of assessing its current mangrove community structure [4, 5].

2.3. Research Permit and Site Access.

Field sampling and access to the study area were formally authorized by the Municipal Environment and Natural Resources Office (MENRO) of Claver, Surigao del Norte. An official permit was obtained before field sampling commenced.

2.4. Sampling Design.

Field sampling was conducted from March 15–17, 2025, during low-tide conditions. A line-transect and quadrat sampling approach was employed following established mangrove vegetation assessment methods [12–14]. Three permanent transects (T1, T2, and T3) were established approximately perpendicular to the shoreline, extending from the seaward margin toward the landward boundary to represent spatial variation across the intertidal mangrove zone [5, 12]. Each transect contained three 10 m × 10 m (100 m²) quadrats, resulting in nine sampling plots and a total sampled area of 900 m². Initial sampling locations were selected randomly along the shoreline, while subsequent quadrats were positioned systematically along each transect at approximately 15–30 m intervals. Minor adjustments were made where necessary because of tidal accessibility and physical obstructions. The spatial arrangement of the transects and sampling plots is presented in Figure 1B.

2.5. Mangrove Species Identification and Enumeration.

Within each 100 m² quadrat, all true mangrove tree rooted within the plot boundaries were identified and counted. Species identification was based on observable morphological characteristics and standardized taxonomic references for Philippine and tropical mangroves [12, 13, 15–17]. Taxonomic identification was cross-checked using the morphological descriptions provided by Primavera et al. [16] and Tomlinson [17]. The number of individuals belonging to each species was recorded for every quadrat and subsequently pooled by transect and for the entire study site. These data were used to determine species composition, abundance, relative abundance, richness, dominance, diversity, and evenness. Tree height, diameter at breast height (DBH), canopy cover, basal area, and demographic classes were not measured; therefore, the analysis was restricted to species composition and abundance-based community structure.

2.6. Community Structure and Diversity Indices.

Mangrove community structure was quantitatively assessed for each transect and for the pooled study site using species richness, relative abundance, Simpson's dominance, Simpson's diversity, Shannon–Wiener diversity, and Pielou's evenness [14, 18].

Species richness (S) was defined as the total number of mangrove species recorded:

$$S = \text{total number of species recorded}$$

Relative abundance (RA) of each species was calculated as:

$$RA_i = \frac{n_i}{N} \times 100$$

where n_i is the number of individuals belonging to species i , and N is the total number of individuals recorded.

Simpson's Dominance Index (D) was calculated as:

$$D = \sum_{i=1}^S \left(\frac{n_i}{N}\right)^2$$

where higher values indicate greater dominance by one or a few species [14].

Simpson's Index of Diversity ($1 - D$) was calculated as:

$$1 - D = 1 - \sum_{i=1}^S \left(\frac{n_i}{N}\right)^2$$

with higher values indicating greater community diversity.

The Shannon–Wiener Diversity Index (H') was calculated as:

$$H' = - \sum_{i=1}^S p_i \ln(p_i)$$

where:

$$p_i = \frac{n_i}{N}$$

and p_i represents the proportional abundance of species i [14, 18].

Pielou's Evenness Index (J) was calculated as:

$$J = \frac{H'}{\ln(S)}$$

where H' is the Shannon–Wiener diversity index and S is species richness. The index ranges from 0 to 1, with values approaching 1 indicating a more even distribution of individuals among species. When only one species was present ($S = 1$), evenness was reported as not applicable (N/A) because $\ln(1) = 0$ [14].

2.7. Data and Statistical Analysis.

Species counts from the nine quadrats were compiled by transect and for the overall study site. Community diversity indices and descriptive statistics were calculated using Paleontological Statistics (PAST), version 4.03 [18]. Species abundance and diversity metrics were compared descriptively among T1, T2, and T3 to evaluate spatial variation in mangrove community composition across the rehabilitated site. Because the study was based on descriptive vegetation sampling and did not include experimental treatments or environmental predictor variables, no inferential statistical tests were applied.

3. Results

3.1. Species Composition.

The mangrove community at Panatao Port showed very low species richness. Only two true mangrove species, both belonging to the family Rhizophoraceae, were recorded across the nine sampling quadrats: *Rhizophora apiculata* (Bakhaw Lalaki) and *Rhizophora mucronata* (Bakhaw Babae) (Table 1). No other true mangrove species or mangrove associates were recorded within the sampled plots. Thus, the surveyed community was taxonomically restricted to a single family and a single genus. The occurrence of only two species indicates a highly simplified floristic composition within the rehabilitated port-adjacent stand. Compared with the broader diversity reported for Philippine mangrove ecosystems [6, 16], the low richness observed at Panatao Port suggests that the surveyed stand represents only a small subset of the regional mangrove flora. However, species richness alone does not indicate how individuals were distributed between the two recorded species; therefore, species abundance and dominance were further evaluated.

Table 1. Species composition of mangroves recorded at Panatao Port, Claver, Surigao del Norte.

Family	Scientific name	Local name	Ecological category
Rhizophoraceae	<i>Rhizophora apiculata</i>	Bakhaw Lalaki	True mangrove
Rhizophoraceae	<i>Rhizophora mucronata</i>	Bakhaw Babae	True mangrove

3.2. Species Abundance and Relative Abundance.

A total of 490 mangrove individuals were recorded within the 900 m² sampled area. The distribution of individuals between species was highly uneven (Table 2). *R. apiculata* accounted for 476 individuals, corresponding to 97.14% of the total abundance, whereas *R. mucronata* comprised only 14 individuals (2.86%). These results demonstrate strong numerical dominance by *R. apiculata* throughout the study site. Abundance also varied among transects. Transect 1 contained the highest number of individuals (N = 210), consisting of 200 *R. apiculata* and 10 *R. mucronata*. Transect 3 contained 174 individuals, including 170 *R. apiculata* and four *R. mucronata*. Transect 2 had the lowest abundance (N = 106) and consisted exclusively of *R. apiculata*. Thus, *R. apiculata* occurred across all three transects, whereas *R. mucronata* showed a restricted distribution and was completely absent from Transect 2 (Table 2). The dominance of *R. apiculata* indicates that the current stand has a strongly skewed community structure rather than an even distribution of species. The monospecific composition observed in Transect 2 further demonstrates spatial variation within the site. Such patterns may reflect differences in establishment, survival, historical planting practices, or localized environmental conditions [4, 5, 19]. However, because environmental variables and historical planting records were not evaluated in this study, the specific mechanisms responsible for these patterns cannot be determined from the present dataset.

Table 2. Abundance and Relative Abundance of Mangrove Species Across the Three Transects at Panatao Port, Claver, Surigao del Norte.

Scientific name	Local name	T1	T2	T3	Total	Relative abundance (%)
<i>Rhizophora apiculata</i>	Bakhaw Lalaki	200	106	170	476	97.14
<i>Rhizophora mucronata</i>	Bakhaw Babae	10	0	4	14	2.86
Total		210	106	174	490	100.00

3.3. Mangrove Diversity and Community Structure.

The diversity indices further demonstrated the simplified structure of the mangrove community (Table 3). Species richness was two in Transects 1 and 3 but only one in Transect 2. Overall species richness for the study site was therefore $S = 2$. Simpson's Dominance Index was high across all transects, ranging from $D = 0.9093$ in Transect 1 to $D = 1.0000$ in Transect 2, with an overall value of $D = 0.9445$. Correspondingly, Simpson's Diversity Index ($1 - D$) was low, with an overall value of only 0.0555 . A similar pattern was observed for Shannon–Wiener diversity. Transect 1 showed the highest diversity ($H' = 0.1914$), followed by Transect 3 ($H' = 0.1095$), whereas Transect 2 had $H' = 0.0000$ because only one species was present. The overall Shannon–Wiener index was $H' = 0.1297$. Pielou's evenness was also low in Transects 1 ($J = 0.2762$) and 3 ($J = 0.1579$), producing an overall value of $J = 0.1872$. Evenness was not calculated for Transect 2 because its species richness was one, making the denominator $\ln(S)$ equal to zero. Collectively, the high Simpson dominance and low Simpson diversity, Shannon diversity, and evenness demonstrate that the sampled mangrove community was characterized by both low species richness and highly unequal species abundance. The pattern was strongest in Transect 2, which was completely dominated by *R. apiculata*. The overall low diversity was therefore not attributable solely to the presence of only two species but was further intensified by the overwhelming numerical dominance of *R. apiculata*.

Table 3. Diversity Indices for Individual Transects and the Overall Sampled Mangrove Community at Panatao Port.

Diversity index	Transect 1	Transect 2	Transect 3	Overall site
Species richness (S)	2	1	2	2
Total individuals (N)	210	106	174	490
Simpson Dominance Index (D)	0.9093	1.0000	0.9551	0.9445
Simpson Diversity Index ($1 - D$)	0.0907	0.0000	0.0449	0.0555
Shannon–Wiener Index (H')	0.1914	0.0000	0.1095	0.1297
Pielou's Evenness Index (J)	0.2762	N/A*	0.1579	0.1872

Note: N/A indicates that evenness could not be calculated because only one species was present ($S = 1$).

3.4. Comparison with Other Mangrove Communities.

The comparatively simplified structure of the Panatao Port mangrove community becomes more apparent when considered alongside mangrove studies from Surigao del Norte and adjacent areas (Table 4). Panatao Port had the lowest reported species richness ($S = 2$) and Shannon diversity ($H' = 0.1297$) among the sites included in the comparison. The stand was also characterized by the strongest single-species dominance, with *R. apiculata* representing 97.14% of all recorded individuals. In comparison, the other listed sites contained between five and more than 20 species and had Shannon diversity values ranging from 0.9800 to 2.1500 (Table 4). Even the rehabilitated/disturbed site at Fabio, Tagana-an, contained six species and showed substantially higher diversity ($H' = 0.9800$). The highest richness and diversity among the compared sites were reported for the Hinatuan Passage, with more than 20 species and $H' = 2.1500$. These comparisons indicate that the Panatao Port stand has a substantially narrower species composition and more pronounced dominance structure than the other mangrove communities considered here. Nevertheless, these cross-site comparisons should be interpreted cautiously because differences in sampling area, survey design, habitat characteristics, disturbance intensity, and analytical procedures among studies may influence reported richness

and diversity values. Therefore, Table 4 provides regional ecological context rather than a direct statistical comparison. The consistently lower values at Panatao Port nevertheless emphasize the importance of continued monitoring and further investigation of the ecological factors associated with its simplified community structure.

Table 4. Comparative Species Richness, Dominant Species, and Shannon Diversity of Selected Mangrove Communities in Surigao del Norte and Adjacent Areas of Mindanao, Philippines.

Study site	Ecosystem type/status	Richness (S)	Dominant species (% abundance)	Shannon index (H')
Panatao Port, Claver	Rehabilitated port-adjacent stand	2	<i>R. apiculata</i> (97.14%)	0.1297 [Present study]
Brgy. Cagdianao, Claver	Mining-adjacent coast	9	<i>R. apiculata</i> (42.1%)	1.6800 [Goloran et al., 2020]
Mahaba Island, Placer	Island mangrove ecosystem	5	<i>R. stylosa</i> (38.5%)	1.2400 [Catulay et al., 2024]
Bagakay Trail Lagoon, Claver	Lagoon/estuarine stand	7	<i>R. mucronata</i> (31.2%)	1.4500 [Bernales et al., 2025]
Fabio, Tagana-an	Rehabilitated/disturbed stand	6	<i>R. apiculata</i> (61.0%)	0.9800 [Plimaco et al., 2023]
Hinatuan Passage	Estuarine network	>20	<i>Sonneratia alba</i> / <i>Rhizophora</i> spp.	2.1500 [Acero et al., 2024]

4. Discussion

The quantitative assessment of the mangrove community at Panatao Port revealed a highly simplified forest structure characterized by very low species richness ($S = 2$) and the overwhelming numerical dominance of *Rhizophora apiculata* (97.14% relative abundance; Tables 1 and 2). This strongly uneven species distribution was reflected in the diversity indices, with a very low overall Shannon–Wiener diversity index ($H' = 0.1297$) and Pielou’s evenness ($J = 0.1872$), accompanied by a high Simpson dominance index ($D = 0.9445$; Table 3). Collectively, these results indicate that the sampled mangrove stand is structurally close to a monospecific community dominated by *R. apiculata* [4, 5].

4.1. Comparative Regional Synthesis.

Comparison with previous mangrove assessments in Surigao del Norte and other Philippine coastal ecosystems further highlights the exceptionally low diversity observed at Panatao Port (Table 4). In nearby Barangay Cagdianao, Claver, Goloran et al. (2020) recorded nine mangrove species with a Shannon–Wiener diversity index of $H' = 1.68$ [5], whereas Bernales et al. (2025) reported seven species ($H' = 1.45$) at Bagakay Trail Lagoon, Claver [9]. Similarly, surveys conducted at Mahaba Island in Placer ($S = 5$, $H' = 1.24$) [8], Barangay Fabio in Tagana-an ($S = 6$, $H' = 0.98$) [6], and the Hinatuan Passage estuarine complex ($S > 20$, $H' = 2.15$) [10] documented substantially greater species richness and diversity than those observed at Panatao Port. More broadly, natural tropical mangrove communities in Mindanao typically comprise multiple species and have been reported to exhibit Shannon–Wiener diversity values ranging from approximately 1.5 to 3.2 [16]. In contrast, the overall value recorded at Panatao Port ($H' = 0.1297$) indicates a markedly simplified community. This difference reflects not only the presence of just two species but also the highly unequal distribution of individuals between them. The results therefore demonstrate a substantial ecological contrast between the rehabilitated Panatao Port stand and the more diverse mangrove communities reported from other regional sites [4, 5]. Nevertheless, these comparisons should be interpreted cautiously

because differences in sampling design, sampling area, habitat characteristics, disturbance intensity, and analytical approaches among studies may influence reported diversity values.

4.2. *Potential Drivers of Rhizophora apiculata Dominance.*

The strong dominance of *R. apiculata* observed at Panatao Port may reflect the combined influence of historical rehabilitation practices, propagule availability, local intertidal conditions, and anthropogenic disturbance. Because these factors were not directly measured in the present study, they should be considered plausible ecological explanations rather than demonstrated causal mechanisms.

4.2.1. *Historical Rehabilitation Practices and Species-Selection Bias.*

Historical species-selection practices may have contributed to the present community structure. Mangrove rehabilitation programs in the Philippines have frequently relied on *Rhizophora* species, particularly *R. apiculata* and *R. mucronata*, because their large propagules are relatively easy to collect, transport, and plant, and they can establish successfully under suitable intertidal conditions [2, 4]. A strong preference for *Rhizophora* during initial planting, particularly without subsequent enrichment using other native taxa such as *Avicennia*, *Sonneratia*, and *Bruguiera*, can result in stands with low species diversity [4, 5]. This explanation is consistent with the strong *R. apiculata* dominance observed at Panatao Port. However, because detailed historical records of the original planting year, species composition, planting density, and subsequent management were unavailable, the extent to which historical planting practices produced the current community structure cannot be directly determined.

4.2.2. *Propagule Availability and Natural Recruitment.*

Propagule characteristics may also influence species establishment and persistence. *Rhizophora apiculata* produces elongated, buoyant propagules that can disperse through tidal waters and establish in suitable muddy intertidal substrates [16, 17]. Once a substantial population becomes established, locally produced propagules may facilitate continued recruitment and reinforce the dominance of the species. Conversely, natural recruitment of other mangrove taxa may be constrained when nearby reproductive populations are sparse or absent. For example, limited availability of propagules from pioneer species such as *Sonneratia alba* and *Avicennia marina* could restrict their natural colonization of rehabilitated sites [4]. Therefore, the low diversity recorded at Panatao Port may partly reflect limitations in propagule supply and natural recruitment. However, propagule availability and recruitment rates were not directly assessed in this study.

4.2.3. *Intertidal Position and Inundation Regime.*

Local hydrological and topographic conditions are important determinants of mangrove species distribution. *R. apiculata* is commonly associated with regularly inundated intertidal environments and fine, muddy substrates [17, 19]. The location of the sampled plots within the intertidal zone may therefore provide conditions favorable to the establishment and persistence of this species while being less suitable for taxa occupying different positions along the tidal gradient [19]. The absence of *R. mucronata* from Transect 2, despite its occurrence in Transects 1 and 3 (Table 2), also suggests small-scale spatial variation within the study area. Such

variation could potentially be associated with differences in elevation, inundation frequency, sediment characteristics, or propagule establishment. However, microtopography, tidal inundation, and sediment properties were not measured; therefore, the observed distribution cannot be attributed to any specific environmental factor based on the present data [4, 19].

4.2.4. Proximity to Port Infrastructure and Anthropogenic Disturbance.

The location of the mangrove stand adjacent to active port infrastructure may represent an additional influence on community development. Port-associated mangroves can be exposed to shoreline modification, altered hydrodynamic conditions, vessel-generated waves, runoff, sediment disturbance, pollution, and human activity [5, 11]. These disturbances may affect seedling establishment, propagule retention, recruitment, and long-term vegetation structure. Species may differ in their tolerance and establishment responses under disturbed coastal conditions, potentially contributing to uneven community composition [4, 11]. Nevertheless, the present study did not directly quantify vessel activity, hydrodynamic alteration, sediment quality, pollution, or other indicators of port-related disturbance. Accordingly, the relationship between port activities and the observed dominance of *R. apiculata* remains a hypothesis that requires further investigation.

4.3. Evidence-Based Findings and Remaining Hypotheses.

An important distinction should be made between patterns directly demonstrated by the present dataset and the ecological mechanisms proposed to explain them. The field data clearly demonstrate that the sampled mangrove community had very low species richness ($S = 2$), was strongly dominated by *R. apiculata* (97.14%), exhibited low Shannon–Wiener diversity ($H' = 0.1297$) and evenness ($J = 0.1872$), and showed spatial variation in the occurrence of *R. mucronata* among transects (Tables 1–3). These findings provide direct quantitative evidence that the rehabilitated stand currently has a highly simplified mangrove community structure. In contrast, the mechanisms responsible for this pattern cannot be conclusively identified from the available data. Environmental variables such as sediment salinity, grain size, heavy-metal concentrations, dissolved oxygen, tidal inundation frequency, and microtopography were not measured, while detailed historical information on planting dates, initial species composition, planting density, and subsequent management was unavailable. Consequently, explanations involving historical species-selection bias, sediment characteristics, contamination associated with nearby activities, hydrological conditions, or differential recruitment should be regarded as testable hypotheses rather than established causal relationships [4, 5, 11]. Future studies integrating vegetation surveys with sediment and water-quality analyses, hydrological measurements, recruitment assessments, and rehabilitation records would help determine the relative importance of these factors in shaping mangrove community development at Panatao Port.

5. Conclusion

This study provides baseline evidence that the rehabilitated mangrove stand at Panatao Port, Claver, Surigao del Norte, has a highly simplified community structure characterized by low species richness and strong dominance of *Rhizophora apiculata* over *Rhizophora mucronata*. The low diversity and evenness values further indicate an uneven community with limited

floristic complexity compared with more diverse mangrove ecosystems reported elsewhere in Surigao del Norte. Although the existing stand provides vegetative cover within the port-adjacent coastal zone, its low species diversity may limit ecological complexity and potentially reduce resilience to future environmental disturbances. These findings highlight the importance of shifting mangrove rehabilitation from predominantly single-species planting toward ecological mangrove restoration (EMR) that considers species diversity, site suitability, tidal conditions, and natural zonation. Future management at Panatao Port should evaluate opportunities for enrichment planting with suitable native species, including *Avicennia marina*, *Sonneratia alba*, and *Bruguiera* spp., while ensuring that species selection is matched to appropriate intertidal conditions. Such measures could improve habitat complexity, biodiversity, ecosystem functioning, and long-term coastal resilience. The interpretation of the present findings is limited by the absence of environmental measurements and detailed historical rehabilitation records. Future studies should therefore integrate multi-season vegetation monitoring with sediment and water physicochemical analyses, tidal and hydrodynamic assessments, recruitment surveys, and comparisons with less-disturbed reference sites. This integrated approach would help identify the environmental and anthropogenic factors controlling mangrove establishment and provide a stronger scientific basis for long-term restoration, monitoring, and coastal resource management in Panatao Port and surrounding areas of Surigao del Norte.

Data Availability

The Datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Author Contribution

Shella Mae T. Laid conceptualized the study, conducted fieldwork, performed data analysis, and prepared the manuscript. Supervision: Dr. Mauricio S. Adlaon.

Competing Interest

No conflict of interest was reported by the author.

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