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Community Structure of Mangrove Species in Bagakay Trail Lagoon, Claver, Surigao del Norte, Philippines

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ABSTRACT

Mangroves are highly valuable ecosystems that provide essential goods and services, including stabilizing coastlines, regulating water, supporting fisheries, and sequestering carbon. This study assessed the community structures of mangroves in Bagakay Trail Lagoon, Claver, Surigao del Norte. Four sampling stations with transect lines ranging from 150–200 m laid perpendicular to the shoreline were established. Additionally, five plots, each measuring 10 m × 10 m, were established at each station, with an interval of 20–30 m between plots. The mangrove leaf specimens were collected for proper identification of species. The study's results identified thirteen mangrove species classified under nine families, all of which were categorized as least concern species based on the International Union for Conservation of Nature. The species diversity of the sampling area falls under very low diversity (H'=0.852), which may be attributed to anthropogenic activities and the recent typhoon Rai, which devastated the area. The most ecologically important species were *Avicennia officinalis* and *Nypa fruticans*, with high importance values suggesting their dominance and significant influence on the ecosystem. It is recommended that both government and non-government organizations implement site-specific conservation interventions to improve species diversity and ensure the sustainability of the mangrove ecosystem.

1. Introduction

Mangroves are vital components of tropical coastal ecosystems, providing essential ecological services and functions. They provide habitat for local flora and fauna, protect and stabilize coastlines, enrich coastal waters, yield commercial forest products and support coastal fisheries (Akram et al. 2023). According to Licuanan et al. (2018), the Philippines is considered one of the biodiverse countries for coastal plant diversity in the world because of its archipelagic orientation and tropical climate. Its coastline stretches approximately 36,000 km, covering more than 7,000 islands (Garcia et al. 2014). However, the Philippines has also been constantly listed as one of the world's top biodiversity hotspots (United Nations Development Programme 2022).

Mangroves provide a wide array of benefits, including wood for firewood, charcoal, and construction (Rasquinha and Mishra 2021). Moreover, they offer coastal protection acting as the first line of defense by breaking the force waves, thereby preventing flooding and erosion (Menéndez et al. 2020). They also serve as vital habitats (Cañizares and Seronay 2016), nurseries for certain marine species (Long and Giri 2011), and nesting grounds for hundreds of bird species (Garcia et al. 2014; Tanalgo et al. 2019). However, despite their immense value, mangroves are still degraded and destroyed through human-made pressure. That is apart from the stress caused by inevitable environmental factors. Some estimates place the annual global loss rate at one million hectares, with certain regions facing the risk of complete collapse. Moreover, mangrove afforestation is constantly challenged by the year-round scarcity of propagules. This scarcity is attributed to several factors, including irregular flowering, insufficient seed viability, seed predation, poor post-dispersal seed growth, and low germination rates (Namitha et al. 2024). Despite dramatic losses and ongoing problems, conservation and rehabilitation measures offer a glimmer of hope for mangroves in the Philippines. The Department of Environment and Natural Resources is responsible for the management of mangroves. A move toward mangrove conservation began in 1976 when the government established the National Mangrove Committee under the Ministry of Natural Resources, the predecessor to the Department of Environment and Natural Resources.

The municipality of Claver, Surigao del Norte, is a rapidly developing municipality. The Bagakay Mangrove Trail Lagoon has become a popular tourist destination, leading to human intervention and habitat modifications for aesthetic and functional purposes. To our knowledge, no prior ecological assessment has been conducted in the Bagakay Trail Lagoon mangrove ecosystem. This study provides the first baseline data on species composition, diversity, and conservation status in this emerging ecotourism site. Given the rapid tourism-driven development and lack of ecological monitoring, there is an urgent need to assess the current condition of the mangrove community to inform appropriate conservation strategies. Thus, this study aims to assess the community structure of mangroves in Bagakay Trail Lagoon, Claver, Surigao del Norte, by determining its species composition, diversity, density, frequency, dominance, and conservation status. The findings will also provide valuable information for concerned agencies, such as the Municipal Environmental and Natural Resources Office (MENRO), to better formulate sustainable development management strategies.

2. Materials and Methods

2.1. Study Site

The study was conducted in Bagakay Trail Lagoon in Brgy. Bagakay, Claver. Bagakay is situated at approximately 9.5747, 125.7308 (9° 34' North, 125° 44' East), in the municipality of Claver (**Fig. 1**). Elevation at these coordinates is estimated at 9.6 meters or 31.5 feet above mean sea level. The Mangrove Trail Lagoon is a sheltered estuary with predominantly muddy, fine-silt substrates that support dense stands of native mangroves, covering a total land area of approximately 8 hectares. It serves as an eco-tourism and community livelihood area, surrounded by mixed residential areas and small-scale tourism facilities, such as boardwalks, floating cottages, and recreation zones. Moreover, the municipality of Claver is a rapidly developing municipality located in the Province of Surigao del Norte, with large-scale mining and port activities (PhilAtlas 2022).

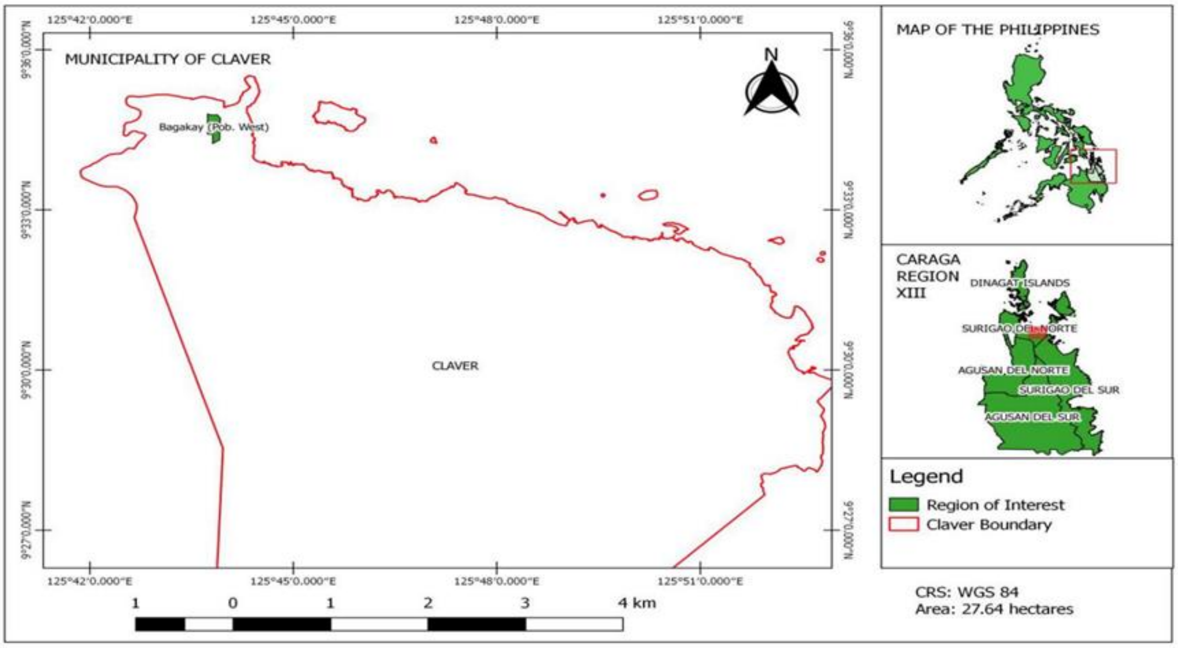

Fig. 1. Map showing the locale of the study.

2.2. Sampling Design and Layout

Four sampling stations were established in the area. The sampling stations were selected to represent the varying levels of anthropogenic disturbance along the lagoon, from the more disturbed to the less disturbed interior section. A transect line ranging from 150–200 m for each station was laid perpendicular to the shoreline to capture the full range of mangrove zonation from the seaward fringe to the landward fringe. This orientation ensures that sampling systematically traverses gradients in tidal inundation, salinity, substrate, and species composition, providing a representative ecological profile of the area (Biodiversity Management Bureau 2017). Moreover, within the transect line, five 10 m × 10 m plots for the sampling of the mangrove trees (mangrove with a diameter at breast height (DBH) of ≥ 4 cm were recorded) were set up with an interval of 20–30 m between plots (**Fig. 2**).

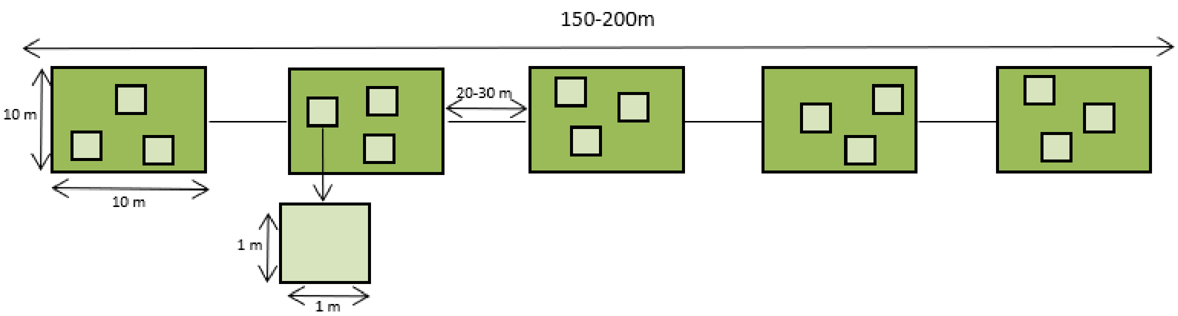

Fig. 2. Plot layout of the study.

All mangrove individuals within each plot were identified and counted; the diameter at breast height (DBH) in cm, basal area in meters, and the density of the mangrove species were also measured. For the regeneration of the mangroves, each 10 m × 10 m plot had three 1 m × 1 m subplots arranged randomly, and all the mangrove species at a seedling stage were counted and identified. All mangrove species within the plots were characterized as a seedling (< 1 m height), sapling (> 4 cm diameter, height > 1 m), and mature trees (> 1 m height and ≥ 4 cm diameter). The height of the mangrove within the sampling plot was measured using marked bamboo poles or sticks. The stick method has been reported to have a mean measurement error of ~15% under field conditions, primarily due to alignment and observer estimation errors (Saliu et al. 2021).

2.3. Mangrove Species Identification

Mangrove species were identified through field characteristics and cross-referenced using the field guide manual of Philippine Mangroves authored by Primavera et al. (2004).

2.4. Diversity Indices

The Mangrove community's species diversity was calculated using Shannon-Wiener's diversity index, which provides a quantitative description of mangrove habitats in terms of species distribution and evenness. Shannon-Wiener diversity index was calculated using Equation 1 (Omoro et al. 2010):

$$\text{Shannon-Wiener Diversity } (H')\text{: } H' = \sum [pi \times (\ln pi)] \tag{1}$$

where *pi* is the proportion of individuals of the i-th species expressed as a portion of the total cover and *ln* is the log base n.

The diversity values for Shannon-Wiener were classified based on the scale developed by Fernando (1998), presented in **Table 1**.

Table 1. Modified scale by Fernando (1998)

H' Values	Descriptive interpretation
> 3.50	Very high
3.00–3.49	High
2.50–2.99	Moderate
2.00–2.49	Low
< 1.99	Very low

2.5. Vegetation Analysis

For the analysis of vegetation, the following parameters were used: population density, frequency, dominance, relative density, relative frequency, relative dominance, and importance value. Species composition and community structure of a plant community can be studied using vegetation analysis. The technique is a crucial tool for land classification, managing endangered plants and animal species, and conserving soil and water (Maridi et al. 2014). Measuring species frequency, density, dominance, and importance value were calculated using Equations 2–8 (Nursanti et al. 2021):

$$\text{Population Density} = \frac{\text{Number of Individuals}}{\text{Total Area Sampled}} \tag{2}$$

$$\text{Relative Population Density (\%)} = \frac{\text{Density for a Species}}{\text{Total Density for all Species}} \times 100\% \tag{3}$$

$$Frequency = \frac{Number\ of\ Plots\ wherein\ Species\ Occurs}{Total\ Number\ of\ Plots} \quad (4)$$

$$Relative\ Frequency\ (\%) = \frac{Frequency\ Value\ of\ a\ Species}{Total\ Frequency\ Value\ for\ all\ Species} \times 100\% \quad (5)$$

$$Dominance = \frac{Total\ Basal\ Area\ of\ each\ Tree\ Species\ in\ all\ Plots}{Total\ Area\ Sampled} \quad (6)$$

$$Relative\ Dominance\ (\%) = \frac{Dominance\ of\ a\ Species}{Total\ Dominance\ of\ all\ Species} \times 100\% \quad (7)$$

$$Importance\ Value\ (\%) = Relative\ Density\ (\%) + Relative\ Frequency\ (\%) + Relative\ Dominance\ (\%) \quad (8)$$

2.6. Mangrove Habitat Assessment

The percent crown cover, regeneration per m², average height, and the number of seedlings (less than 1 m) and saplings (more than 1 m but with less than 4 cm DBH) were also recorded. Crown diameter was measured as the average of the widest crown width and its perpendicular measurement taken at 90°. The crown cover was calculated using Equations 9–11.

$$Percent\ crown\ cover\ (\%) = \frac{Total\ Crown\ Cover\ of\ All\ Trees}{Total\ Area\ Sampled} \quad (9)$$

$$Regeneration\ per\ m^2 = \frac{Total\ Regeneration\ Count}{Total\ Regeneration\ Plots} \quad (10)$$

$$Average\ height\ (m) = \frac{Total\ Height\ of\ Trees\ Recorded}{Total\ Number\ of\ Trees\ Recorded} \quad (11)$$

2.7. Conservation Status

The conservation status of each mangrove species in the area was determined through the International Union for Conservation of Nature (IUCN 2020) Red List data.

3. Results and Discussion

3.1. Species Composition

A total of thirteen (13) mangrove species were identified in Bagakay Trail Lagoon, Claver, Surigao del Norte, belonging to nine families (**Table 2**). The family Rhizophoraceae exhibited the highest species richness, represented by *Rhizophora apiculata*, *Rhizophora mucronata*, and *Bruguiera parviflora*. A similar trend was reported by Arfan et al. (2023), who identified *R. mucronata* as the most dominant mangrove species in Ampekale Tourism Village, South Sulawesi, Indonesia. The dominance of Rhizophoraceae is a common characteristic of many mangrove ecosystems (Md Isa and Suratman 2021). This is likely attributed to their specialized adaptations, such as aerial roots, viviparous embryos, salt tolerance and high tannin content. These characteristics enhance survival and propagation in challenging environments, even in high-salinity, waterlogged soils, and fluctuating conditions (Tomlinson 2016).

Table 2. Species composition and conservation status of mangroves in Bagakay Trail Lagoon, Claver, Surigao del Norte

Common Name	Scientific Name	Family	Conservation Status (IUCN 2020)	Station Present
Langarai	*Bruguiera parviflora*	Rhizophoraceae	Least Concern	1
Bakauan lalaki	*Rhizophora apiculata*	Rhizophoraceae	Least Concern	1, 2, 4
Bakauan babae	*Rhizophora mucronata*	Rhizophoraceae	Least Concern	1, 2, 3, 4
Bungalon	*Avicennia alba*	Verbenaceae	Least Concern	1, 3, 4
Api-api	*Avicennia officinalis*	Verbenaceae	Least Concern	1,2,3, 4
Saging-saging	*Aegiceras corniculatum*	Myrsinaceae	Least Concern	1,2, 4
Pagatpat	*Sonneratia alba*	Lythraceae	Least Concern	1,2, 4
Buta-buta	*Excoecaria agallocha L.*	Euphorbiaceae	Least Concern	2
Tabigi	*Xylocarpus granatum*	Meliaceae	Least Concern	3
Piagao	*Xylocarpus moluccensis*	Meliaceae	Least Concern	3, 4
Gapas-gapas	*Campostemon philippinensis*	Bombacaceae	Least Concern	1
Dungon	*Heritiera littoralis*	Sterculiaceae	Least Concern	3
Nipa palm	*Nypa fruticans*	Arecaeae	Least Concern	1, 2, 3, 4

In terms of conservation status, all identified species were classified as of least concern by the IUCN (2020). Similar studies have also reported least concern species, but they have emphasized the ecological and biodiversity significance of these species at the global scale (Pulido et al. 2025). Moreover, the number of individuals per species distribution was generally widespread across the four sampling stations (**Table 2**); however, the quadrat sizes varied substantially. Notably, the presence of *Nypa fruticans* significantly exhibited a trend suggesting a potential influence on the abundance of other mangrove species, which is known to be found behind mangrove forest formations with habitats along rivers influenced by sea tides (Harefa et al. 2023). Quadrats 14, 16, and 19, where *N. fruticans* was not observed, exhibited the lowest counts of mangrove individuals (**Fig. 3**). This observation is purely speculative, as it lacks statistical validation. Further investigation and statistical testing are needed to substantiate this hypothesis and confirm any potential competitive interaction or habitat displacement effect of *N. fruticans*, a common associate of mangrove forests and the only palm species better adapted to mangrove forests (Cheablam and Chanklap 2020). This species can sometimes form dense stands that alter light availability and substrate conditions for other mangrove species.

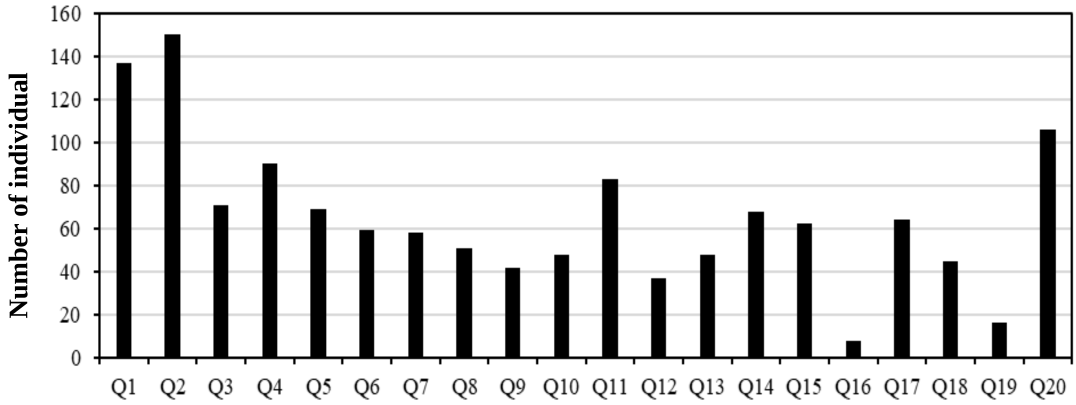

Fig. 3. Number of individuals per sampling quadrats.

3.2. Mangrove Diversity Indices

The analysis of diversity indices across the twenty (20) quadrats within Bagakay Trail Lagoon reveals a pattern of generally low mangrove diversity, with Shannon diversity values ranging from 0 to 1.381 (**Table 3**), indicating a monospecific dominance in several quadrats, a common sign of ecological stress or disturbance. Notably, a significant number of quadrats (Q2, Q4) exhibited a Shannon diversity of 0, which is directly attributed to the presence of only dead or cut mangroves within these plots. This highlights a localized disturbance in the mangrove community. This extremely low diversity suggests a lack of species heterogeneity, which could imply several underlying ecological factors or anthropogenic influences. In a systematic review conducted by Bhowmik et al. (2022), they identified several drivers of mangrove deforestation, which are largely contributed to by aquaculture and agriculture. Other factors include climate variability, salinity intrusion, and increased coastal acidity.

Table 3. Diversity indices and the number of species per quadrant

Quadrat	Shannon	Simpson	Evenness	Number of species	Relative values
Q1	0.04	0.01	0.52	2	Very low
Q2	0.00	0.00	1.00	1	Very low
Q3	0.29	0.13	0.44	3	Very low
Q4	0.00	0.00	1.00	1	Very low
Q5	0.92	0.38	0.31	8	Very low
Q6	0.27	0.09	0.32	4	Very low
Q7	0.89	0.48	0.61	4	Very low
Q8	0.57	0.38	0.88	2	Very low
Q9	0.55	0.26	0.43	4	Very low
Q10	1.38	0.67	0.66	6	Very low
Q11	0.57	0.28	0.44	4	Very low
Q12	0.28	0.15	0.66	2	Very low
Q13	0.29	0.15	0.67	2	Very low
Q14	0.48	0.21	0.40	4	Very low
Q15	0.27	0.12	0.44	3	Very low
Q16	1.32	0.72	0.94	4	Very low
Q17	1.37	0.64	0.56	7	Very low
Q18	0.88	0.41	0.48	5	Very low
Q19	1.16	0.65	0.79	4	Very low
Q20	0.91	0.47	0.79	5	Very low

The overall diversity indices within Bagakay Trail Lagoon reveal a very low species diversity across all stations (**Table 4**), with values ranging from 0.48 to 1.25 and an overall value of 0.85, indicating both limited species richness and uneven species abundance, a pattern often associated with stressed or anthropogenic activities (Goloran et al. 2020). Similarly, the Simpson diversity index (Simpson_1-D), ranging from 0.19 to 0.59 with an overall value of 0.34, suggests a degree of dominance within the mangrove community, where a few species hold numerical superiority. Such reduced diversity in mangrove ecosystems can have implications for their resilience and ecological functioning, potentially stemming from factors such as habitat disturbance or environmental stressors (Carugati et al. 2018).

3.3. Mangrove Vegetation Analysis

Table 4 presents the analysis of the mangrove vegetation in the study area. The species importance value (SIV) was calculated by adding the relative density, relative frequency, and relative dominance, which provides the overall indication of each species' ecological significance within the community. Due to the challenges of determining the basal area for relative dominance, the SIV of this species was derived from the sum of its relative density and relative frequency. The results reveal that *Avicennia officinalis* has the highest SIV (68.20), indicating its prominent ecological role in the area's mangrove ecosystem. The high value is driven by its substantial relative dominance (52.34), suggesting that, although its relative density (2.35) is low, the existing individuals are likely mature trees with significant basal area, thereby contributing substantially to the forest's structure. The dominance of *A. officinalis* may be linked to its robust root systems, which stabilize sediments, and its capacity to thrive in fluctuating salinity conditions.

Table 4. Overall diversity indices of mangrove species in Bagakay Trail Lagoon, Claver, Surigao del Norte

Station	Shannon_H	Simpson_1-D	Evenness_e^H/S	Relative values
1	0.58	0.22	0.18	Very low
2	0.95	0.42	0.37	Very low
3	0.48	0.19	0.23	Very low
4	1.25	0.59	0.43	Very low
Overall	0.85	0.34	0.18	Very low

Nypa fruticans also presents a high SIV (105.19), although this value excludes relative dominance (**Table 5)**. The difficulty in determining basal area for *Nypa fruticans* is noted in other studies, where population structure is often assessed based on the number of leaves rather than DBH (Middeljans 2014). Furthermore, the high relative density (82.21%) and relative frequency (22.97%) indicate that this species is the most numerically abundant and widely distributed within the sampled area. This aligns with field observations where dense *N. fruticans* stands limited the establishment of other species in several quadrats. While its structural contribution through basal area is not quantified here, its sheer abundance suggests a significant influence on the ecosystem, potentially affecting light availability and substrate conditions for other mangrove species (Primavera et al. 2004).

Table 5. Mangrove vegetation Analysis in Bagakay Trail Lagoon

Name of species	Relative density (%)	Relative frequency (%)	Relative dominance (%)	SIV
Aegiceras corniculatum	1.43	10.81	21.99	34.23
Avicennia alba	0.50	5.41	0.96	6.87
Avicennia officinalis	2.35	13.51	52.34	68.20
Campostemon philippinensis	0.34	1.35	0.01	1.70
Excoecaria agallocha L.	1.34	4.05	5.05	10.45
Heriteria littoralis	0.08	1.35	0.01	1.45
Bruguiera parviflora	0.08	1.35	0.00	1.44
Rhizophora apiculata	5.20	12.16	2.92	20.28
Rhizophora mucronata	4.19	14.86	0.45	19.51
Sonneratia alba	1.43	8.11	15.93	25.46
Xylocarpus granatum	0.08	1.35	0.21	1.65
Xylocarpus molluccensis	0.76	2.70	0.13	3.59
Nypa fruticans	82.21	22.97		105.19

The overall mangrove vegetation analysis highlights a community structure where *Avicennia officinalis* and *Nypa fruticans* are the most ecologically important species in the sampled area, with other species contributing to varying degrees to the forest's composition and structure. This dominance affects overall diversity and forest resilience because it influences regeneration capabilities and shapes the future community structure. However, this dominance was also driven by the significant impact on the local livelihood. *Nypa fruticans* is directly utilized as a traditional and cost-effective roofing material. Its sap can also serve as a source of sugar and alcoholic beverages (CABI Digital Gallery 2019). Beyond its direct use, the mangrove ecosystem, significantly shaped by the presence of both *Avicennia officinalis* and *Nypa fruticans*, serves as a crucial habitat and nursery ground for various fish species, crabs, and shellfish (Gargaran et al. 2024; Primavera et al. 2017). These resources form the basis of livelihoods for some community members, highlighting the indirect economic benefits derived from a healthy and diverse mangrove ecosystem (**Table 5**).

3.4. Mangrove Habitat Assessment

Based on the evaluation of percent crown cover, regeneration per square meter, and average height, the following characteristics are revealed (**Table 6**). The percent crown cover was recorded at 61%, the regeneration rate was 1.63 seedlings per m², and the average mangrove height was 5.46 meters. According to the classification guidelines outlined in the BMB Technical Bulletin 2017-05. The observed percent crown cover of 61% falls within the 'Good' category. Furthermore, both the regeneration rate of 1.63 seedlings per m² and the average height of 5.46 m are classified as 'Excellent' (**Table 6**). The 'Excellent' category, as defined by the BMB Technical Bulletin, indicates habitat conditions ranging from undisturbed to negligible disturbance, characterized by only slight disturbances and few instances of cutting. The results demonstrate a 'Good' category for percent crown cover and an excellent category for regeneration. This can be attributed to the devastation caused by Typhoon Rai, which struck the province of Surigao del Norte and nearby provinces in December 2021. Since the study was conducted in the early months of 2022, the recent disturbance likely affected the upper canopy, while the understorey continued to regenerate.

Table 6. Analysis of the condition of mangroves in Bagakay Trail Lagoon

Parameter	Value	Category
Percent crown cover (%)	61	Good
Regeneration per m²	1.63	Excellent
Average height (m)	5.46	Excellent

4. Conclusions

This study assessed the species composition, diversity, conservation status and canopy cover of mangroves at Bagakay Trail Lagoon. The study's results identified thirteen mangrove species, classified under nine families, all of which were categorized as least concern species based on the International Union for the Conservation of Nature. Although least concern species have a lower risk of extinction, they remain vital in sustaining ecological functions and maintaining global biodiversity. Furthermore, the species diversity of the sampling area falls under very low diversity (H'=0.852), which may have been significantly contributed to by anthropogenic activities and the recent typhoon Rai, which devastated the area. The most ecologically important species were *Avicennia officinalis* and *Nypa fruticans*, with high importance values suggesting their dominance and significant influence on the ecosystem. These findings highlight the importance of site-species conservation interventions be implemented by both government and non-government organizations. It is further recommended that long-term changes be tracked and that local management strategies remain effective to sustain this valuable ecosystem.

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Author Contributions

W.F.B.: Conceptualization, Methodology, Data Curation, Writing – Original Draft Preparation; F.A.D.G.: Conceptualization, Methodology, Data Curation, Writing – Original Draft Preparation; C.J.L.P.: Conceptualization, Methodology, Data Curation, Writing – Original Draft Preparation; J.A.M.: Methodology, Data Curation; J.A.T.: Methodology, Data Curation, Writing – Review and Editing; L.B.C.: Methodology, Data Analysis; V.L.C.: Conceptualization, Methodology, Supervision, Data Curation, Writing – Original Draft Preparation, Writing – Review and Editing.

Conflict of Interest

The authors declare no conflict of interest.

Declaration of Generative AI and AI-Assisted Technologies in the Manuscript Preparation

During the preparation of this work, the authors used Quillbot.com, a paraphrasing tool, to smartly enhance the clarity of the writing, making it easy for the readers to understand and avoid plagiarism. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the publication's content.

References

Akram, H., Hussain, S., Mazumdar, P., Chua, K. O., Butt, T. E., and Harikrishna, J. A. 2023. Mangrove Health: A Review of Functions, Threats, and Challenges Associated with Mangrove Management Practices. *Forests* 14(9): 1698. DOI: 10.3390/f14091698

Arfan, A., Maru, R., Nyompa, S., Sukri, I., and Juanda, M. F. 2024. Analysis of Mangrove Density using NDVI and Macrobenthos Diversity in Ampekale Tourism Village, South Sulawesi, Indonesia. *Jurnal Sylva Lestari* 12(2): 230–241. DOI: 10.23960/jsl.v12i2.788

Bhowmik, A. K., Padmanaban, R., Cabral, P., and Romeiras, M. M. 2022. Global Mangrove Deforestation and Its Interacting Social-Ecological Drivers: A Systematic Review and Synthesis. *Sustainability* 14(8): 4433. DOI: 10.3390/su14084433

Biodiversity Management Bureau. 2017. *Manual on Biodiversity Assessment and Monitoring System for Terrestrial Ecosystems (Guidelines No. 2016-05).* Biodiversity Management Bureau and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Manila, Philippines.

CABI Digital Gallery. 2019. *Nypa fruticans*. CABI Digital Library. <https://www.cabidigitallibrary.org/doi/full/10.1079/cabicompendium.36772> (August 29, 2025).

Carugati, L., Gatto, B., Rastelli, E., Lo Martire, M., Coral, C., Greco, S., and Danovaro, R. 2018. Impact of Mangrove Forests Degradation on Biodiversity and Ecosystem Functioning. *Scientific Reports* 8(1): 1–11. DOI: 10.1038/s41598-018-31683-0

Cañizares, L. P., and Seronay, R. A. 2016. Diversity and Species Composition of Mangroves in Barangay Imelda, Dinagat Island, Philippines. *AACL Bioflux* 9(3): 518–526.

Cheablam, O., and Chanklap, B. 2020. Sustainable Nipa Palm (*Nypa fruticans* Wurmb.) Product Utilization in Thailand. *Scientifica* 2020: 1–10. DOI: 10.1155/2020/3856203

Fernando, E. S. 1998. *Forest Formations and Flora of the Philippines: Handout in FBS 21*. College of Forestry and Natural Resources. University of the Philippines, Los Baños.

Garcia, J. R., Aurelio, M. A., David, C. P. C., and Siringan, F. P. 2014. *Geology for Everyone: Understanding the Philippines' Geological Landscape*. University of the Philippines Press, Philippines.

Gargaran, J. P. S., Capuno, R. D. Y., Novicio, V. F. P., Petiluna, C. C., Catalba, C. E. T., Paras, D. A. P., and Garces, J. J. C. 2024. Mangrove Ecosystem in Asia: Review and Synthesis of Ecosystem Services and Economic Valuation Methods. *Environmental and Experimental Biology* 22(2): 59–70. DOI: 10.22364/eeb.22.06

Goloran, A. 2020. Species Composition, Diversity and Habitat Assessment of Mangroves in the Selected Area along Butuan Bay, Agusan Del Norte, Philippines. *OALib* 7(4): 1–11. DOI: 10.4236/oalib.1106249

Hammer, O., Harper, D. A. T., and Ryan, P. D. 2001. PAST 2.17c: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontologia Electronica* 4(1): 1–9.

Harefa, M. S., Nasution, Z., Tuhono, E., and Susilowati, A. 2024. Floristic Diversity of Mangrove Restoration Area: A Case Study in Pasar Rawa, North Sumatra. *Jurnal Sylva Lestari* 12(1): 158–169. DOI: 10.23960/jsl.v12i1.824

IUCN. 2020. *The IUCN Red List of Threatened Species (Version 2020-3)*. <https://www.iucnredlist.org> (July 30, 2022).

Licuanan, W. Y., Cabreira, R. W., and Aliño, P. M. 2018. *The Philippines in World Seas: An Environmental Evaluation (Second Edition)*. Academic Press, London. DOI: 10.1016/b978-0-08-100853-9.00051-8

Long, J. B., and Giri, C. 2011. Mapping the Philippines Mangrove Forests using Landsat Imagery. *Sensors* 11(3): 2972–2981. DOI: 10.3390/s110302972

Maridi, M., Agustina, P., and Saputra, A. 2014. Vegetation Analysis of Samin Watershed, Central Java as Water and Soil Conservation Efforts. *Biodiversitas* 15(2): 215–223. DOI: 10.13057/biodiv/d150214

Md-Isa, N. N., and Suratman, M. N. 2021. *Structure and Diversity of Plants in Mangrove Ecosystems*. Mangroves: Ecology, Biodiversity and Management. Springer, Singapore. DOI: 10.1007/978-981-16-2494-0_15

Menéndez, P., Losada, I. J., Narayan, S., and Beck, M. W. 2020. The Global Flood Protection Benefits of Mangroves. *Scientific Reports* 10(1): 1–11. DOI: 10.1038/s41598-020-61136-6

Middeljans, M. J. 2014. *The Species Composition of the Mangrove Forest along the Abatan River in Lincod, Maribojoc, Bohol, Philippines, and the Mangrove Forest Structure and its Regeneration Status between Managed and Unmanaged Nipa palm* (*Nypa fruticans* Wurmb). Van Hall Larenstein University of Applied Sciences, The Netherlands.

Namitha, K., Drisya, P., Sreekumar, V. B., Sandeep S., and Sreejith, K. A. 2024. Vegetative Propagation in Selected Mangrove Species of Kerala. *National Academy of Science Letters* 35(1): 1–4. DOI: 10.1007/s40009-024-01521-1

Nursanti, Hardiyanti, R. A., Adriadi, A. 2021. Association between Dominant Trees Species in Lowland Tropical Forest (Education Forest of Jambi University). *Media Konservasi* 26(2): 92–98. DOI: 10.29244/medkon.26.2.92-98

Omoro L. M., Pellikka P. K., and Rogers P. C. 2010. Tree Species Diversity, Richness, and Similarity Between Exotic and Indigenous Forests in the Cloud Forests of Eastern Arc Mountains, Taita Hills, Kenya. *Journal of Forestry Research* 21(3): 255–264. DOI: 10.1007/s11676-010-0069-0

PhilAtlas. 2022. *Bagakay, Claver, Surigao del Norte Profile*. <https://www.philatlas.com/mindanao/caraga/surigaodelnorte/claver/bagakay.html>(August 29, 2025).

Primavera, J. 2004. *Philippine Mangroves: Status, Threats and Sustainable*. Springer Science Business Media, New York.

Primavera, J. H. 2017. Mangroves as Mud Crab Habitats. *The Forefront of the Mud Crab Industry Development: Proceedings of the 1st National Mud Crab Congress, Iloilo City, Philippines*.

Pulido, R. L., Casendac, E. F., Rozano, M. J., Jandug, C. M., Obo, L., Sabado, J. M., Elvira, M., and Corbita, V. 2025. Assessment of Mangrove Species Diversity in the Municipality of Nasipit, Agusan del Norte, Philippines. *Jurnal Sylva Lestari* 13(3): 761–773. DOI: 10.23960/jsl.v13i3.1192

Rasquinha, D. N., and Mishra, D. R. 2021. Impact of Wood Harvesting on Mangrove Forest Structure, Composition and Biomass Dynamics in India. *Estuarine, Coastal and Shelf Science* 248(6): 106974. DOI: 10.1016/j.ecss.2020.106974

Saliu, I. S., Satyanarayana, B., Bin Fisol, M. A., Wolswijk, G., Decannière, C., Lucas, R., Otero, V., and Dahdouh-Guebas, F. 2021. An Accuracy Analysis of Mangrove Tree Height Mensuration using Forestry Techniques, Hypsometers and UAVs. *Estuarine, Coastal and Shelf Science* 248(9): 106971. DOI: 10.1016/j.ecss.2020.106971

Tanalgo, K. C. M., Achondo, J. M., and Hughes, A. C. 2019. Small Things Matter: The Value of Rapid Biodiversity Surveys to Understanding Local Bird Diversity Patterns in Southcentral Mindanao, Philippines. *Tropical Conservation Science* 12(1): 1–10. DOI: 10.1177/1940082919869482

Tomlinson, P. B. 2016. *The Botany of Mangroves*. Cambridge University Press, Cambridge.

United Nations Development Programme (UNDP). 2022. Building Back Biodiversity. <https://www.undp.org/philippines/blog/building-back-biodiversity> (September 02, 2025)