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The mangrove of Tablas Island, Romblon, Philippines: Composition, conservation status, distribution and threats

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ABSTRACT

Mangrove ecosystems provide critical ecological services but face increasing threats from anthropogenic activities and climate change. This study presents a comprehensive assessment of mangrove composition, conservation status, distribution, and threats across Tablas Island, Romblon, Philippines. Using transect walk surveys across all nine municipalities, botanical specimens were collected, identified based on morphological characteristics, and banked at the Romblon State University, San Agustin Campus Biological Repository. A total of 29 species from 17 genera and 14 families were documented, representing approximately 88% of Philippine mangrove diversity. Eight species dominated the family Rhizophoraceae, while widespread species, including *Rhizophora apiculata*, *R. mucronata*, and *R. stylosa*, occurred in eight municipalities. Alcantara and Calatrava exhibited the highest species richness (22 species each), while Santa Maria showed limited mangrove presence with only one minor species (*Acrostichum speciosum*). Conservation status assessment revealed 27 species (93.1%) classified as Least Concern, with *Avicennia rumphiana* (Vulnerable) and *Aegiceras floridum* (Near Threatened) requiring priority protection. Six anthropogenic threats were identified: aquaculture (7 municipalities), garbage accumulation (8 municipalities), illegal settlements (7 municipalities), agricultural encroachment (5 municipalities), mangrove cutting (4 municipalities), and infrastructure development (3 municipalities). Ferrol and Looc faced all six threat categories, creating critical conservation challenges. The study establishes Tablas Island as a significant biodiversity reservoir for Philippine mangroves, warranting immediate implementation of municipality-specific conservation strategies, restoration of degraded areas, and integrated coastal zone management to ensure long-term ecosystem sustainability.

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INTRODUCTION

Mangrove ecosystems are among the most productive and biologically diverse ecosystems on Earth, serving as critical transition zones between terrestrial and marine environments (Alongi, 2002). Globally, these unique intertidal forests provide invaluable ecological services, including carbon sequestration and nutrient cycling, as well as shoreline stabilization and protection against storm surges (Donato *et al.*, 2011; Barbier *et al.*, 2011). Furthermore, they function as vital nurseries for a myriad of aquatic species, thereby supporting fisheries that sustain millions of coastal communities worldwide (Nagelkerken *et al.*, 2008). Despite their ecological and economic significance, mangrove forests remain under severe threat from anthropogenic pressures, including deforestation, aquaculture expansion, and coastal development (Valiela *et al.*, 2001; Richards and Friess, 2016). Understanding the current state of these ecosystems is therefore a prerequisite for effective management and restoration efforts.

The Philippines, an archipelago endowed with extensive coastlines, historically harbored rich mangrove forests estimated at 450,000 hectares in the early 20th century (Primavera, 2000).

However, this coverage has drastically declined by more than half due to conversion into fishponds, overharvesting for timber and charcoal, and rapid urbanization (Long and Giri, 2011; Spalding *et al.*, 2010). While national efforts towards conservation and reforestation have gained momentum in recent decades, the status of mangrove ecosystems varies significantly across the country's diverse islands. Effective conservation planning requires localized data, as generalized national statistics often fail to capture the specific species composition and localized threats present in smaller island ecosystems (Duke *et al.*, 2007).

Tablas Island, the largest island in Romblon province, offers a compelling case study for mangrove assessment. Situated in the Sibuyan Sea, Tablas is characterized by a rugged topography and a complex coastline that supports various mangrove patches. Unlike more extensively studied areas in the Philippines, the mangrove forests of Tablas Island have received comparatively less attention in scientific literature (Garcia *et al.*, 2014). This lack of comprehensive baseline data hinders the development of island-specific conservation strategies necessary to protect these resources against increasing local development pressures and climate change impacts (Ellison, 2015).

This study aims to bridge this knowledge gap by providing a comprehensive assessment of the mangrove ecosystems on Tablas Island. The research focuses on four key dimensions: floristic composition, conservation status, spatial distribution, and prevailing threats. By systematically inventorying the species present, the study will determine the biodiversity index of the island's coastal forests. Concurrently, an evaluation of the conservation status will identify rare or endangered species that require immediate protection. The study also maps the distribution of these mangroves to understand their spatial fragmentation and connectivity.

Finally, this research critically examines the anthropogenic and natural threats facing the mangroves of Tablas Island. From local resource extraction to the looming impacts of sea-level rise, identifying these stressors is crucial for policymakers and local government units (LGUs).

The significance of studying the Tablas Island mangroves extends beyond academic inquiry; it serves as a foundational step toward formulating sustainable management plans that balance the livelihood needs of local communities with the imperative of environmental preservation. Through this multi-dimensional assessment, the study aspires to contribute to the broader discourse on island ecosystem resilience in the Philippines.

MATERIALS AND METHODS

Study area

The study was conducted across the entire Tablas Island, the largest island in the province of Romblon, Philippines (Fig. 1). Tablas Island, strategically located in the Sibuyan Sea, comprises multiple municipalities, each with distinct coastal characteristics and mangrove coverage. The island's diverse coastal topography supports a variety of mangrove habitats, ranging from riverine to fringing forests. All municipalities within Tablas Island were included in the survey to ensure comprehensive coverage and representativeness of the island's mangrove ecosystems.

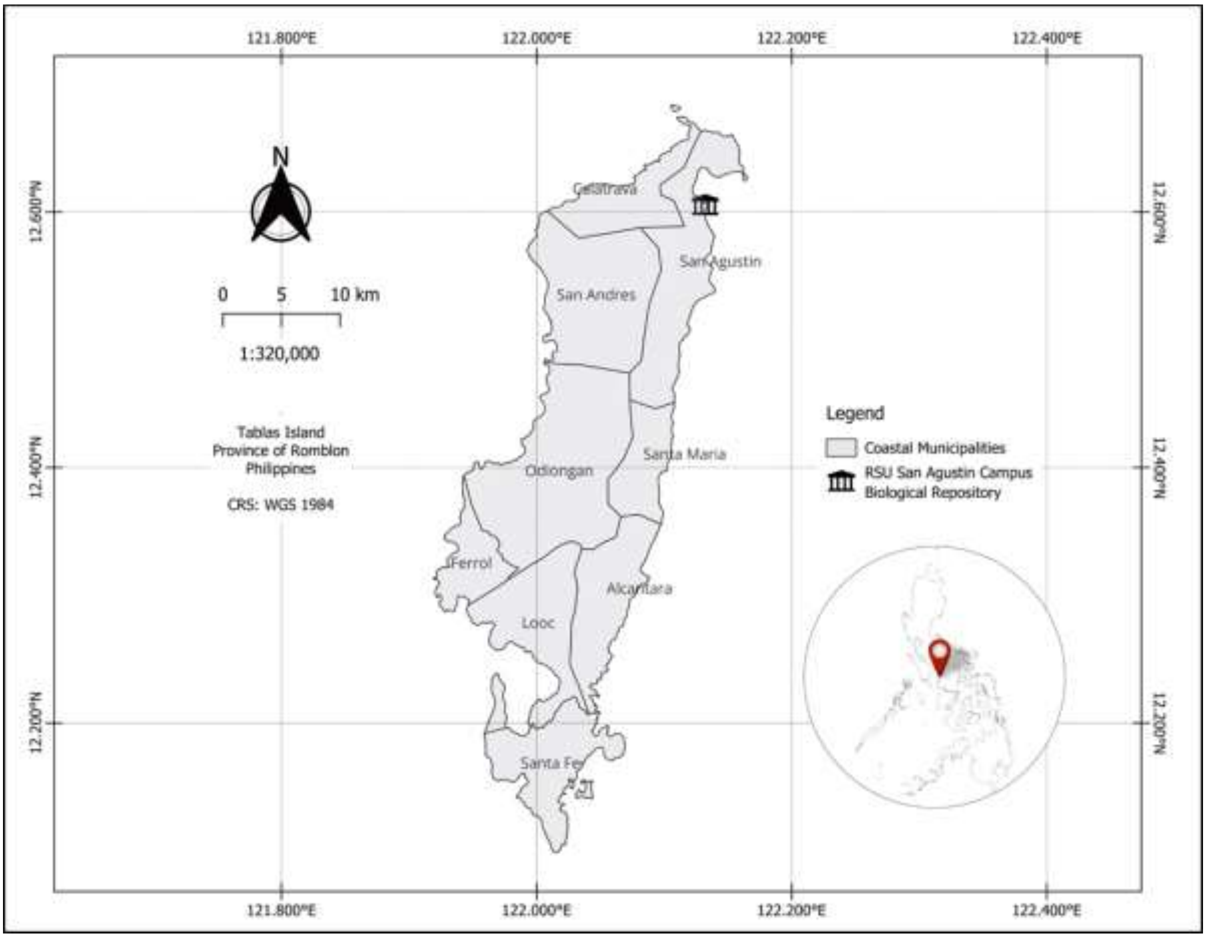

Fig. 1. The map of Tablas Island, Romblon, Philippines

Site selection

Study sites were purposively selected based on the presence of substantial mangrove forest areas within each municipality of Tablas Island. Large mangrove stands were prioritized to capture the maximum species diversity and to assess areas of significant ecological importance. Selection criteria included accessibility, forest extent, and representation of the island's different mangrove habitat types. Coordination with local government units (LGUs) and coastal communities was conducted prior to site visits to identify key mangrove areas and obtain necessary permits for specimen collection.

Field survey and data collection

A transect walk method was used to inventory mangrove species across selected sites systematically. This approach involved traversing the entire length and breadth of each mangrove forest area to ensure comprehensive species documentation. During field surveys, all mangrove species encountered were recorded, photographed, and documented with GPS coordinates to facilitate subsequent distribution mapping. Environmental parameters such as substrate type, zonation patterns, and associated fauna were also noted to provide ecological context for each site.

Specimen collection and processing

Botanical specimens, including leaves, flowers, and fruits, were carefully collected from representative individuals of each mangrove species encountered. The collection was conducted in accordance with standard herbarium procedures to ensure specimen quality and preservation.

Upon collection, specimens were sorted according to preliminary field identification, labeled with collection data (date, location, collector, and field notes), and pressed using standard plant pressing techniques to preserve morphological characteristics. Pressed specimens were allowed to dry properly to prevent fungal growth and deterioration.

Specimen banking and identification

All collected specimens were transported to the Romblon State University San Agustin Campus Biological Repository for long-term storage and reference. The repository serves as a permanent archive of the island's mangrove biodiversity and provides material for future taxonomic studies.

Species identification was performed through detailed examination of morphological characteristics, including leaf arrangement, leaf shape and size, presence and type of pneumatophores, bark texture, flower morphology, and fruit and propagule characteristics. The taxonomic identification followed the comprehensive field guide developed by Primavera (2010), which provides diagnostic keys and detailed descriptions of Philippine mangrove species. Specimens that could not be identified with certainty were cross-referenced with additional taxonomic literature and, where necessary, consulted with mangrove taxonomy experts for verification.

Conservation status assessment

The conservation status of identified mangrove species was evaluated using the IUCN Red List of Threatened Species and relevant Philippine biodiversity conservation frameworks. Species were categorized by threat level, with particular attention paid to endemic, rare, or threatened species. This assessment provides critical baseline information for prioritizing conservation interventions on Tablas Island.

Threat assessment

Anthropogenic and natural threats to mangrove ecosystems were documented through field observations, key informant interviews with residents and LGU officials, and review of existing land-use plans and coastal development projects. Observed threats included habitat conversion, resource extraction, pollution, and climate change-related impacts. The spatial extent and severity of each threat category were recorded to inform management recommendations.

RESULTS

Species composition of mangroves in Tablas Island

The comprehensive survey of mangrove ecosystems across Tablas Island revealed a rich diversity of both true mangroves and mangrove associates. A total of 29 species belonging to 17 genera and 14 families were documented (Fig. 2). The family Rhizophoraceae was the most species-rich, with eight species distributed across three genera (*Bruguiera, Ceriops*, and *Rhizophora*). Among the documented species, *Rhizophora apiculata, R. mucronata*, and *R. stylosa* were the most widely distributed, occurring in all major municipalities surveyed. These species, locally known as "Bakawan," form the structural foundation of most mangrove stands on Tablas Island and are characteristic of the seaward fringe zones where tidal inundation is frequent. The genus *Avicennia* was represented by three species (*A. marina, A. officinalis*, and *A. rumphiana*), all locally referred to as "Api-api." These species typically occupy the middle to landward zones of mangrove forests and are well-adapted to higher salinity conditions. The presence of *Nypa fruticans* (Nipa palm) was notable in all municipalities except Santa Maria.

Spatial distribution patterns across municipalities

The distribution analysis across the nine municipalities of Tablas Island (Fig. 3, Table 1) reveals significant spatial heterogeneity in mangrove species occurrence. Alcantara and Calatrava emerged as the municipalities with the highest species richness, each hosting 22 species, followed closely by Ferrol and San Agustin with 21 and 22 species, respectively. In contrast, Santa Maria recorded only one minor mangrove species (*Avicennia speciosum*) in this survey.

Fig. 2. The minor and major mangroves in Tablas Island, Philippines

Eight species demonstrated island-wide distribution, occurring in eight or all nine municipalities: *Avicennia marina*, *A. rumphiana*, *Excoecaria agallocha*, *Nypa fruticans*, *Rhizophora apiculata*, *R. mucronata*, *R. stylosa*, and *Sonneratia alba*. Conversely, several species exhibited highly restricted distributions, appearing in only one or two municipalities. *Osbornia octodonta* was recorded exclusively in Ferrol, *Ceriops tagal* only in Looc, *Phimpis acidula* only in Calatrava, and *Aegiceras floridum* only in Calatrava. The genus *Rhizophora* showed remarkable consistency, with all three species (*R. apiculata*, *R. mucronata*, *R. stylosa*) occurring in eight of nine municipalities, absent only in Santa Maria.

Table 1. Mangrove species richness across the Philippine archipelago

Cluster	Location	Number of species	Author
Luzon	Aurora Province, Philippines	30	Rotaquio *et al.*, 2007
	Basing, Binmaley, Pangasinas, Philippines	8	Rosario *et al.*, 2021
	Cagayan, Philippines	15	Salmo *et al.*, 2015
	Catanduanes Island, Philippines	31	Masagca and Trinidad, 2021
	Ilocos Sur, Philippines	18	Salmo *et al.*, 2015
	Lagadlarin Mangrove Forest in Lobo, Batangas	16	Calzeta *et al.*, 2024
	Maligaya, Palanan, Isabela	14	Baleta and Casalamitao, 2016
	Pangasinan, Philippines	25	Salmo *et al.*, 2015
	Puerto Princesa Bay, Palawan, Philippines	28	Dangan-Galon *et al.*, 2018
	Subic Bay, Freeport Zone	20	Salmo *et al.*, 2015
	Sukol River, Oriental Mindoro, Philippines	4	Quitain, 2024
	Tablas Island, Romblon	29	This study
	Zambales, Philippines	11	Paz-Alberto *et al.*, 2020
	Zambales, Philippines	22	Salmo *et al.*, 2015
Visayas	Argao Mangrove Forest, Cebu, Philippines	11	Lillo and Buot, 2016
	Bohol Island, Philippines	22	Abejo *et al.*, 2025, Salmo *et al.*, 2019
	Camotes Group of Islands, Philippines	18	Juario and Ontoy, 1996
	Cebu Island, Philippines	33	Primavera 2008
	Leyte (Leyte Island), Philippines	23	Patindol and Casa, 2019; Salmo *et al.*, 2019
	Negros Oriental (Negros Island), Philippines	26	Salmo *et al.*, 2019
	Ormoc Bay, Leyte, Philippines	18	Salmo *et al.*, 2019
	Panay Island, Philippines	23	Salmo *et al.*, 2019
	Samar Island, Philippines	12	Salmo *et al.*, 2019
	Southern Leyte, (Leyte Island), Philippines	26	Salmo *et al.*, 2019
	Tacloban City, Leyte, Philippines	26	Salmo *et al.*, 2019
Mindanao	Claver, Surigao Del Norte, Philippines	5	Alimbon and Manseguiao, 2021
	Imelda, Dinagat Island, Philippines	29	Mangaoang and Flores, 2019
	Katunggan Coastal Eco-Park,, Sultan Kudarat	9	Goloran *et al.*, 2020
	Panabo Mangrove Park, Philippines	23	Agduma and Cao, 2023
	Panguil Bay, Mindanao Island, Philippines	10	Cañizares and Seronay, 2016
	Sarangani Bay Protected Seascape, Philippines	10	Osing *et al.*, 2019
	Philippines	33	Primavera *et al.*, 2016

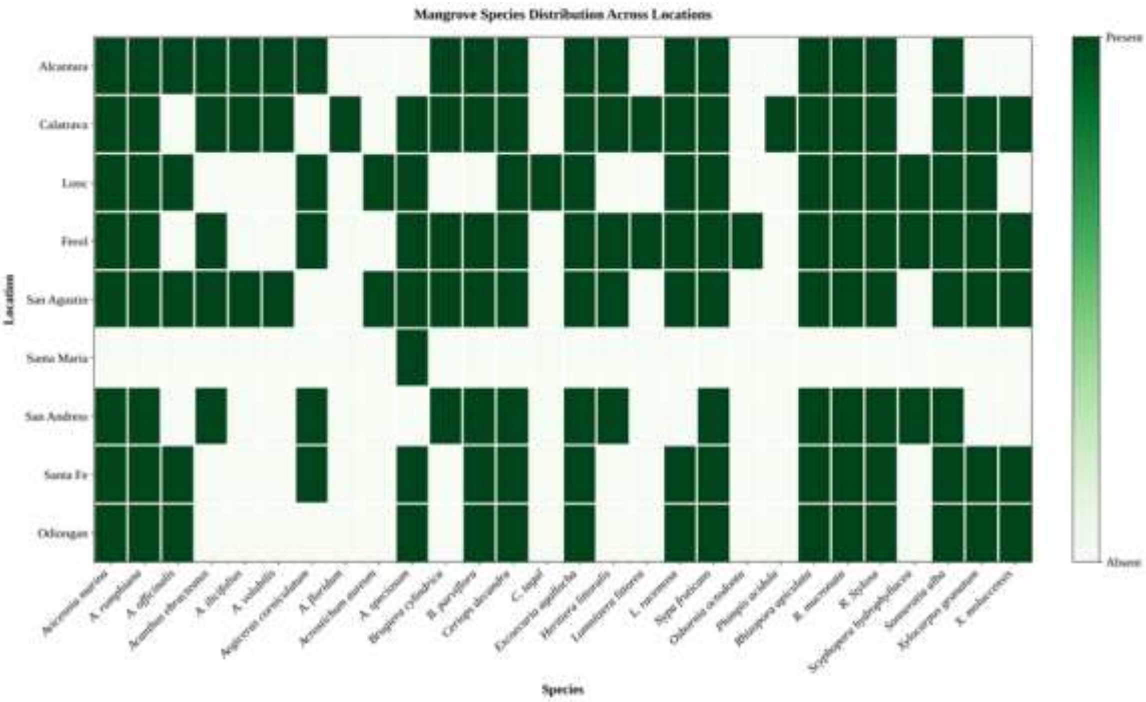

Fig. 3. Spatial distribution of mangroves across municipalities in Tablas Island, Philippines

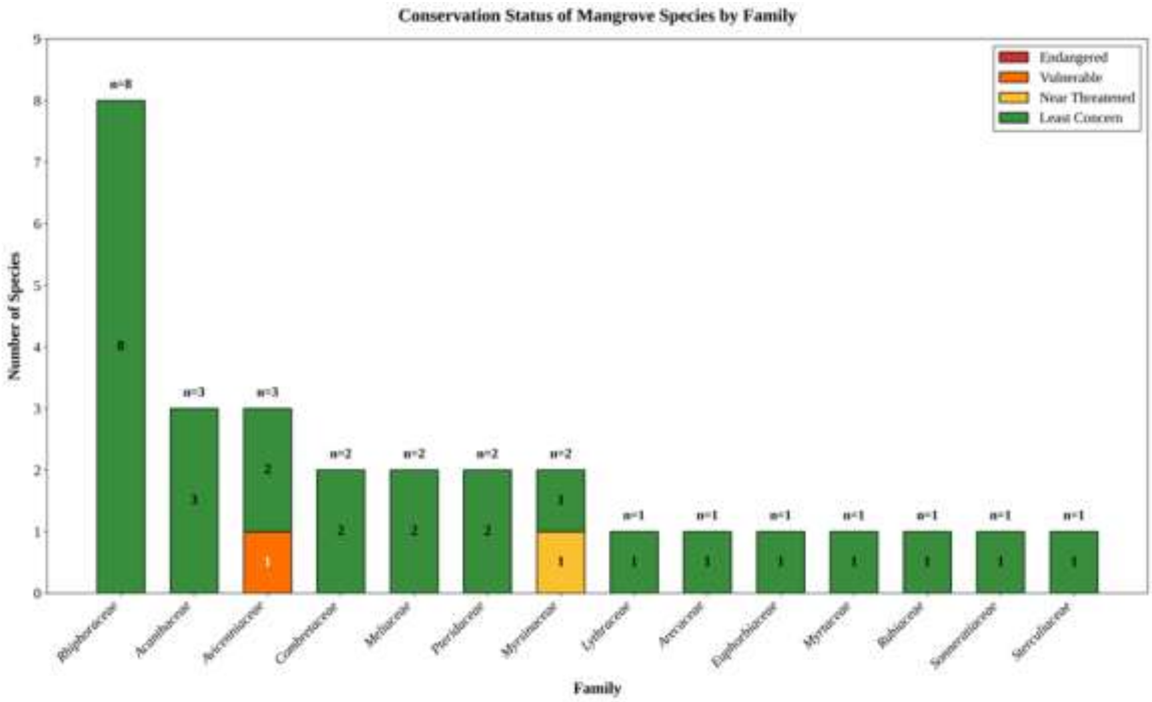

Fig. 4. Conservation status of mangrove species

Conservation status of mangrove species

The assessment of conservation status for the 29 mangrove species documented on Tablas Island, based on IUCN Red List categories (Fig. 4), reveals a generally favorable conservation picture with most species classified as Least Concern (IUCN, 2024). Of the total species inventory, 27 species (93.1%) fall under the Least Concern category. However, two species require particular conservation attention due to their elevated threat status. *Avicennia rumphiana* is classified as Vulnerable, while *Aegiceras floridum* is classified as Near Threatened.

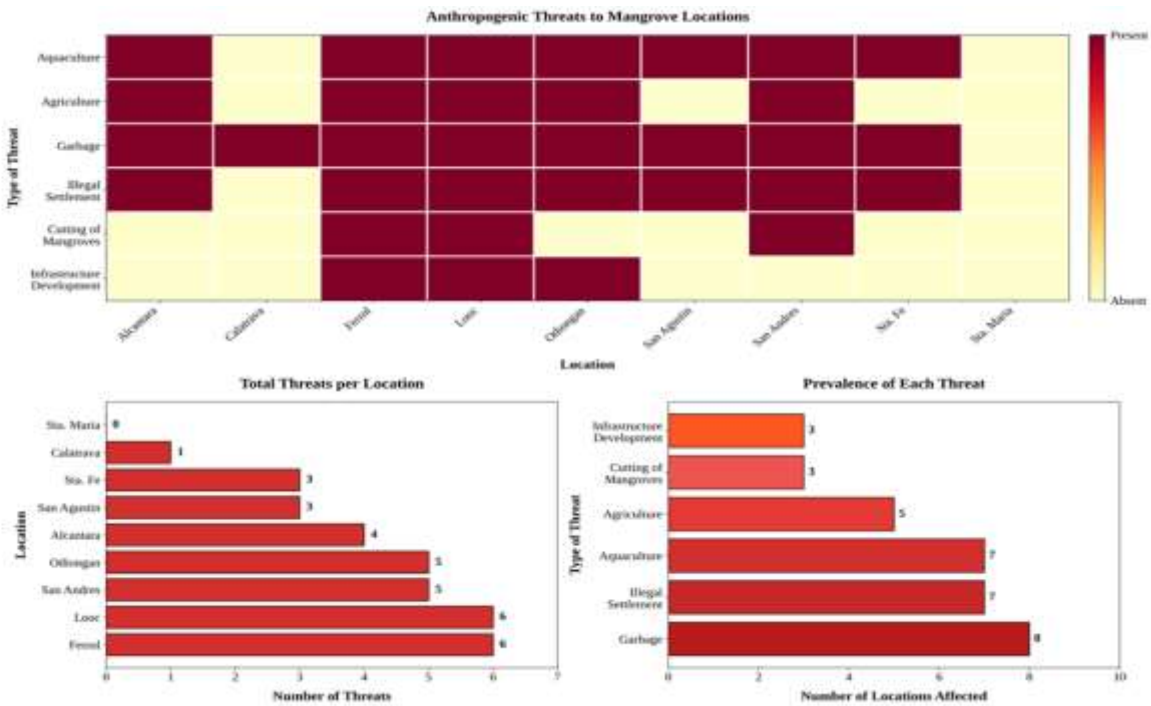

Fig. 5. Anthropogenic threats to the mangrove ecosystem in Tablas Island, Philippines

Anthropogenic threats to mangrove ecosystems

Field observations and community consultations revealed multiple anthropogenic threats affecting mangrove ecosystems across Tablas Island (Fig. 5). Six primary threat categories were documented. The distribution and intensity of these threats varied considerably among municipalities. Notably, Santa Maria municipality showed no documented threats in this assessment, consistent with the severe degradation of mangrove habitat in that area (only one minor species, *Acrostichum speciosum*, remains). Aquaculture emerged as one of the most widespread threats, documented in seven of the nine municipalities (Alcantara, Ferrol, Looc, Odiongan, San Agustin, San Andres, and Sta. Fe). Garbage accumulation was documented in eight municipalities (all except Santa Maria and Calatrava), making it the most ubiquitous threat category observed. Illegal settlements were identified in seven municipalities (Alcantara, Ferrol, Looc, Odiongan, San Agustin, San Andres, and Sta. Fe), indicating widespread encroachment into mangrove zones. Agricultural encroachment was documented in five municipalities (Alcantara, Ferrol, Looc, Odiongan, and San Andres). Mangrove cutting was observed in four municipalities (Ferrol, Looc, San Andres, and Odiongan), representing the most direct form of habitat destruction. Infrastructure development was documented in three municipalities (Ferrol, Looc, and Odiongan), typically involving the construction of roads, ports, bridges, and other facilities that require coastal land. The threat assessment reveals a concerning pattern: municipalities with the highest species diversity (Alcantara, Ferrol, Looc) are simultaneously facing multiple concurrent threats. Ferrol and Looc, in particular, are subject to all six threat categories documented in this study, placing exceptional pressure on their mangrove ecosystems.

DISCUSSION

Species composition of mangroves in Tablas Island

Tablas Island recorded 29 mangrove species, comparable to other well-studied mangrove areas in the Philippines and a significant contribution to the island's coastal biodiversity (Primavera *et al.*, 2004). The family Rhizophoraceae exhibited the highest species richness, reflecting its dominance in Philippine mangrove ecosystems (Tomlinson, 2016). This finding is consistent with the ecological role of Rhizophoraceae as primary framework species that structure mangrove forest architecture and provide essential habitat for diverse faunal communities (Duke and Schmitt, 2015). The widespread occurrence of *Nypa fruticans* (Nipa palm) indicates its ecological preference for riverine and brackish-water environments throughout the island's coastal landscape.

The documentation of less common species, such as *Osbornia octodonta* (recorded only in Ferrol), *Ceriops tagal* (recorded only in Looc), *Phimpis acidula* (recorded only in Calatrava), and *Aegiceras floridum* (recorded only in Calatrava), highlights microhabitat variation across the island. These species, though limited in distribution, are important components of mangrove biodiversity and may require targeted conservation attention given their restricted occurrence (Friess *et al.*, 2016). The mangrove ferns *Acrostichum aureum* and *A. speciosum* were found in several municipalities, typically in disturbed or transitional zones, serving as indicators of habitat succession and disturbance history (Walters *et al.*, 2008).

Comparative analysis with other Philippine mangrove ecosystems

When compared with mangrove studies conducted across the Philippine archipelago, Tablas Island's species count of 29 ranks favorably among documented sites. The island's mangrove diversity exceeds that of several Luzon sites, including Sukol River, Oriental Mindoro (4 species) (Quitain, 2024), Basing, Binmaley, Pangasinan (8 species) (Rosario *et al.*, 2021), and Zambales (11 species) (Salmo *et al.*, 2015), while approaching the diversity levels of highly biodiverse areas such as Catanduanes Island (31 species) (Masagca and Trinidad, 2021) and Cebu Island (33 species) (Primavera, 2008). Within the Visayas cluster, Tablas Island demonstrates comparable or superior species richness to neighboring islands, with only Cebu Island (33 species) (Primavera, 2008) surpassing it in the regional context.

The similarity in species composition between Tablas Island and other Visayan sites such as Bohol Island (22 species) (Salmo *et al.*, 2019), Panay Island (23 species) (Primavera *et al.*, 2004), and Southern Leyte (26 species) (Salmo *et al.*, 2019) suggests a biogeographic affinity within the central Philippine region (Salmo *et al.*, 2019). This pattern reflects the influence of oceanographic connectivity and larval dispersal mechanisms that facilitate gene flow among island populations (Triest, 2008). Notably, Tablas Island shares its species count (29) with Imelda, Dinagat Island in Mindanao (Mangaoang and Flores, 2019), indicating that despite geographic separation, similar environmental conditions can support comparable levels of mangrove biodiversity. The presence of all major *Rhizophora* species (*R. apiculata, R. mucronata, R. stylosa*) on Tablas Island aligns with regional patterns observed throughout the Visayas, where these species serve as ecological dominants.

However, it is important to note that while species richness provides a quantitative measure of biodiversity, it does not capture information about population sizes, forest health, or ecosystem functionality. Some areas with lower species count, such as protected sites like Katunggan Coastal Eco-Park in Sultan Kudarat (9 species) (Goloran *et al.*, 2020), may exhibit better conservation status and forest structure compared to more diverse but heavily disturbed sites.

The high diversity recorded in Tablas Island reflects both favorable environmental conditions and the comprehensive sampling approach employed in this study, which covered all municipalities across the entire island.

Spatial distribution patterns across municipalities

The distribution analysis reveals significant spatial heterogeneity in mangrove species occurrence. The pattern suggests that the municipalities of Alcantara, Caltrava, Ferrol, and San Agustin possess more diverse habitat types and relatively intact mangrove ecosystems. The municipality of Santa Maria, which recorded only one minor mangrove species, indicates severe degradation that has eliminated most mangrove vegetation, leaving only this single minor species. This finding warrants immediate attention for potential restoration initiatives in the municipality.

The widespread occurrence of eight mangrove species: *Avicennia marina*, *A. rumphiana*, *Excoecaria agallocha*, *Nypa fruticans*, *Rhizophora apiculata*, *R. mucronata*, *R. stylosa*, and *Sonneratia alba*, indicates these species' ecological plasticity and their ability to thrive across the varied coastal environments on Tablas Island. These ubiquitous species likely serve as keystone taxa, maintaining ecosystem structure and function across the island's mangrove network. Their consistent presence also suggests relatively successful natural regeneration and dispersal capabilities within the island's coastal system.

Conversely, the restricted distributions of *Osbornia octodonta*, *Ceriops tagal, Phimpis acidula*, and *Aegiceras floridum* may reflect either genuine rarity and specific microhabitat requirements or localized survival in the face of widespread habitat loss. Species with limited distributions are particularly vulnerable to local extinction events and should be prioritized in conservation planning. The concentration of unique species in municipalities such as Calatrava and Ferrol suggests these areas represent biodiversity hotspots on the island that merit enhanced protection measures.

The remarkable consistency of *Rhizophora* reinforces the ecological importance of this genus as a foundation species in Philippine mangrove ecosystems. Similarly, the three *Avicennia* species demonstrated wide but varying distributions, with *A. marina* and *A. rumphiana* being more widespread than *A. officinalis*, potentially reflecting differential tolerance to environmental gradients or varying degrees of anthropogenic disturbance across municipalities.

Conservation implications and biodiversity significance

The documentation of 29 mangrove species on Tablas Island accounts for approximately 88% of the total mangrove diversity reported for the entire Philippines by Primavera (2016), who recorded 33 species nationwide. This remarkable proportion positions Tablas Island as a critical biodiversity reservoir for Philippine mangroves and underscores the conservation significance of the island's coastal ecosystems. The presence of nearly all prominent mangrove families documented in the Philippines indicates that Tablas Island provides a comprehensive representation of the country's mangrove flora within a relatively confined geographic area.

The family Rhizophoraceae, with eight species on Tablas Island, demonstrates the island's capacity to support diverse representatives of this ecologically critical family. The presence of both *Bruguiera cylindrica* and *B. parviflora*, along with species such as *Ceriops decandra* and *C. tagal*, indicates mature forest stands with well-developed zonation patterns. These species typically require stable environmental conditions and extended periods to establish, suggesting that at least portions of Tablas Island's mangroves have experienced relatively low disturbance intensity in recent decades. However, the restricted distribution of particular species warns that localized threats may be fragmenting populations and reducing genetic connectivity.

The presence of mangrove associates, such as Acanthus species (three documented), *Acrostichum* ferns (two species), and *Heritiera littoralis*, enriches overall coastal forest complexity and provides critical habitat diversity for wildlife. These associate species often colonize disturbed areas or represent transitional zones between mangroves and terrestrial vegetation, thus serving as indicators of ecosystem health and succession dynamics. Their presence suggests that Tablas Island maintains ecotonal gradients that support both core mangrove species and peripheral associates, contributing to overall ecosystem resilience.

Comparison with other Visayan islands reveals that Tablas Island holds a unique position in regional mangrove conservation. While Cebu Island historically supported 33 species (Primavera, 2004), many of its mangrove areas have since experienced substantial degradation due to intense urbanization and aquaculture development. Tablas Island's relatively lower population density and development pressure may have afforded its mangroves greater protection, thereby maintaining high species diversity. This comparative advantage presents both an opportunity and a responsibility: Tablas Island could serve as a source population for regional mangrove restoration efforts and as a reference site for studying intact Philippine mangrove ecosystems.

Ecological zonation and habitat heterogeneity

The diversity of species documented across Tablas Island reflects the presence of multiple mangrove habitat types, each characterized by distinct environmental conditions and species assemblages. The widespread occurrence of *Rhizophora* species in seaward zones, *Avicennia* in middle zones, and *Nypa fruticans* in riverine areas indicates well-developed ecological zonation patterns typical of mature, functional mangrove ecosystems. This zonation is driven by gradients in tidal inundation frequency, salinity, sediment characteristics, and wave energy, creating a mosaic of microhabitats that collectively support high biodiversity.

The presence of species such as *Sonneratia alba*, which typically occupies pioneer zones in soft, muddy substrates subject to frequent tidal inundation, suggests active accretion and colonization processes are occurring in some areas of Tablas Island. Similarly, the documentation of *Lumnitzera* species (*L. littorea* and *L. racemosa*) in several municipalities indicates the presence of sandy or well-drained substrates in landward or elevated portions of the mangrove forest. These species are often associated with older, more stable mangrove stands and contribute to structural complexity through their distinctive growth forms and phenology.

The distribution of *Xylocarpus* species (*X. granatum* and *X. moluccensis*) across multiple municipalities is noteworthy from both ecological and economic perspectives. These species, locally known as "Tabigi" and "Piagao," produce large, woody fruits and typically occur in the landward zones of mature mangrove forests. Their presence indicates the existence of forest interior habitats with reduced tidal influence, which support distinct faunal communities and ecosystem processes compared to seaward zones. Historically, *Xylocarpus* species have been harvested for timber and traditional medicine, making their current distribution an indicator of past and present anthropogenic pressure.

Threats to mangrove diversity and distribution

Despite the impressive species diversity documented in this study, several factors threaten the long-term persistence of Tablas Island's mangrove ecosystems. The complete absence of mangrove species in the Santa Maria municipality represents the most severe manifestation of habitat loss. It serves as a cautionary indicator of potential future scenarios for other areas if protective measures are not implemented. The drivers of mangrove loss typically include conversion to aquaculture ponds, residential and tourism development, overharvesting for fuelwood and construction materials, and pollution from agricultural and domestic sources.

The restricted distribution of particular species raises concerns about their vulnerability to local extinction. Species occurring in only one or two municipalities face heightened risk from stochastic events such as typhoons, disease outbreaks, or localized habitat destruction. Small, isolated populations also experience reduced genetic diversity and limited capacity for adaptation to environmental changes, including those associated with climate change, such as sea-level rise, altered rainfall patterns, and increased storm intensity. The loss of even a single population of rare species could significantly diminish the island's overall biodiversity and reduce ecosystem resilience.

Observed anthropogenic threats during field surveys included evidence of selective logging, conversion of mangrove areas to fish ponds and salt farms, accumulation of garbage in coastal areas, and encroachment of settlements into mangrove zones. In several municipalities, mangrove forests have been fragmented into small, isolated patches separated by cleared or developed areas. This fragmentation disrupts ecological connectivity, impedes natural regeneration, and reduces habitat quality for mangrove-dependent wildlife. The combination of direct habitat destruction and degradation of remaining forests through edge effects and altered hydrology poses a compound threat to mangrove persistence.

Climate change represents an emerging threat that may alter mangrove species composition and distribution patterns on Tablas Island. Projected sea-level rise could inundate low-lying mangrove areas while simultaneously preventing landward migration due to coastal development and topographic constraints. Changes in rainfall patterns may affect salinity regimes in estuarine mangroves, potentially favoring some species while stressing others. Increased frequency and intensity of tropical cyclones could cause extensive physical damage to mangrove canopies and accelerate erosion in exposed areas. The capacity of Tablas Island's mangroves to adapt to these changes will depend critically on maintaining connectivity among populations, preserving genetic diversity, and ensuring adequate space for natural migration and succession.

Conservation status of mangrove species

Nearly all recorded species (93.1%) fall under the Least Concern category, indicating that these species maintain stable populations and face relatively low extinction risk globally (Polidoro *et al.*, 2010). This predominance of Least Concern species suggests that the mangrove flora of Tablas Island consists primarily of widespread, adaptable species that persist across varied environmental conditions and moderate levels of anthropogenic disturbance (Duke *et al.*, 1998).

Conversely, two species stand out as conservation priorities. *Avicennia rumphiana* is classified as Vulnerable, indicating that this species faces a high risk of extinction in the wild in the medium-term future (Polidoro *et al.*, 2010; IUCN, 2024). The Vulnerable status of *A. rumphiana* on Tablas Island is particularly significant given its relatively widespread distribution across eight municipalities. This apparent contradiction—wide distribution yet vulnerable status—reflects global population trends and habitat loss affecting this species throughout its range (Ellison *et al.*, 2010). The presence of *A. rumphiana* across multiple municipalities on Tablas Island suggests that the island may serve as an important refuge for this threatened species, elevating the conservation priority of protecting these populations (Primavera *et al.*, 2004).

Aegiceras floridum is classified as Near Threatened, indicating that, although it does not currently qualify for a threatened category, it is approaching threatened status. It may qualify in the near future if current trends continue (IUCN, 2024). On Tablas Island, *A. floridum* was recorded only in Calatrava municipality, making it one of the most range-restricted species documented in this study. The combination of Near Threatened global status and highly localized distribution on Tablas Island places *A. floridum* at considerable risk of local extinction (Frankham, 2005). Any habitat disturbance in Calatrava could eliminate the island's entire population of this species, representing a significant biodiversity loss. This species exemplifies the conservation challenge posed by taxa with restricted distributions, where local threats can have disproportionate impacts on regional and national populations (Brooks *et al.*, 2002).

The conservation status assessment reveals that although the majority of Tablas Island's mangrove species are not immediately threatened globally, local and regional factors may pose significant risks that are not captured by global assessments (Rodrigues *et al.*, 2006). The IUCN Red List evaluates species based on worldwide population trends, but localized extinctions and population declines can occur even for species classified as Least Concern globally (Mace *et al.*, 2008). For instance, species like *Osbornia octodonta* and *Ceriops tagal,* though globally classified as Least Concern, occur in only a single municipality on Tablas Island, making them vulnerable to local extinction regardless of their global status. This disparity between global conservation status and local rarity underscores the importance of island-specific conservation planning (Cardoso *et al.*, 2011).

The family Rhizophoraceae, despite being the most species-rich family on the island with eight species, shows uniformly Least Concern conservation status across all its representatives. This consistency reflects the ecological resilience and wide distribution of *Rhizophora, Bruguiera*, and *Ceriops* species throughout the Indo-Pacific region (Duke, 2006). Nevertheless, the Least Concern status should not lead to complacency, as these foundation species face ongoing threats from habitat conversion and climate change (Gilman *et al.*, 2008). Maintaining healthy Rhizophoraceae populations is critical to the overall function of mangrove ecosystems, as these species provide structural complexity, support diverse faunal communities, and drive key ecosystem processes such as sediment stabilization and nutrient cycling (Kathiresan and Bingham, 2001).

From a conservation planning perspective, the presence of Vulnerable and Near Threatened species on Tablas Island necessitates proactive management interventions (Salafsky *et al.*, 2002).

For *Avicennia rumphiana*, conservation efforts should focus on monitoring population health across all eight municipalities where it occurs, identifying and protecting core populations, and ensuring connectivity between populations to maintain genetic diversity (Triest, 2008). *Ex-situ* conservation through seed banking and nursery propagation could provide insurance against population decline (Guerrant *et al.*, 2004). For *Aegiceras floridum*, immediate priority should be given to protecting its habitat in Calatrava municipality, surveying for potential undiscovered populations in other areas, and establishing *ex-situ* populations in botanical gardens or conservation facilities. Translocation to suitable habitats in other municipalities could be considered a risk-mitigation strategy, though such actions should be carefully evaluated to avoid genetic contamination and ecological disruption (IUCN/SSC, 2013).

Anthropogenic threats to mangrove ecosystems

The distribution and intensity of the anthropogenic threats identified in the study varied considerably among municipalities, reflecting differences in population pressure, economic activities, and enforcement of environmental regulations (Nguyen *et al.*, 2019). The absence of anthropogenic threats in the Santa Maria municipality is consistent with the severe degradation of mangrove habitat in that area (only one minor species, *Acrostichum speciosum*, remains)—a condition reflecting historical habitat destruction (Richards and Friess, 2016).

The conversion of mangrove areas to fishponds and brackish-water aquaculture facilities is a persistent driver of habitat loss throughout the Philippines (Primavera, 2005; Lebel *et al.*, 2002).

While aquaculture provides economic benefits and livelihood opportunities for coastal communities, poorly planned or excessive conversion can eliminate mangrove habitat, disrupt hydrological connectivity, and degrade water quality through effluent discharge (Stevenson *et al.*, 1999; Armitage, 2002). The prevalence of aquaculture-related threats across Tablas Island indicates that this sector requires careful regulation to balance economic development with ecosystem conservation (Barbier and Cox, 2004). Sustainable aquaculture practices, such as mangrove-friendly pond design and maintenance of greenbelts, should be promoted as alternatives to complete habitat conversion (Nhuong *et al.*, 2002; Fitzgerald, 2002).

The presence of solid waste in mangrove areas reflects inadequate waste management infrastructure and practices in coastal communities (Ivar do Sul and Costa, 2014). Plastic debris, household waste, and fishing-related materials (nets, floats, ropes) were commonly observed entangled in mangrove roots and accumulated along shorelines. Beyond the aesthetic degradation, garbage accumulation poses multiple ecological threats: physical smothering of pneumatophores and seedlings, chemical contamination from decomposing materials, entanglement and ingestion hazards for wildlife, and alteration of sediment dynamics (Martin *et al.*, 2020; Debrot *et al.*, 2013). Addressing this threat requires improved municipal waste collection systems, community education programs, and regular coastal cleanup initiatives involving local stakeholders (Dsikowitzky *et al.*, 2016).

Establishing residential structures within mangrove areas typically involves clearing vegetation, constructing access paths, and introducing domestic waste and wastewater (Kuenzer *et al.*, 2011).

These settlements often occupy strategic locations along waterways or coastal areas, precisely where mangrove ecosystems provide critical ecological services, such as storm protection and maintenance of water quality (Mazda *et al.*, 2006; Barbier, 2016). The presence of illegal settlements reflects complex socioeconomic challenges, including poverty, lack of affordable housing, and weak land-use enforcement (Glaser, 2003). Resolving this threat requires comprehensive approaches that address both ecological protection and social welfare, including the provision of alternative housing, community relocation with adequate compensation, and strengthened tenure rights that discourage informal settlement (Datta *et al.*, 2012).

This threat involves converting mangrove-adjacent areas or landward mangrove zones to agricultural uses, particularly rice paddies and coconut plantations (Alongi, 2002). Agricultural development often involves modification of natural hydrology through dike construction and drainage alterations, which can affect salinity regimes and tidal flushing in remaining mangrove areas (Duke *et al.*, 2007). Additionally, agricultural runoff containing fertilizers, pesticides, and sediments can degrade water quality in mangrove ecosystems (Tam and Wong, 2000). The interface between agriculture and mangroves requires careful management, including the establishment of buffer zones, the adoption of sustainable farming practices that minimize chemical inputs, and the maintenance of natural drainage patterns (Lewis *et al.*, 2019).

Mangrove harvesting serves various purposes, including fuelwood collection, charcoal production, construction materials, and land clearing for development (Dahdouh-Guebas *et al.*, 2000; Walters *et al.*, 2008). While selective harvesting at sustainable levels can be compatible with ecosystem persistence, unregulated cutting leads to forest degradation, reduced regeneration capacity, and eventual habitat loss (Walters, 2005; Berger *et al.*, 2008). The concentration of cutting activities in certain municipalities suggests either higher resource dependence in these areas or weaker enforcement of forestry regulations. Community-based forest management approaches, combined with alternative livelihoods and sustainable harvesting guidelines, provide pathways to reduce pressure on mangrove resources while addressing local needs (Huxham *et al.*, 2015; Walters *et al.*, 2008).

Such developments often result in permanent mangrove loss and fragmentation of remaining habitat (Lovelock *et al.*, 2015; Brown *et al.*, 2006). The municipalities showing infrastructure-related threats are generally those with higher levels of economic activity and population growth, suggesting that development pressure will likely intensify in these areas (Polidoro *et al.*, 2010).

Strategic environmental assessments and rigorous enforcement of environmental impact assessment requirements are essential to ensure that development projects adequately consider and mitigate impacts on mangrove ecosystems (Maneewong, 2015). Alternative siting, impact avoidance, and compensatory restoration should be standard components of coastal infrastructure planning (Bosire *et al.*, 2008).

This convergence of threats in biodiversity-rich areas creates a conservation dilemma, as the very locations that warrant the highest protection priority are experiencing the most intense pressures for degradation (Myers *et al.*, 2000; Brooks *et al.*, 2002). Conversely, Calatrava shows relatively few documented threats despite its high species richness, suggesting that this municipality may offer the best opportunity to establish well-protected conservation zones. Variation in threat profiles across municipalities indicates that conservation strategies must be tailored to local contexts, with interventions addressing the specific threats in each area (Margules and Pressey, 2000; Knight *et al.*, 2008).

CONCLUSION

This study establishes Tablas Island, Romblon, as a nationally significant mangrove biodiversity reservoir, documenting 29 species that represent 88% of Philippine mangrove diversity. The spatial distribution analysis revealed pronounced ecological heterogeneity, with Alcantara and Calatrava emerging as primary biodiversity hotspots. At the same time, Santa Maria's severe degradation to a single remaining species serves as a critical warning of irreversible habitat loss under unchecked anthropogenic pressure.

The convergence of six major threat categories—aquaculture expansion, garbage accumulation, illegal settlements, agricultural encroachment, mangrove cutting, and infrastructure development—particularly in high-biodiversity municipalities like Ferrol and Looc, underscores the urgent need for municipality-specific, rather than generalized, conservation strategies. The protection of vulnerable *Avicennia rumphiana* and near-threatened *Aegiceras floridum*, alongside range-restricted species, demands immediate in-situ habitat protection and ex-situ propagation programs.

Priority actions must include formal marine protected area designations, active coastal restoration in degraded zones, sustainable aquaculture regulation, improved waste management infrastructure, and community-based monitoring systems. As climate change intensifies coastal vulnerabilities, safeguarding Tablas Island's mangrove ecosystems is not merely an ecological imperative but a socioeconomic necessity for the dependent coastal communities whose livelihoods, food security, and resilience are intrinsically tied to the health of these irreplaceable ecosystems.

RECOMMENDATION(S)

The conservation of Tablas Island's mangrove ecosystems demands an integrated, multi-layered approach that addresses both ecological priorities and the socioeconomic drivers of habitat degradation. Local government units, in coordination with the Department of Environment and Natural Resources (DENR) and the Bureau of Fisheries and Aquatic Resources (BFAR), should immediately pursue the formal designation of Marine Protected Areas in the biodiversity hotspot municipalities of Alcantara, Calatrava, Ferrol, and Looc to establish enforceable legal protection against further habitat loss. A comprehensive ecological restoration program must be initiated urgently in Santa Maria, using native species assemblages from neighboring municipalities to rehabilitate the severely degraded coastline. Threatened species, particularly Vulnerable *Avicennia rumphiana* and Near Threatened *Aegiceras floridum*, require targeted interventions, including ex situ propagation programs, seed banking, and continuous population monitoring, to prevent local extinction. Aquaculture expansion must be regulated through mandatory mangrove greenbelt requirements. At the same time, improved municipal waste management infrastructure and enforcement of solid waste laws are essential to address the pervasive accumulation of garbage threatening coastal ecosystems. Finally, the establishment of community-based resource management frameworks that empower local stakeholders to monitor and steward, supported by long-term biodiversity research and strengthened institutional policies, will ensure the sustained ecological integrity of Tablas Island's irreplaceable mangrove heritage.

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