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Native, endemic, and threatened flora species in a swamp forest in Tagum City, Philippines: Implications for species and habitat conservation

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Abstract. *Raganas AFM, Gamalo LED, Chavez Jr JB, De Cadiz AE. 2025. Native, endemic, and threatened flora species in a swamp forest in Tagum City, Philippines: Implications for species and habitat conservation. Biodiversitas 26: 1189-1201.* Endemic and threatened plants are among the most susceptible species, and are considered the most effective surrogates for identifying and evaluating conservation priority areas. This study aimed to provide critical information regarding native, endemic, and threatened flora species within the swampy beach forest ecosystem of Hijo, Tagum City, Davao Del Norte, Philippines. A plant survey was conducted using plots along a series of 100 m transect lines within the forest, where all plants were identified, and their distribution and conservation status were assessed. The study focused on native and endemic species, with vegetation analyses examining their influence on forest community structure. The survey identified 117 native and 28 endemic species across 55 families and 116 genera from 239 vascular plant species recorded. Among these, nine species were classified as threatened. *Saribus rotundifolius* had the highest importance value reflecting its dominance and strong ecological influence within the forest. Threats such as saltwater intrusion and flooding during wet season can potentially endanger regenerating plants. A conservation strategy framework has been developed using ex situ and in situ methods to effectively protect the ecosystem. Furthermore, this study addresses gaps in the insufficient data on beach flora species across the country.

Keywords: Endemic and threatened plants, Philippine native flora, *Saribus rotundifolius*, swamp forest ecosystem, transect method

INTRODUCTION

Plants are essential for life providing food, medicine, oxygen, and ecosystem services, yet many species face increasing threats due to human activities, such as habitat destruction, overexploitation, and environmental changes (Corlett 2017; Coelho et al. 2020). The Philippines is home to diverse native and endemic plant species, but habitat loss is a major concern (Perez et al. 2020). Forest cover has declined from its original extent to about 24% as of 2020, fragmenting habitats and increasing species vulnerability (Agduma et al. 2023). Agricultural expansion particularly for crops like coconut and rice, exacerbates this decline.

With species loss accelerating worldwide, urgent ecological and biological studies are needed to minimize this loss and improve conservation efforts (Hamabata et al. 2019). Philippine flora, known for high endemism (1.9% including vertebrates), remains threatened by deforestation, climate change, illegal logging, and infrastructure development (Apan et al. 2017; Perez et al. 2020; Agduma et al. 2023). Despite conservation initiatives such as the establishment of protected areas, biodiversity threats persist, emphasizing the need for stronger conservation policies (Veridiano et al. 2020). Endemic species, highly sensitive to environmental changes, are particularly at risk (Coelho et al. 2020). Conservation programs exist in the country but face challenges due to illegal logging, poaching, and land-use changes (Agduma et al. 2023). While national parks and wildlife reserves protect some biodiversity, the rapid pace of deforestation continues (FMB 2021) which underscores the importance of policy enforcement and community engagement (Veridiano et al. 2020).

Globally, the International Union for Conservation of Nature (IUCN) identifies over 8,000 plant species as threatened (IUCN 2024). The Philippines harbors over 10,000 plant species, with approximately 9,000 native and 4,800 endemic (Pelser et al. 2011). As per the local records, the Department of Environment and Natural Resources (DENR) Administrative Order (DAO 2017) has listed nearly 1,000 threatened species ranging from Other Threatened Species to Critically Endangered. Despite efforts to mitigate biodiversity loss, the gaps in law enforcement leave many species and habitats at continued risk.

Among the tropical forest ecosystems, beach forests remain understudied, with little data on species composition, and limited conservation efforts in the Philippines (Sabulao et al. 2020). These supratidal forests, dominated by coastal creepers, shrubs, and trees serve as natural buffers that protect coastal communities against typhoons, storm surges, and tsunamis. They also play a crucial role in carbon sequestration, as well as reducing greenhouse gases, and conserving biodiversity (Sabulao et al. 2020). Environmental factors such as temperature, salinity, and humidity influence their plant composition (Kongapai et al. 2016). Unfortunately, unregulated human activities have drastically reduced coastal forests (Primavera et al. 2019).

Between 1920 and 2020, the coastal forests in the Philippines declined from 450,000 ha to 311,400 ha (Agduma and Cao 2023), but this data only accounts for mangroves, as no reliable data is currently available for beach forest cover.

An initial inventory at the swampy beach forest within Hijo Resources Corporation was conducted in 2010 and recorded 216 plant species, including trees, palms, herbs, vines, grasses, and ferns, though this data remains unpublished (Montero 2010, unpublished data). This recent study identified plant species composition, emphasizing native, endemic, and threatened species to inform conservation planning and analyzed native vegetation structure to understand their role in maintaining ecosystem functions critical for sustainable management. Findings will provide valuable information on undocumented flora species, guiding future research and conservation efforts in the study area.

MATERIALS AND METHODS

Study site

The study was conducted in a roughly 93 ha swampy beach forest located within the property of Hijo Resources Corporation (HRC) (7° 21 '9.22" N and 125° 47' 24.70" E) in Tagum City, Philippines (Figure 1). The study site is a popular tourist destination in the province. It has an approximately 325 ha total land area composed of coconut plantations, coastlines, forest reserves, and rivers. The area is surrounded by water bodies, such as Libuganon River on the western side, Nabintad River on the northern side, and the southern side facing the Davao Gulf. The beach forest is considered secondary old-growth and is home to hundreds of plants, including native and endemic species. Tagum City, the locality in which the swampy beach forest was located, experiences a tropical rainforest climate (Type IV) which is characterized by a uniform distribution of rainfall, temperature, humidity, and air pressure all year round with no pronounced wet or dry season (Beck et al. 2018). Annual rainfall in the region is 1,449 mm with an average annual temperature of 25.8°C. The city also experiences its peak relative humidity (82.83%) during January and its lowest (77.36%) in October (Climate-data.org 2019). The area is inundated by brackish water through creeks and river networks within the forest and its surrounding areas that cause flooding during rainy months. The area has an elevation ranging from 8 to 26 m above sea level.

Procedures

Sampling techniques

The field survey was conducted quarterly from July 2021 to July 2022. Before the conduct of the study, necessary permits such as the Prior Informed Consent (PIC) and Gratuitous Permit (WGP No. XI-2021-25) were secured from the locality and the Department of Environment and Natural Resources Regional Office, respectively. A modified belt transect method (Grant et al. 2004) was employed in the study, wherein a series of transect lines adjacent to one another (100 m interspace) were established within the forest. Each transect line was 100 m long and 20 m wide, and within each transect line five plots of 20 × 20 m^2 were placed at a distance of 20 m and all the plant species present there were recorded. A total of 21 transect lines and 105 plots were established in the whole sampling area with approximately 42,000 m^2 (4.2 ha) total area sampled. A digital camera (Nikon EOS M100) and a global positioning system (GPS, Garmin eTrex 10) navigation device were used for photo documentation and for obtaining coordinates from the area.

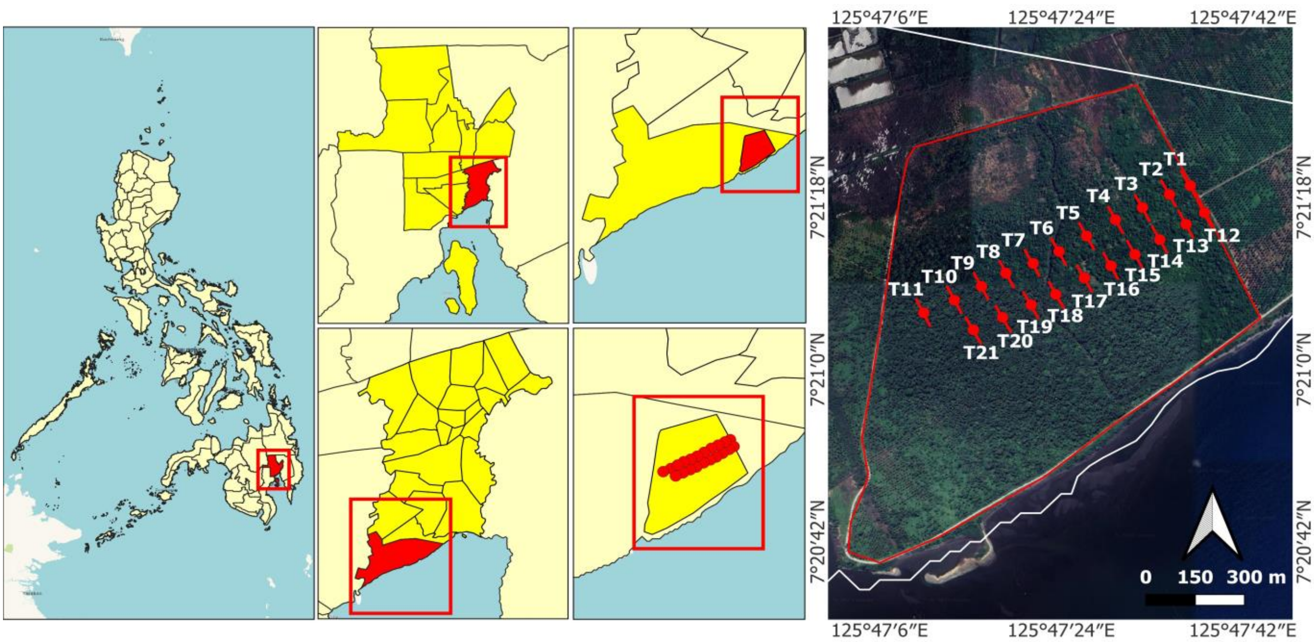

Figure 1. Location of the sampling site at Hijo Resources Corporation, Tagum City, Philippines with transect points

Data collection and processing

From the established transect lines and plots, all the plant species were identified in situ with the help of the local field guides. The verification of species identity was done using the beach forest species identification guidebook, Beach Forest Species and Mangrove Associates in the Philippines by Primavera and Sadaba (2012) and through the Philippine plant's database website, Co's Digital Flora of the Philippines (CDFP) (Pelser et al. 2011). Herbarium specimens with photographs of their habits were also taken in situ for proper identification and deposited in the Herbarium Facility of the Department of Biological Sciences and Environmental Studies, College of Science and Mathematics, the University of the Philippines Mindanao.

After the field sampling, all the plants listed were then processed to identify native, endemic, and threatened species through an extensive literature search. The validly published accepted name and distribution of each species were verified through the CDFP (https://www.philippineplants.org/), and Kew Royal Botanic Garden (https://powo.science.kew.org/) websites. The identified native and endemic plants were then summarized and separated from the whole dataset for further verification and checking. For the conservation statuses of all the recorded plant species, verification was done through IUCN (2024) and the local list of threatened species under DAO (2017). All species were categorized based on the following criteria set by the DAO (2017) and IUCN (2024): Critically Endangered (CR) which are plant species considered to be facing an extremely high risk of extinction in the wild in the immediate future; Endangered (EN) which are species considered not critically endangered but facing a very high risk of extinction in the wild if the causal factors continue operating; and Vulnerable (VU) which are species considered not critically endangered nor endangered but is under threat from adverse factors throughout its range and is likely to move to the endangered category in the future. In this study, species considered at low risk include Near Threatened (NT), Other Threatened Species (OTS), and Least Concern (LC). Meanwhile, those species that have inadequate information to make a direct or indirect assessment for their extinction, distribution, and population size were noted as Data Deficient (DD). Moreover, ecological information such as types of disturbances (anthropogenic and natural) were also noted to determine the types of threats that may have impacts on the native, endemic, and threatened species in the study area.

Data analysis

Studying the community structure of plants provides valuable insights into the composition and ecological dynamics of the study site. The community structure of the study site was determined by calculating the Importance Value Index (IVI) of each species. This metric was the sum of the relative density, relative frequency, and relative dominance of each species. Density provided information about the population size of each species within the area (Pulhin et al. 2021). Typically, species with high density had a significant influence on competition and resource availability. Frequency reflected the spatial distribution of a species across the site. Highly frequent species were often considered generalists, capable of tolerating a broad range of ecological variations (Dehling et al. 2021; Pulhin et al. 2021). Dominance identified species that exerted the greatest influence on the community structure. Dominant species played a critical role in shaping ecosystem dynamics. In this study, dominance was measured by the Diameter at Breast Height (DBH, in cm) of each plant.

The importance value encapsulates the ecological significance of a species within the community. Species with high importance values were considered foundational to the ecosystem (Pulhin et al. 2021). The vegetation analysis parameters used in the studies of Dehling et al. (2021) and Pulhin et al. (2021) were computed using the following formulae:

$$\text{Relative density} = \frac{Density\ of\ species}{Total\ density\ of\ all\ species}\ X\ 100$$

$$\text{Relative frequency} = \frac{Frequency\ of\ species}{Total\ frequency\ of\ all\ species}\ X\ 100$$

$$\text{Relative dominance} = \frac{Dominance\ of\ species}{Total\ dominace\ of\ all\ species}\ X\ 100$$

$$\text{Importance Value Index (IVI)} = Rel.density + Rel.frequency + Rel.dominance$$

RESULTS AND DISCUSSION

Species diversity

The plant survey documented an assemblage of 239 vascular species, of which 117 species (48.95%) are native and 28 species (11.72%) are endemic to the Philippines (Table 1). Trees constituted the largest group, comprising 67 species, including 52 native species (21.76%) and 15 Philippine endemic species (6.28%). Palms were represented by five species, with one species (0.42%) classified as native and four (1.67%) as Philippine endemic. Shrubs comprised ten species with eight species (3.35%) considered native and two (0.84%) considered Philippine endemic. Other plant groups such as grasses, herbs, vines, and sedges accounted for 42 species with 38 species (15.90%) considered native and four as Philippine endemic species (1.67%). Ferns were represented by 16 species (6.69%), all of which were native to the country. Meanwhile, epiphytes accounted for five species with two (0.84%) considered native and three (1.26%) considered Philippine endemic. The species richness of the swampy beach forest in Hijo Resources Corporation is relatively high compared to other beach forest studies conducted in the Philippines. For instance, Sabulao et al. (2020) reported only 39 species in Eastern Samar, while Primavera and Sadaba (2012) in their comprehensive work on beach forest species in the Philippines documented approximately 140 species only. Similarly, Romeroso et al. (2021) reported 103 species on Homonhon Island, including 29 species listed in the DAO (2017) and IUCN (2024). Meanwhile, Millamena et al. (2022) recorded just 16 species in San Fernando, San Jose, Antique in Visayas. The observed discrepancies in species richness across these studies can be attributed to variations in sampling methodologies, the geographic scale of the surveyed areas, and the diversity of plant taxa considered. Notably, this research accounted for all vascular plant taxa, which likely contributed to the higher species count observed. Furthermore, it is important to highlight that most of these studies were concentrated in the Visayas region, with few comparable studies conducted in Mindanao or Luzon, thereby underscoring the regional gap in available data.

Threatened species

In terms of conservation status, nine species were clasified as threatened, representing 3.76% of the total recorded species (Table 1 and Figure 2). According to the IUCN (2024) classification, four species fall under threatened categories with one species classified as CR (*Syzygium lancilimbum* (Merr.) Merr.), one species as EN (*Oncosperma gracilipes* Becc.), and two species as VU (*Celtis luzonica* Warb. and *Huberantha flava* (Merr.) I.M.Turner). Similarly, based on the national list of threatened species stipulated in DAO (2017), five species were identified as threatened. These include one species categorized as CR (*Helminthostachys zeylanica* (L.) Hook.), one species as EN (*Canarium ovatum* Engl.), and three species as VU (*Dracontomelon dao* (Blanco) Merr. & Rolfe, *Nephelium ramboutan-ake* (Labill.) Leenh., and *Rubroshorea negrosensis* (Foxw.) P.S.Ashton & J.Heck. (Figure 3). However, there were also species categorized as NT and OTS under IUCN and DAO (2017) classification, but these categories do not fall under the high risk threatened categories. Moreover, the rest of the species were considered LC and/or DD (Table 2). A large fraction of these threatened species belong to tree taxon.

When compared to other ecosystems studied in Mindanao, this study yielded relatively lower threatened species counts than those of Zapanta et al. (2019) in Sta. Cruz, Mt. Apo Natural Park, where 19 threatened species were recorded. Similarly, the threatened species recorded in this study was lower than those reported by Coritico et al. (2022) in Mt. Pantaron Range (41 species), Coritico et al. (2020) in Mt. Tago Range, Bukidnon (11 species), Amoroso and Aspiras (2011) in Mt. Hamiguitan Range (26 species), and Lillo et al. (2019) in Dinagat Island (22 species). The lower number of threatened species recorded in this study implies variability in species composition and conservation status across different ecosystems of Mindanao, reflecting both the ecological diversity of these areas in the region.

However, the aforementioned studies were conducted in mountain ranges in Mindanao Islands with multiple sampling sites. This study was conducted only in one sampling area with a much smaller land size compared to the cited studies on the island. It is also important to note that this study site is a beach forest surrounded by agricultural areas which may have a detrimental impact on the health and regeneration of the forest, particularly the use of harmful chemicals such as pesticides and herbicides through water and air pollution. The area also experiences periodic inundation by brackish water during rainy months, which may impede the growth of seedlings particularly those of non-salt-tolerant species. Nonetheless, this study suggests that the beach forest can support certain non-salt-tolerant species despite exposure to brackish water. According to Flowers and Colmer (2015), the high concentrations of sodium chloride in seawater are typically detrimental to plant growth. However, soil salinity is subject to spatial and temporal variation, which may influence the adaptive responses of plant populations (Moriuchi et al. 2016). Such variability in soil salinity could drive different adaptations among plant populations, potentially leading to plasticity over time (Moriuchi et al. 2016). Furthermore, there are observable signs of some tree and coconut decay in the back of the forest, which we suspect is linked to saltwater intrusion. The affected plants are likely non-salt-tolerant species, making them vulnerable to salinity stress, which could explain their deterioration and death. However, this hypothesis requires further investigation to verify the role of saltwater intrusion in the observed plant mortality.

Table 1. Number of native, endemic, and threatened species identified in a swamp forest in Tagum City, Davao del Norte, Philippines

Plant group	Native	Philippine endemic	Threatened	
			IUCN (2024)	DAO (2017)
Trees	52 (21.76)	15 (6.28)	3	4
Palms	1 (0.42)	4 (1.67)	1	0
Shrubs	8 (3.35)	2 (0.84)	0	0
Grasses, herbs, vines, & sedges	38 (15.90)	4 (1.67)	0	0
Ferns	16 (6.69)	0 (0.0)	0	1
Epiphytes	2 (0.84)	3 (1.26)	0	0
Total	117 (48.95)	28 (11.72)	4 (1.67)	5 (2.09)

Notes: Numbers inside parentheses are percent (%) fraction from the total 239 species recorded

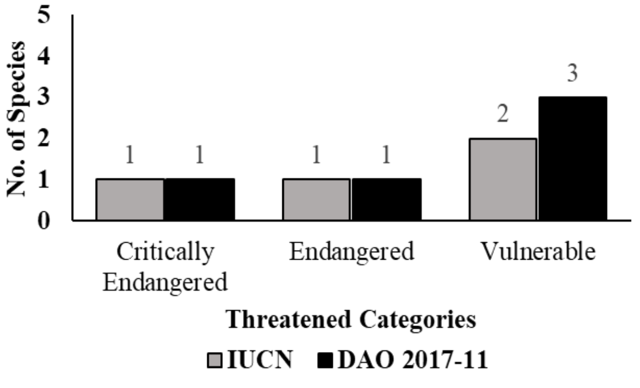

Figure 2. Number of threatened native and endemic species recorded in the study site

Table 2. List of identified native, endemic, and threatened species recorded in the study site

Family	Species name	Local name	Common name	Distri-bution	Conservation status
Trees					
Anacardiaceae	*Buchanania arborescens* (Blume) Blume	*Balinghasai*	Sparrows' mango	N	LC (IUCN 2024)
	Dracontomelon dao (Blanco) Merr. & Rolfe	*Dao*	Pacific walnut	N	VU (DAO 2017)
	Koordersiodendron pinnatum (Blanco) Merr.	*Amugis*	-	N	OTS (DAO 2017)
	Mangifera caesia Jack	*Baluno*	White mango	N	NT (IUCN 2024)
Annonaceae	*Huberantha flava* (Merr.) I.M.Turner	*Lanutan*	Yellow trumphet	PE	VU (IUCN 2024)
Apocynaceae	*Alstonia macrophylla* Wall. ex G.Don	*Batino*	Hard alstonia	N	LC (IUCN 2024)
	Alstonia scholaris (L.) R.Br.	*Dita*	Devil-tree	N	LC (IUCN 2024)
	Voacanga globosa (Blanco) Merr.	*Bayag-usa*	Testicle tree	PE	LC (IUCN 2024)
	Wrightia pubescens R.Br.	*Lanete*	-	N	LC (IUCN 2024)
Araliaceae	*Polyscias nodosa* (Blume) Seem.	*Malapapaya*	Dog-bone tree	N	LC (IUCN 2024)
Bignoniaceae	*Dolichandrone spathacea* (L.f.) K.Schum.	*Tui*	Mangrove trumpet tree	N	LC (IUCN 2024)
	Oroxylum indicum (L.) Kurz	*Pingka-pingkahan*	Indian trumpet tree	N	DD (IUCN 2024)
Burseraceae	*Canarium hirsutum* Willd.	*Malapili*	White dhup	N	DD (IUCN 2024)
	Canarium ovatum Engl.	*Pili*	Pili nut	PE	EN (DAO 2017)
	Santiria apiculata A.W.Benn.	*Kangko*	Apiculate santiria	N	DD (IUCN 2024)
Calophyllaceae	*Calophyllum blancoi* Planch. & Triana	*Bitaog*	Beach touriga/ laurelwood	N	DD (IUCN 2024)
Cannabaceae	*Celtis luzonica* Warb.	*Magabuyo*	-	N	VU (IUCN 2024)
Clusiaceae	*Garcinia binucao* (Blanco) Choisy	*Binukao*	Batuan fruit	PE	LC (IUCN 2024)
	Garcinia rubra Merr.	*Kamandiis*	-	PE	NT (IUCN 2024)
Combretaceae	*Terminalia catappa* L.	*Talisay*	Sea almond	N	LC (IUCN 2024)
	Terminalia foetidissima Griff.	*Talisay gubat*	Stinking terminalia	N	LC (IUCN 2024)
	Terminalia nitens C. Presl	*Sakat*	Sakat	N	LC (IUCN 2024)
Dilleniaceae	*Dillenia philippinensis* Rolfe	*Katmon*	Philippine dillenia	PE	DD (IUCN 2024)
Dipterocarpaceae	*Rubroshorea negrosensis* (Foxw.) P.S.Ashton & J.Heck.	*Red lauan*	Red lauan	PE	VU (DAO 2017)
Euphorbiaceae	*Macaranga tanarius* (L.) Müll.Arg.	*Binunga*	Parasol leaf tree	N	LC (IUCN 2024)
	Mallotus philippensis (Lam.) Müll.Arg.	*Banato*	Kamala tree	N	LC (IUCN 2024)
	Melanolepis multiglandulosa (Reinw. ex Blume) Rchb. & Zoll.	*Alim*	Chawan	N	LC (IUCN 2024)
Fabaceae	*Adenanthera intermedia* Merr.	*Tanglin*	Saga bean	PE	OTS (DAO 2017)
	Albizia saponaria (Lour.) Blume ex Miq.	*Salingkugi*	Whiteflower albizia	N	LC (IUCN 2024)
	Erythrina variegata L.	*Dapdap*	Tiger's claw	N	LC (IUCN 2024)
Hypericaceae	*Cratoxylum sumatranum* (Jack) Blume	*Pag-uringon*	Sumatran tree	N	LC (IUCN 2024)
Lauraceae	*Litsea philippinensis* Merr.	*Bakan*	Philippine litsea	PE	NT (IUCN 2024)
Malvaceae	*Colona serratifolia* Cav.	*Anilau*	Serrate-leaved colona	N	LC (IUCN 2024)
	Commersonia bartramia (L.) Merr.	*Kakaag*	Scrub christmas tree	N	LC (IUCN 2024)
	Hibiscus tiliaceus L.	*Malabago*	Sea hibiscus	N	LC (IUCN 2024)
	Pterocymbium tinctorium (Blanco) Merr.	*Taloto*	Winged boot tree	N	LC (IUCN 2024)
	Pterospermum niveum S.Vidal	*Bayok*	Snowy pterospermum	N	DD (IUCN 2024)
	Sterculia ceramica R.Br.	*Anagas*	Tropical chestnut	N	DD (IUCN 2024)
	Sterculia stipulata Korth.	*Uos*	-	N	LC (IUCN 2024)
Meliaceae	*Aglaia edulis* (Roxb.) Wall.	*Malasaging*	Aglaia	N	OTS (DAO 2017)
	Didymocheton gaudichaudianus A.Juss.	*Igyo*	Ivory mahogany	N	LC (IUCN 2024)
	Epicharis parasitica (Osbeck) Mabb.	*Bagolan*	Yellow mahogany	N	LC (IUCN 2024)
	Sandoricum koetjape (Burm.f.) Merr.	*Santol*	Cotton fruit	N	LC (IUCN 2024)
Moraceae	*Artocarpus blancoi* (Elmer) Merr.	*Antipolo*	-	PE	LC (IUCN 2024)
	Ficus ampelos Burm.f.	*Upling-gubat*	-	N	LC (IUCN 2024)
	Ficus botryocarpa Miq.	*Basikong kalauang*	-	N	LC (IUCN 2024)
	Ficus callosa Willd.	*Kalukoy*	Calloused fig	N	DD (IUCN 2024)
	Ficus caulocarpa (Miq.) Miq.	*Botgo*	Stem-fruited fig	N	LC (IUCN 2024)
	Ficus nota (Blanco) Merr.	*Tibig*	Sacking tree	N	LC (IUCN 2024)
	Ficus septica Burm.f.	*Hauili*	White-veined fig	N	DD (IUCN 2024)
	Ficus variegata Blume	*Tangisang-bayauak*	Variegated fig	N	LC (IUCN 2024)
Myrtaceae	*Syzygium lancilimbum* (Merr.) Merr.	*Salimbangon*	-	PE	CR (IUCN 2024)
	Syzygium tripinnatum (Blanco) Merr.	*Hagis*	-	N	DD (IUCN 2024)
Phyllanthaceae	*Glochidion littorale* Blume	*Kayong*	Monkey apple	N	LC (IUCN 2024)
Rhamnaceae	*Ziziphus talanai* (Blanco) Merr.	*Balakat*	Balakat	PE	OTS (DAO 2017)
Rubiaceae	*Neonauclea formicaria* (Elmer) Merr.	*Hambabalud*	-	PE	LC (IUCN 2024)
	Morinda citrifolia L.	*Apatot*	Indian mulberry	N	LC (IUCN 2024)
	Nauclea orientalis (L.) L.	*Bangkal*	Yellow cheesewood	N	LC (IUCN 2024)
	Villaria odorata (Blanco) Merr.	*Kumbatol*	-	PE	LC (IUCN 2024)

Salicaceae	*Flacourtia rukam* Zoll. & Mor	*Bitongol*	Governor's plum	N	DD (IUCN 2024)
Sapindaceae	*Dictyoneura acuminata* Blume	*Cubao*	Acuminate dictyoneura	N	LC (IUCN 2024)
	Mischocarpus pentapetalus (Roxb.) Radlk.	*Ambalag*	Purple aril mischocarp	N	DD (IUCN 2024)
	Nephelium ramboutan-ake (Labill.) Leenh.	*Kapulasan*	Pulasan	N	VU (DAO 2017)
	Trigonachras cuspidata Radlk.	*Salab*	Spiked trigonachras	PE	DD (IUCN 2024)
Sapotaceae	*Planchonella duclitan* (Blanco) Bakh.f.	*Duklitan*	White nato	N	LC (IUCN 2024)
Tetramelaceae	*Octomeles sumatrana* Miq.	*Binuang*	Benuang	N	LC (IUCN 2024)
Vitaceae	*Leea aculeata* Blume ex Spreng.	*Kaliantan*	Mali-mali	N	DD (IUCN 2024)
Palms					
Arecaceae	*Calamus zollingeri* subsp. *merrillii* (Becc.) A.J. Hend.	*Palasan*	-	PE	OTS (DAO 2017)
	Caryota cumingii Lodd. ex Mart.	*Pugahan*	Fishtail palm	PE	DD (IUCN 2024)
	Oncosperma gracilipes Becc.	*Anibong-liitan*	Gracilipes-type oncosperma	PE	EN (IUCN 2024)
	Saribus rotundifolius (Lam.) Blume	*Anahaw*	Footstool palm	N	OTS (DAO 2017)
	Plectocomia elongata var. *philippinensis* Madulid	*Uway*	Giant rattan palm	PE	OTS (DAO 2017)
Shrubs					
Annonaceae	*Friesodielsia bakeri* (Merr.) Steenis	*Lagdañgang-bibit*	-	PE	DD (IUCN 2024)
Apocynaceae	*Tabernaemontana pandacaqui* Poir.	*Pandakaking puti*	Windmill bush	N	LC (IUCN 2024)
Araliaceae	*Heptapleurum ellipticum* (Blume) Seem.	*Galamay-amo*	Climbing umbrella	N	LC (IUCN 2024)
Asteraceae	*Blumea balsamifera* (L.) DC.	*Sambong*	Buffalo-ear	N	LC (IUCN 2024)
Lamiaceae	*Clerodendrum minahassae* Teijsm. & Binn.	*Bagawak puti*	Tube flower	N	LC (IUCN 2024)
Lauraceae	*Lindera erythrocarpa* Makino	*Bayabas-bayabasan*	Red-fruit spicebush	N	LC (IUCN 2024)
Loganiaceae	*Strychnos ignatii* P.J.Bergius	*Katbalonga*	Saint ignatius bean	N	DD (IUCN 2024)
Melastomataceae	*Melastoma malabathricum* L.	*Malatungao*	Malabar melastome	N	DD (IUCN 2024)
Pandanaceae	*Benstonea copelandii* (Merr.) Callm. & Buerki	*Bariw*	Copeland's false foxglove	PE	LC (IUCN 2024)
Phyllanthaceae	*Breynia vitis-idaea* (Burm.f.) C.E.C. Fisch.	*Matang hipon*	Indian snowberry	N	LC (IUCN 2024)
Grasses, herbs, vines, sedges					
Amaranthaceae	*Achyranthes aspera* L.	*Hangod*	Chaff-flower	N	DD (IUCN 2024)
	Alternanthera sessilis (L.) DC.	*Bunga-bunga*	Sessile joyweed	N	LC (IUCN 2024)
	Amaranthus viridis L.	*Kulitis*	Slender amaranth	N	DD (IUCN 2024)
Araceae	*Alocasia macrorrhizos* (L.) G.Don	*Badiang*	Giant taro	N	DD (IUCN 2024)
	Epipremnum pinnatum (L.) Engl.	*Tibatib*	Dragon-tail plant	N	DD (IUCN 2024)
	Pothoidium lobbianum Schott	*Baralta*	Lobb's pothos	N	DD (IUCN 2024)
	Raphidophora cf. *elmeri*	*Rapidophora*	Rapidophora	PE	DD (IUCN 2024)
Asteraceae	*Acmella grandiflora* (Turcz.) R.K.Jansen	*Biri*	Swamp daisy	N	DD (IUCN 2024)
	Adenostemma viscosum J.R.Forst. & G.Forst.	*Boton*	Dung weed	N	LC (IUCN 2024)
	Emilia sonchifolia (L.) DC.	*Tagulinau*	Lilac tasselflower	N	DD (IUCN 2024)
Cleomaceae	*Cleome viscosa* L.	*Silisilihan*	Asian spiderflower	N	DD (IUCN 2024)
Commelinaceae	*Murdannia nudiflora* (L.) Brenan	*Kolasi*	Doveweed	N	DD (IUCN 2024)
Convolvulaceae	*Decalobanthus peltatus* (L.) A.R.Simões & Staples	*Bulakan*	Merremia	N	DD (IUCN 2024)
Cucurbitaceae	*Zehneria mucronata* (Blume) Miq.	*Zenerya*	Toothed zehneria	N	DD (IUCN 2024)
Cyperaceae	*Cyperus brevifolius* (Rottb.) Hassk.	*Pugo-pugo*	Shortleaf spikesedge	N	DD (IUCN 2024)
	Cyperus compressus L.	*Baki-baki*	Annual sedge	N	LC (IUCN 2024)
	Cyperus difformis L.	*Bankoan*	Variable flatsedge	N	LC (IUCN 2024)
	Cyperus haspan L.	*Ballayang*	Dwarf papyrus	N	LC (IUCN 2024)
	Cyperus iria L.	*Sud-sud*	Rice flatsedge	N	LC (IUCN 2024)
	Cyperus rotundus L.	*Boto-botones*	Purple nutsedge	N	LC (IUCN 2024)
	Fimbristylis dichotoma (L.) Vahl	*Gumi*	Forked fimbry	N	LC (IUCN 2024)
	Scleria scrobiculata Nees & Meyen	*Daat*	Nutrush	N	DD (IUCN 2024)
Dioscoreaceae	*Dioscorea hispida* Dennst.	*Nami*	Indian three-leaved yam	N	DD (IUCN 2024)
Fabaceae	*Abrus precatorius* L.	*Saga*	Rosary pea	N	DD (IUCN 2024)
	Alysicarpus vaginalis (L.) DC.	*Banig-usa*	Buffalo clover	N	DD (IUCN 2024)
Flagellariaceae	*Flagellaria indica* L.	*Baling-uai*	Whip vine	N	DD (IUCN 2024)
Linderniaceae	*Lindernia procumbens* (Krock.) Philcox	*Pimpernel*	Creeping slitwort	N	DD (IUCN 2024)
Menispermaceae	*Anamirta cocculus* (L.) Wight & Arn.	*Lagtang*	Indian cockle	N	DD (IUCN 2024)
	Pycnarrhena tumefacta Miers	*Ambal*	Bekai	N	DD (IUCN 2024)
Moraceae	*Ficus sagittata* Vahl	*Layad*	Trailing fig	N	LC (IUCN 2024)
	Ficus subulata Blume	*Malaisus*	-	N	DD (IUCN 2024)
	Ficus villosa Blume	*Villous*	Shaggy-leaved fig	N	DD (IUCN 2024)
Pandanaceae	*Freycinetia multiflora* Merr.	*Daplas pandan*	Climbing pandanus	N	DD (IUCN 2024)

Phyllanthaceae	*Phyllanthus niruri* L.	*Sampa-sampalukan*	Gale of the wind	N	DD (IUCN 2024)
Piperaceae	*Piper betle* L.	*Ikmo*	Betel	N	DD (IUCN 2024)
Poaceae	*Dinochloa acutiflora* (Munro) S.Dransf.	*Bikal*	Acute-flowered dinochloa	N	OTS (DAO 2017)
	Dinochloa dielsiana Pilg.	*Bikal baboy*	Climbing bamboo	PE	DD (IUCN 2024)
	Echinochloa colona (L.) Link	*Dukayang*	Jungle rice	N	LC (IUCN 2024)
Urticaceae	*Elatostema whitfordii* Merr.	*Elatostema*	-	PE	DD (IUCN 2024)
	Poikilospermum suaveolens (Blume) Merr.	*Hanopol*	Fragrant conehead	N	DD (IUCN 2024)
Vitaceae	*Causonis trifolia* (L.) Mabb. & J.Wen	*Alangingi*	Bush grape	N	DD (IUCN 2024)
Zingiberaceae	*Hornstedtia conoidea* Ridl.	*Tugis*	-	PE	DD (IUCN 2024)
Ferns					
Aspleniaceae	*Asplenium cymbifolium* Christ	*Dapong babae*	Spleenwort	N	DD (IUCN 2024)
	Asplenium nidus L.	*Pugad lawin*	Bird's nest fern	N	DD (IUCN 2024)
	Stenochlaena palustris (Burm.f.) Bedd.	*Hagnaya*	Climbing fern	N	DD (IUCN 2024)
	Thelypteris dentata E.P.St.John	*Tibubog*	Downy maiden fern	N	LC (IUCN 2024)
Ophioglossaceae	*Helminthostachys zeylanica* (L.) Hook.	*Tukod-langit*	Kamraj	N	CR (DAO 2017)
Polypodiaceae	*Davallia solida* (G.Forst.) Sw.	*Pako*	Dainty rabbits-foot fern	N	OTS (DAO 2017)
	Drynaria quercifolia (L.) J.Sm.	*Pakpak-lawin*	Oakleaf basket fern	N	DD (IUCN 2024)
	Nephrolepis biserrata (Sw.) Schott	*Alolokdo*	Broad sword fern	N	DD (IUCN 2024)
	Pyrrosia lanceolata (L.) Farw.	*Pagong-pagongan dako*	Lanceleaf tongue fern	N	DD (IUCN 2024)
	Pyrrosia piloselloides (L.) M.G.Price	*Pagong-pagongan*	Dragon's scale fern	N	DD (IUCN 2024)
Pteridaceae	*Acrostichum aureum* L.	*Lagolo*	Swamp fern	N	LC (IUCN 2024)
	Acrostichum speciosum Willd.	*Palaypay*	Mangrove fern	N	LC (IUCN 2024)
	Antrophyum reticulatum (G.Forst.) Kaulf.	*Antropayum*	Lineleaf fern	N	DD (IUCN 2024)
	Pteris tripartita Sw.	*Pakong bundok*	Giant brake fern	N	DD (IUCN 2024)
Schizaeaceae	*Lygodium circinnatum* (Burm.f.) Sw.	*Nito*	Red finger fern	N	DD (IUCN 2024)
	Lygodium japonicum (Thunb.) Sw.	*Nitong hapon*	Japanese climbing fern	N	DD (IUCN 2024)
Epiphytes					
Apocynaceae	*Dischidia cleistantha* Livsh.	*Pag-ong-pag-ongan*	Shingle plant	PE	DD (IUCN 2024)
	Dischidia oiantha Schltr.	*Nanaog ka irog*	Hanging coin vine	PE	DD (IUCN 2024)
	Dischidia platyphylla Schltr.	*Timbáng-timbáng*	Flat-leaved dischidia	PE	DD (IUCN 2024)
Orchidaceae	*Brachypeza unguiculata* (Lindl.) Kocyan & Schuit.	*Sage orchid*	Sage orchid	N	DD (IUCN 2024)
	Dendrobium crumenatum Sw.	*Karamosi*	Pigeon orchid	N	DD (IUCN 2024)

Note: Distribution: N: Native; PE: Philippine Endemic; Conservation status based on DAO (2017) and IUCN (2024) classification: CR: Critically Endangered; EN: Endangered; VU: Vulnerable; NT: Near Threatened; OTS: Other Threatened Species; LC: Least Concern; DD: Data Deficient

Several common beach forest species were also identified in this study, including footstool palm (*Saribus rotundifolius* (Lam.) Blume), sea almond (*Terminalia catappa* L.), devil-tree (*Alstonia scholaris* (L.) R.Br.), beach touriga (*Calophyllum inophyllum* L.), snowy pterospermum (*Pterospermum diversifolium* Blume), tiger's claw (*Erythrina variegata* L.), sumatran tree (*Cratoxylum sumatranum* (Jack) Blume), sea hibiscus (*Hibiscus tiliaceus* L.), monkey apple (*Glochidion littorale* Blume), yellow cheesewood (*Nauclea orientalis* (L.) L.), and various *Ficus* species. Notably, *S. rotundifolius* was particularly abundant in the area. The high abundance of this species may be attributed to its habitat suitability, as well as to dispersal by local mammals, such as macaques and the palm civet, which are present in the area (Gamalo et al. 2023). In comparison, other dominant species commonly found across beach forests in the Indo-Pacific region include *Barringtonia asiatica* (L.) Kurz, *C. inophyllum*, *T. catappa*, *Pandanus tectorius* Parkinson ex Du Roi, and *H. tiliaceus* (Kongapai et al. 2016). These species are also present in the study site, further aligning the local flora with established patterns of beach forest composition in the region.

Several other dominant tree species, including *D. dao*, *Artocarpus blancoi* (Elmer) Merr., *Albizia saponaria* (Lour.) Blume ex Miq., and *Terminalia foetidissima* Griff., complement *S. rotundifolius* in shaping the forest's structure and ecological functions. These species also contribute to habitat provision by offering nesting, feeding, and shelter opportunities for wildlife; soil stabilization and nutrient cycling where their root systems help prevent soil erosion, while decomposing leaf litter enhances soil organic matter; and canopy diversity where variations in crown height and structure create a multilayered canopy, enhancing microhabitat availability and supporting diverse species (Gámez and Harris 2022; Nakamura et al. 2022). The presence of these trees, which represent various successional stages, suggests a mature and ecologically stable forest capable of supporting a rich assemblage of flora and fauna (Huffman et al. 2009; Amoroso and Aspiras 2011; Lillo et al. 2020).

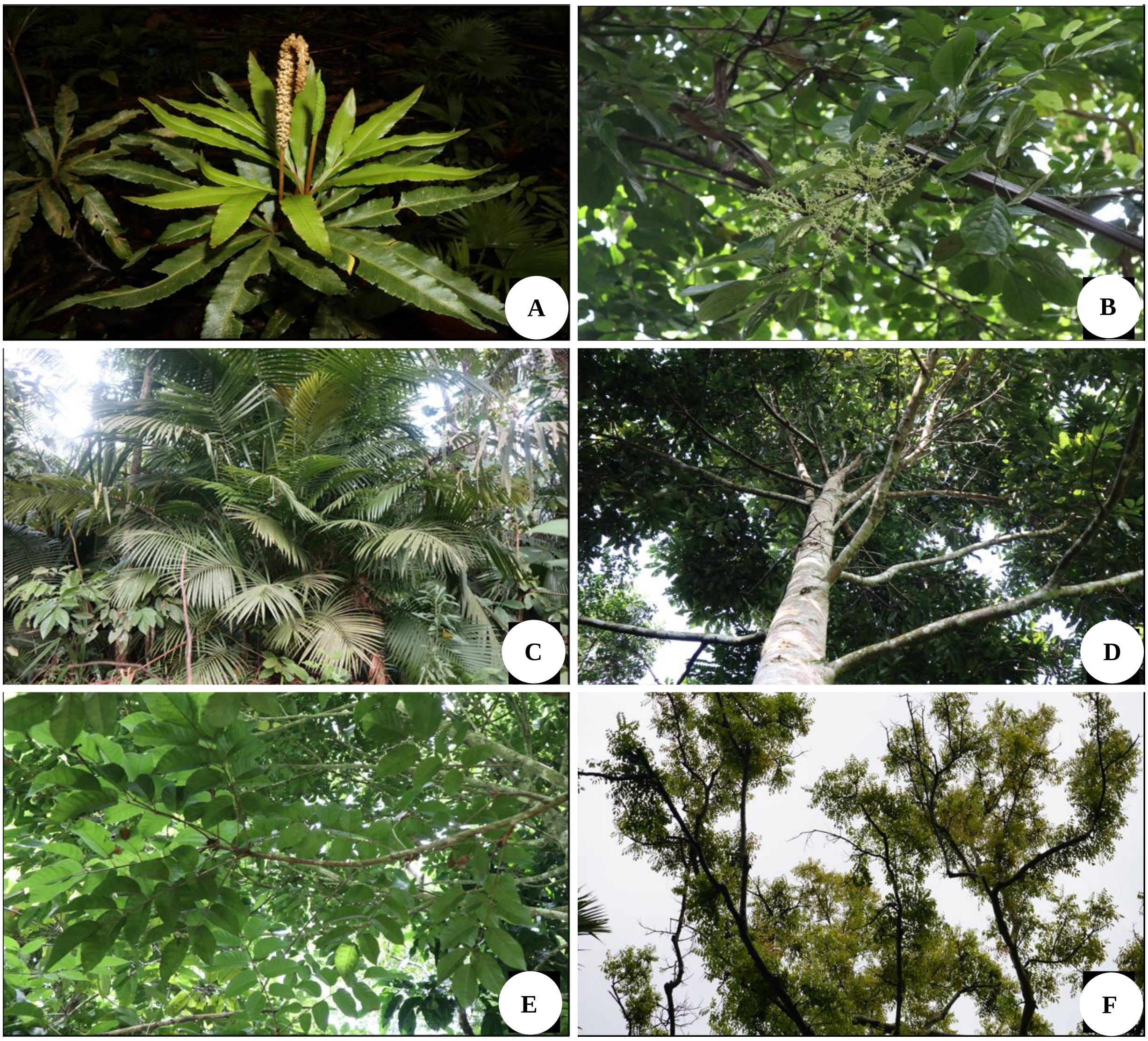

Figure 3. Representative threatened and native vascular plants in Hijo, Tagum City, Davao Del Norte, Philippines: A. *Helminthostachys zeylanica* (kamraj); B. *Terminalia nitens* (sakat); C. *Oncosperma gracilipes* (gracilipes-type oncosperma); D. *Rubroshorea negrosensis* (red lauan); E. *Canarium ovatum* (pili nut); F. *Dracontomelon dao* (pacific walnut)

Climbing species, such as *Flagellaria indica* L., *Freycinetia multiflora* Merr., and *Calamus zollingeri* subsp. *merrillii* (Becc.) A.J. Hend., along with understory species like *Nephrolepis biserrata* (Sw.) Schott and *Epicharis parasitica* (Osbeck) Mabb., further reflect the forest's layered complexity. Climbing species enhance vertical connectivity by creating pathways and habitats for arboreal organisms while contributing to overall canopy density. Meanwhile, understory species play essential roles in soil protection, moisture retention, and nutrient cycling (Landuyt et al. 2019; Balandier et al. 2022; Deng et al. 2023). Their presence indicates a healthy forest floor with sufficient light and resources for growth. The coexistence of these climbers and understory species with dominant trees and palms demonstrates a balanced and functioning ecosystem, where diverse layers collectively enhance resilience and biodiversity (Coritico et al. 2020; Deng et al. 2023). In contrast, species with low IVI scores, though less dominant, remain ecologically significant. Their limited abundance and distribution reflect a minor structural contribution, yet they can add to the ecosystem's genetic diversity and resilience.

The study area supports a substantial number of native and endemic species (145 species, 60.67%) with the majority consisting of trees (Table 2). This number is relatively high compared to findings from other studies on beach forest ecosystems in the country conducted by Sabulao et al. (2020), Romeroso et al. (2021), and Gonzalez et al. (2022). Some of the identified species, especially trees, are usually found growing in highland areas but their presence in the beach forest site is quite interesting. This suggests that these species may have evolved adaptive mechanisms to withstand salinity (although more research is needed), or they may have been disseminated by birds and bats. Interestingly, the forest also harbors numerous endemic plant species. The presence of these endemic plants is indispensable for site conservation as they face high risks of extinction in the future.

Most represented families

Moraceae is the most represented among the plant families with 11 species recorded, followed by Apocynaceae and Cyperaceae both with eight species, Malvaceae with seven species, and Fabaceae, Polypodiaceae, and Arecaceae with five species, respectively. The rest of the families are represented by four species and below. The findings of this study are comparable to the study of Zapanta et al. (2019) in a highland forest ecosystem in Mt. Apo, Mindanao where Moraceae is the most represented family in their study site. Moraceae is arguably one of the most important plant family in tropical lowland rainforests. *Ficus*, a genus under the family is commonly diverse in lowland rainforests which is also true to this study. They consist of semi-epiphytic to dioecious figs that have diversified into various niches. Many fig species have recruitment opportunities that limit competition and have an efficient long-distance pollination system, which allows them to breed at low densities (Harrison 2005).

Apocynaceae is also a large family which can be found mostly in tropical regions of the world. This family consists of approximately 5,350 species with diverse morphology and ecology, ranging from large trees, herbs, succulents, and vines in a wide variety of habitats (Bitencourt et al. 2021). In the Philippines, they can be found from low to high elevations which may indicate their abundance in the study area. Moreover, Cyperaceae is considered the third largest monocot family (Govaerts et al. 2020; Bezerra and Pinheiro 2021) and is of considerable economic and ecological importance (Spalink et al. 2016, et al. 2018; Larridon et al. 2021). The diversity in this family is represented by a wide range of growth forms, from tiny ephemerals to climbing herbs (Larridon et al. 2021). It occurs in a wide variety of habitats ranging from aquatic to high-elevation vegetation (Simpson et al. 2011). The family Malvaceae which thrives in lowland and disturbed forests, is also well-represented in tropical forests including the Philippines. Fabaceae is considered the third-largest family of flowering plants and is well-represented in tropical forests as well (Vargas et al. 2015). Its dominance is due to its numerous subfamilies, including Caesalpinioideae, Mimosoideae, and Faboideae. These observations support the claim that legumes are particularly abundant in tropical forests (Félix et al. 2019). The family Polypodiaceae comprising epiphytic and terrestrial ferns, thrives in humid, shaded habitats and is abundant in both disturbed and undisturbed forests such as those in Mt. Apo (Cano-Mangaoang et al. 2020). Similarly, Arecaceae (palm) occurs in all tropical and subtropical regions of the world. Palms are of high ecological and economical importance and display complex spatial patterns of species distributions and diversity. With over 2,500 species worldwide, the palm family and its five subfamilies exhibit an astounding geographic variation in species richness and life forms (Abdullah et al. 2024).

Forest community structure

The species with the highest IVI is *S. rotundifolius* (Figure 4). This indicates that it holds the most significant cumulative vegetation parameter values, reflecting its dominance and strong ecological influence within the study area (Pulhin et al. 2021). As observed, the species has been well-established in the area for a long period. Other dominant tree species in the study site include *D. dao*, *A. blancoi*, *A. saponaria*, and *T. foetidissima*. Additionally, prominent climbing and understory species include *F. indica*, *F. multiflora*, *C. z.* subsp. *merrillii*, *N. biserrata*, and *E. parasitica*. The rest are species with IVI values below 2.07.

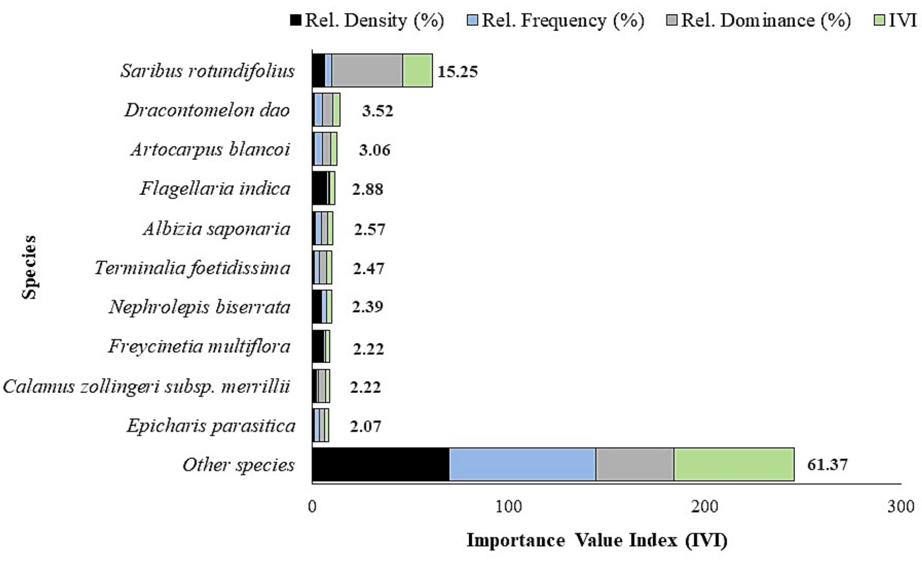

Figure 4. Top ten species with the highest Importance Value Index (IVI)

The results highlight the ecological significance and structural dynamics of the vegetation community in the study area, as indicated by the Importance Value Index (IVI) scores. The dominance of *S. rotundifolius* can be attributed to its widespread distribution, high abundance, and notable structural attributes, such as tall height and large boles in the study site. These traits indicate that *S. rotundifolius* has been well-adapted to the local environmental conditions. Optimal factors such as suitable soil, favorable climate, and competitive ability likely contribute to its prevalence. Ecologically, the dominance of *S. rotundifolius* highlights its critical role in stabilizing the habitat, supporting biodiversity, and influencing nutrient cycling. Its large boles and tall stature provide essential habitat for various fauna, including birds, primates, and insects, further emphasizing its ecological importance (Viana et al. 2016).

Conservation implications

The findings underscore the importance of both dominant and less dominant native and endemic species across various strata highlighting the complexity and richness of the study area's biodiversity. This makes the site a priority for conservation efforts, aligning with broader biodiversity conservation goals in the region (Amoroso and Aspiras 2011; Lillo et al. 2020). The proposed conservation strategy designed for Hijo forest aligns with the successful habitat and forest preservation efforts implemented throughout the Philippines. This approach combines both ex situ and in situ conservation methods, focusing on habitat rehabilitation, safeguarding species, and fostering community involvement as presented in Figure 5.

Ex situ conservation indicated in the strategy framework includes bioresource preservation, educational campaigns, and the participation of civil society groups. These efforts are critical for maintaining genetic diversity and preserving local extinction, especially for native and endemic species (Coelho et al. 2020). A comparable initiative is the mainstreaming of Philippine native trees led by the Energy Development Corporation (EDC) through its BINHI program. This program promotes the propagation of threatened Philippine native trees through nursery propagation, seed banking, and reforestation projects (EDC 2023). Similar efforts have been undertaken at the Rainforestation (RF) technology research pioneered by Milan (2020) in Leyte, where native trees are cultivated to educate the public on their ecological importance. Such ex situ measures complement in situ conservation by ensuring that vulnerable species can be reintroduced into degraded forests, supporting ecosystem restoration efforts.

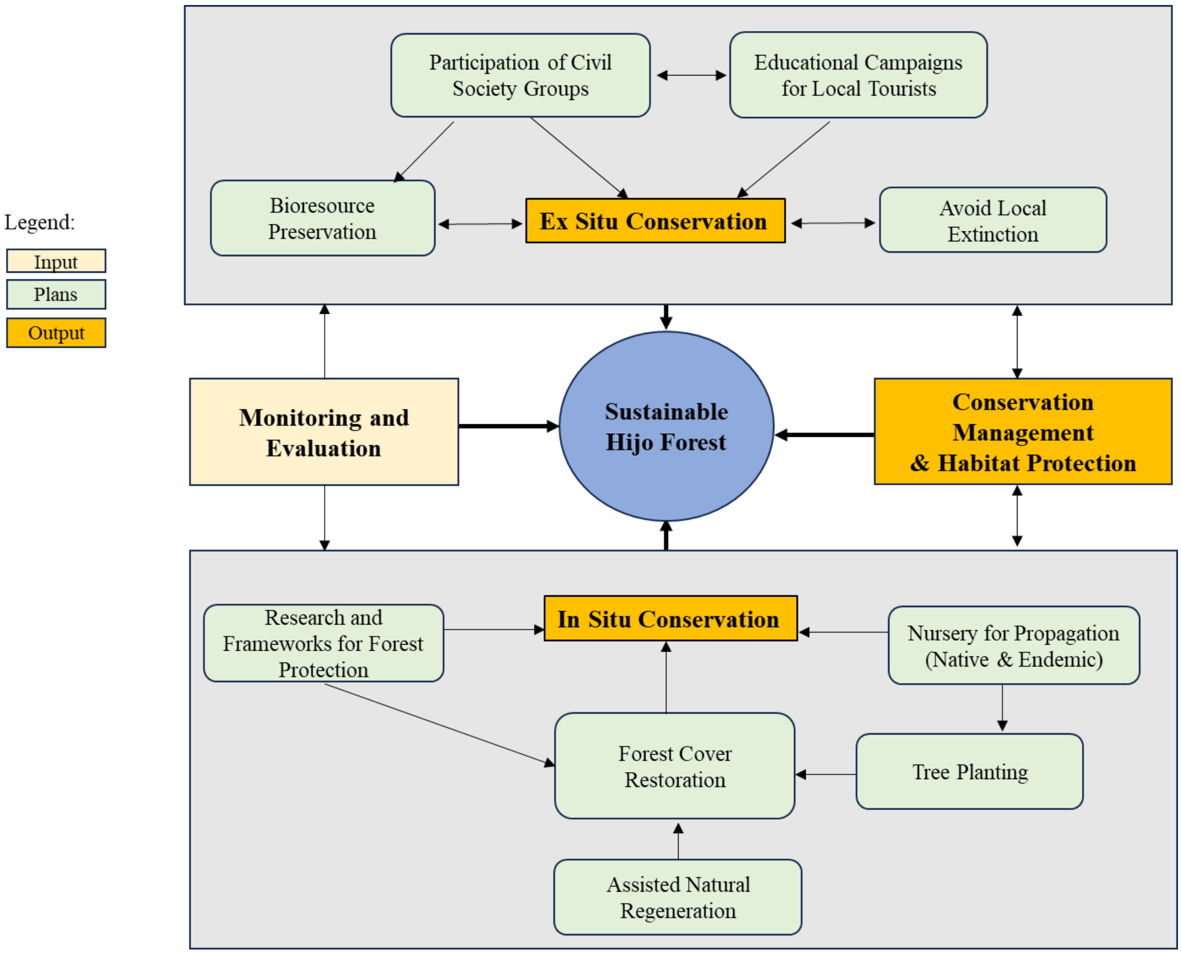

Figure 5. The proposed conservation strategy framework for the Hijo forest

The conservation strategy places a strong emphasis on in situ methods, particularly forest cover restoration, tree planting, and Assisted Natural Regeneration (ANR). These approaches have been effectively applied in various forest conservation programs across the Philippines. One notable initiative is the National Greening Program (NGP), a large-scale reforestation effort led by the Department of Environment and Natural Resources (DENR). This program has successfully rehabilitated more than 1.5 million ha of degraded forest lands using native trees and other plant species (Diwa et al. 2024). The initiative aligns with Hijo's strategy, which prioritizes nursery propagation and reforestation efforts to enhance forest cover and biodiversity. Another key program is the Leyte Sab-a Peatland Forest Restoration Project, which implements assisted natural regeneration —a technique that promotes natural seed dispersal and growth while minimizing human disturbances (Matutes and Densing 2022). The proposed Hijo's conservation framework adopts a similar approach, encouraging forest recovery through selective planting and minimal intervention to maintain ecological balance. Additionally, the Mt. Kitanglad Range Natural Park Conservation Project serves as a model for integrating scientific research, community engagement, and habitat protection to safeguard one of Mindanao's most ecologically significant forest ecosystems (Amoroso et al. 2011). Hijo's conservation framework, which incorporates research-driven management and policy integration, mirrors this strategy to ensure sustainable forest governance.

The framework also underscores the importance of monitoring and evaluation as a key pillar of conservation. Systematic monitoring enables adaptive management, ensuring that conservation strategies are continuously refined based on scientific data and real-time ecological assessments. A notable example is the Northern Sierra Madre Natural Park Conservation Project, which employs a community-based monitoring system to track deforestation trends and biodiversity shifts (Araño and Persoon 1998). Implementing similar methodologies in Hijo Forest will enhance conservation effectiveness, allowing interventions to remain dynamic and responsive to environmental changes. Another crucial aspect is conservation management and habitat protection through multi-sectoral collaboration. The long-term success of any forest conservation initiative hinges on robust governance structures and multi-stakeholder partnerships. The Hijo framework emphasizes conservation management through collaborative efforts involving academic institutions, Local Government Units (LGUs), Non-Governmental Organizations (NGOs), and private sector stakeholders. A comparable approach has been successfully applied in the Mt. Malindang Range Natural Park, where scientists, policy makers, and local communities work together to develop and implement sustainable forest management strategies (Ureta et al. 2016).

In conclusion, beach forests are vital ecosystems that support coastal biodiversity, provide ecosystem services, and serve as natural buffers against disturbances. This study identified the plant species composition of the swamp forest of HRC, Tagum City, Philippines highlighting 117 native, 28 endemic, and nine threatened species that contribute to ecosystem resilience. However, the forest faces threats from saltwater intrusion, flooding, and anthropogenic pressures like harmful agricultural chemicals which may hinder regeneration, fragment habitats, and reduce ecological and economic value. Dominant species like *S. rotundifolius* enhance stability, while less dominant species contribute to biodiversity complexity. To address these threats, a comprehensive conservation strategy was developed. This strategy focuses on habitat restoration, nursery propagation of native and endemic species, and community involvement through ex situ and in situ conservation. Effective conservation requires collaboration among HRC, academic institutions, government agencies, NGOs, and private stakeholders. An integrated governance framework combining policy, planning, and research will further strengthen these initiatives. As among the first studies to document beach forest in Mindanao, these findings fill a knowledge gap and provide insights for conservation planning. Continued research and long-term monitoring are crucial for protecting native and endemic species in coastal forests.

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REFERENCES

Abdullah MF, Jaafar SM, Ahmad N, Sukri RS. 2024. Tropical palms and factors influencing their distributions and diversity, with a focus on *Pinanga* diversity in Southeast Asia. Biotropia 31 (2): 291-307. DOI: 10.11598/btb.2024.31.2.2023.

Agduma AR, Cao K-F. 2023. Species richness, extent and potential threats to mangroves of Sarangani Bay Protected Seascape, Philippines. Biodivers Data J 11: e100050. DOI: 10.3897/BDJ.11.e100050.

Agduma AR, Garcia FG, Cabasan MT, Pimentel J, Ele RJ, Rubio M, Murray S, Hilario-Husain BA, Dela Cruz KC, Abdullah S, Balase SM, Tanalgo KC. 2023. Overview of priorities, threats, and challenges to biodiversity conservation in the southern Philippines. Reg Sustain 4 (2): 203-213. DOI: 10.1016/j.regsus.2023.05.003.

Amoroso VB, Aspiras RA. 2011. Hamiguitan range: A sanctuary for native flora. Saudi J Biol Sci 18 (1): 7-15. DOI: 10.1016/j.sjbs.2010.07.003.

Amoroso VB, Laraga SH, Calzada BV. 2011. Diversity and assessment of plants in Mt. Kitanglad Range Natural Park, Bukidnon, Southern Philippines. Gard Bull Singapore 63 (1 and 2): 219-236.

Apan A, Suarez LA, Maraseni T, Castillo JA. 2017. The rate, extent and spatial predictors of forest loss (2000-2012) in the terrestrial protected areas of the Philippines. Appl Geogr 81: 32-42. DOI: 10.1016/j.apgeog.2017.02.007.

Araño RR, Persoon GA. 1998. Action research for community-based resource management and development: The case of the Northern Sierra Madre Natural Park Conservation Project, Northeastern Philippines. In: Sem Proc, Research in Tropical Rain forests: Its Challenges for the Future. The Tropenbos Foundation, Wageningen, the Netherlands.

Balandier P, Gobin R, Prévosto B, Korboulewsky N. 2022. The contribution of understorey vegetation to ecosystem evapotranspiration in boreal and temperate forests: A literature review and analysis. Eur J For Res 141: 979-997. DOI: 10.1007/s10342-022-01505-0.

Beck HE, Zimmermann NE, McVicar TR, Vergopolan N, Berg A, Wood EF. 2018. Present and future Köppen-Geiger climate classification maps at 1-km resolution. Sci Data 5: 180214. DOI: 10.1038/sdata.2018.214.

Bezerra JJL, Pinheiro AAV. 2021. Traditional uses, phytochemistry, and anticancer potential of *Cyperus rotundus* L. (Cyperaceae): A systematic review. S Afr J Bot 144: 175-186. DOI: 10.1016/j.sajb.2021.08.010.

Bitencourt C, Nürk NM, Rapini A, Fishbein M, Simões AO, Middleton DJ, Meve U, Endress ME, Liede-Schumann S. 2021. Evolution of dispersal, habit, and pollination in Africa pushed Apocynaceae diversification after the eocene-oligocene climate transition. Front Ecol Evol 9: 719741. DOI: 10.3389/fevo.2021.719741.

Cano-Mangaoang C, Bretaña BLP, Amoroso VB. 2020. Rapid assessment of epiphytic pteridophyte biodiversity in Mt. Apo Natural Park, North Cotabato Province, Philippines: A comparison of disturbed and undisturbed forests. Philipp J Syst Biol 14 (3): 1-13. DOI 10.26757/pjsb2020c14004.

Climate-Data.Org. 2019. Davao del Norte. Climate-Data.org. Retrieved from https://en.climate-data.org/asia/philippines/davao-del-norte-1896/ on 2 Apr 2023.

Coelho N, Gonçalves S, Romano A. 2020. Endemic plant species conservation: Biotechnological approaches. Plants 9 (3): 345. DOI: 10.3390/plants9030345.

Coritico FP, Lagunday NE, Galindon JMM, Tandang DN, Amoroso VB. 2020. Diversity of trees and structure of forest habitat types in Mt. Tago range, Mindanao, Philippines. Philipp J Syst Biol 14 (3): 1-11. DOI: 10.26757/pjsb2020c14006.

Coritico FP, Legaspi ML, Lagunday NE, Guiang MMM, Tandang DN, Galindon JMM, Acma FM, Amoroso VB. 2022. Threatened and endemic seed plants of Mt. Pantaron range, Mindanao, Philippines. Philipp J Sci 151 (6B): 2433-2445. DOI: 10.56899/151.6b.09.

Corlett RT. 2017. A bigger toolbox: Biotechnology in biodiversity conservation. Trends Biotechnol 35 (1): 55-65. DOI: 10.1016/j.tibtech.2016.06.009.

Dehling DM, Bender IMA, Blendinger PG, Böhning-Gaese K, Muñoz MC, Neuschulz EL, Quitián M, Saavedra F, Santillán V, Schleuning M, Stouffer DB. 2021. Specialists and generalists fulfil important and complementary functional roles in ecological processes. Funct Ecol 35 (8): 1810-1821. DOI: 10.1111/1365-2435.13815.

Deng J, Fang S, Fang X, Jin Y, Kuang Y, Lin F, Liu J, Ma J, Nie Y, Ouyang S, Ren J, Tie L, Tang S, Tan X, Wang X, Fan Z, Wang Q-W, Wang H, Liu C. 2023. Forest understory vegetation study: Current status and future trends. For Res 3: 6. DOI: 10.48130/FR-2023-0006.

Department of Environment and Natural Resources (DNER) Administrative Order (DAO). 2017. Updated National List of Threatened Philippine Plants and their Categories. https://bmb.gov.ph.

Diwa RR, Borlongan NJB, Tabardillo JIA, Sabuito AJC, Candido CG, De La Cruz RM, Blanco AC. 2024. Development of methodology for monitoring and assessing the national greening program using optical and SAR data. Intl Arch Photogramm Remote Sens Spatial Inf Sci XLVIII-4/W8-2023: 175-181. DOI: 10.5194/isprs-archives-xlviii-4-w8-2023-175-2024.

Energy Development Corporation (EDC). 2023. Mainstreaming Philippine Native Trees. www.binhi.ph/mainstreaming.

Félix K, Adeline ANL, Fédriche NS, Averti IS. 2019. Relationship between tropical forest distribution and soils on different types of mother rocks in the Republic of Congo. Open J For 9 (4): 341-354. DOI: 10.4236/ojf.2019.94019.

Flowers TJ, Colmer TD. 2015. Plant salt tolerance: Adaptations in halophytes. Ann Bot 115 (3): 327-331. DOI: 10.1093/aob/mcu267.

Forest Management Bureau (FMB). 2021. Philippine Forestry Statistics 2021. [2022-11-14]. Retrieved from https://drive.google.com/file/d/1V2JS74-DPvMc4A8r3AJwrMDoAmXptI9f/view?usp=embed_facebook.

Gamalo LED, Cabrera SME, De Los Reyes NCL, De Cadiz AE, Chavez Jr JB, Raganas AFM, Quibod MANRM. 2023. Inventory of terrestrial vertebrate wildlife species in a private-owned forest patch in Tagum City, Mindanao, Philippines. Biodiversitas 24 (2): 1104-1116. DOI: 10.13057/biodiv/d240250.

Gámez S, Harris NC. 2022. Conceptualizing the 3D niche and vertical space use. Trends Ecol Evol 37 (11): 953-962. DOI: 10.1016/j.tree.2022.06.012.

Gonzalez J, Mazo XJ, Mangao SM. 2022. Beach forest communities of San Agustin, Romblon with notes on coastal threats. Romblon State Univ Res J 4 (1): 1-15. DOI: 10.58780/rsurj.v4i1.95.

Govaerts R, Jiménez-Mejías P, Koopman J, Simpson DA, Goetghebeur P, Wilson KL, Egorova T, Bruhl JJ. 2020. World Checklist of Selected Plant Families. Cyperaceae. Facilitated by the Royal Botanic Gardens, Kew. http://www.kew.org/wcsp/monocots.

Grant TA, Madden EM, Murphy RK, Smith KA, Nenneman MP. 2004. Monitoring native prairie vegetation: The belt transect method. Ecol Restor 22 (2): 106-111. DOI: 10.3368/er.22.2.106.

Hamabata T, Kinoshita G, Kurita K, Cao P-L, Ito M, Murata J, Komaki Y, Isagi Y, Makino T. 2019. Endangered island endemic plants have vulnerable genomes. Commun Biol 2: 244. DOI: 10.1038/s42003-019-0490-7.

Harrison RD. 2005. Figs and the diversity of tropical rainforests. BioScience 55 (12): 1053-1064. DOI: 10.1641/0006-3568(2005)055[1053:fatdot]2.0.co;2.

Huffman DW, Laughlin DC, Pearson KM, Pandey S. 2009. Effects of vertebrate herbivores and shrub characteristics on arthropod assemblages in a northern Arizona forest ecosystem. For Ecol Manag 258 (5): 616-625. DOI: 10.1016/j.foreco.2009.04.025.

International Union for Conservation of Nature (IUCN). 2024. The IUCN Red List of Threatened Species. http://www.iucnredlist.org.

Kongapai P, Sompongchaiyakul P, Jitpraphai S, Gerald Plumley F. 2016. Beach forest changes (2003-2013) in the tsunami-affected area of Phang Nga, Thailand from multi-temporal satellite data. ScienceAsia 42 (3): 159. DOI: 10.2306/scienceasia1513-1874.2016.42.159.

Landuyt D, De Lombaerde E, Perring MP, Hertzog LR, Ampoorter E, Maes SL, De Frenne P, Ma S, Proesmans W, Blondeel H, Sercu BK, Wang B, Wasof S, Verheyen K. 2019. The functional role of temperate forest understorey vegetation in a changing world. Glob Change Biol 25 (11): 3625-3641. DOI: 10.1111/gcb.14756.

Larridon I, Zuntini AR, Léveillé-Bourret É et al. 2021. A new classification of Cyperaceae (Poales) supported by phylogenomic data. J Syst Evol 59 (4): 852-895. DOI: 10.1111/jse.12757.

Lillo EP, Fernando ES, Lillo MJR. 2019. Plant diversity and structure of forest habitat types on Dinagat Island, Philippines. J Asia-Pac Biodivers 12 (1): 83-105. DOI: 10.1016/j.japb.2018.07.003.

Lillo EP, Malaki AB, Alcazar SMT, Redoblado BR, Diaz JLB, Pinote JP, Rosales R, Buot Jr IE. 2020. Native trees in Nug-as forest key biodiversity area, Cebu, Philippines. Biodiversitas 21 (9): 4162-4167. DOI: 10.13057/biodiv/d210930.

Matutes HE, Densing LA. 2022. Biodiversity Resources in the Leyte Sab-a Basin Peatland. International Institute of Rural Reconstruction. Y.C James Yen Center, Silang, Cavite, Philippines.

Milan PP. 2020. Rainforestation: Paradigm Shift in Forest Restoration in the Philippines. Forest Foundation Philippines, Makati, Philippines.

Millamena AG, Daylusan FA, Alian DCH, Sansait MM, Malabarbas GT. 2022. Species diversity and community structure of beach forests in San Fernando, San Jose, Antique, Philippines. Intl J Appl Res Soc Sci 4 (7): 237-246. DOI: 10.51594/ijarss.v4i7.370.

Montero R. 2010. Inventory of the Flora and Fauna, Site Mapping and Ecosystem Assessment of the Hijo forest. [Report]. Hijo Resources Corporation, Philippines.

Moriuchi KS, Friesen ML, Cordeiro MA, Badri M, Vu WT, Main BJ, Aouani ME, Nuzhdin SV, Strauss SY, von Wettberg EJB. 2016. Salinity adaptation and the contribution of parental environmental effects in Medicago truncatula. PLoS One 11 (3): e0150350. DOI: 10.1371/journal.pone.0150350.

Nakamura A, Ashton LA, Scheffers BR, Kitching RL. 2022. Editorial: Understanding patterns and mechanisms of forest canopy diversity and ecosystem functions in a changing world. Front For Glob Change 5: 944981. DOI: 10.3389/ffgc.2022.944981.

Pelser PB, Barcelona JF, Nickrent DL. 2011. Co's Digital Flora of the Philippines. www.philippineplants.org.

Perez GJ, Comiso JC, Aragones LV, Merida HC, Ong PS. 2020. Reforestation and deforestation in Northern Luzon, Philippines: Critical issues as observed from space. Forests 11 (10): 1071. DOI: 10.3390/f11101071.

Primavera JH, Palijon AM, Granert WG, Cercado EL, Barillo ME, Tungol AM, Avila RTM, Bande MJM, Buduan ED, Coching JD, Loma RJA, Montilijao CL. 2019. Manual on Nursery and Outplanting of Beach Forest Trees. ZSL, London.

Primavera JH, Sadaba RB. 2012. Beach Forest Species and Mangrove Associates in the Philippines. SEAFDEC Aquaculture Department, Iloilo, Philippines and UNESCO Office, Jakarta.
Pulhin F, Torres AM, Pampolina NM, Lasco RD, Alducente AM. 2021. Vegetation analysis of sanctuary and forest areas of Kalahan Forest Reserve Nueva Vizcaya and Pangasinan, Philippines. Philipp J Sci 150 (S1): 271-280. DOI: 10.56899/150.s1.18.
Romeroso RB, Tandang DN, Navarrete IA. 2021. Taxonomic list and conservation status on the beach forest flora of Homonhon Island, Philippines. Asian J Biol Life Sci 10 (2): 434-442. DOI: 10.5530/ajbls.2021.10.58.
Sabulao JB, Magtolis JM, Capanang CA, Ingente DE, Paa MWE, Hitosis Jr RC, Mabag JA, Raga CC. 2020. A preliminary survey of beach forest species in Guiuan Eastern Samar, Philippines: An ethnobotanical study. Indian J Sci Technol 13 (9): 1098-1106. DOI: 10.17485/ijst/2020/v013i09/149706.
Simpson DA, Yesson C, Culham A, Couch CA, Muasya AM. 2011. Climate change and Cyperaceae. In: Hodkinson TR, Jones MB, Waldren S, Parnell JAN (eds). Climate Change, Ecology and Systematics. Systematics Association Special Volume Series. Cambridge University Press, Cambridge. DOI: 10.1017/CBO9780511974540.020.
Spalink D, Drew BT, Pace MC, Zaborsky JG, Li P, Cameron KM, Givnish TJ, Sytsma KJ. 2016. Evolution of geographical place and niche space: Patterns of diversification in the North American sedge (Cyperaceae) flora. Mol Phylogenet Evol 95: 183-195. DOI: 10.1016/j.ympev.2015.09.028.
Spalink D, Pender J, Escudero M, Hipp AL, Roalson EH, Starr JR, Waterway MJ, Bohs L, Sytsma KJ. 2018. The spatial structure of phylogenetic and functional diversity in the United States and Canada: An example using the sedge family (Cyperaceae). J Syst Evol 56 (5): 449- 465. DOI: 10.1111/jse.12423.
Ureta JCP, Lasco RD, Sajise AJU, Calderon MM. 2016. A ridge-to-reef ecosystem-based valuation approach to biodiversity conservation in Layawan Watershed, Misamis Occidental, Philippines. J Environ Sci Manag 19 (2): 64-75. DOI: 10.47125/jesam/2016_2/07.
Vargas GG, Werden LK, Powers JS. 2015. Explaining legume success in tropical dry forests based on seed germination niches: A new hypothesis. Biotropica 47 (3): 277-280. DOI: 10.1111/btp.12210.
Veridiano RK, Schröder JM, Come R, Baldos A, Günter S. 2020. Towards forest landscape restoration programs in the Philippines: Evidence from logged forests and mixed-species plantations. Environments 7 (3): 20. DOI: 10.3390/environments7030020.
Viana FAP, Costa AP, Moro FV, Pivetta KFL. 2016. Morpho-anatomical characterization of diaspores and seedlings of *Livistona rotundifolia*. Ornam Hortic 22 (3): 249. DOI: 10.14295/oh.v22i3.924.
Zapanta BR, Achondo MJMM, Raganas AFM, Camino FA, Delima AGD, Mantiquilla JA, Puentespina Jr RP, Salvaña FRP. 2019. Species richness of trees in disturbed habitats within a protected area and its implications for conservation: The case of Mt. Apo Natural Park, Mindanao Island, Philippines. Biodiversitas 20 (7): 2081-2091. DOI: 10.13057/biodiv/d200740.