DIVERSITY OF MANGROVES AND ASSOCIATED PLANTS IN MANDANGISIAO ESTUARY, MISAMIS ORIENTAL, PHILIPPINES

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ABSTRACT

SITOY, W. B. O. & BUENAVISTA, D. P. 2024. Diversity of mangroves and associated plants in Mandangisiao Estuary, Misamis Oriental, Philippines. *Reinwardtia* 23(1): 1–14. — The study aimed to assess the diversity status of mangroves and associates. Four transect lines were established perpendicular to the shoreline, ranging from 20 to 100 meters based on mangrove stand size. Along these transects, three 10 m × 10 m quadrat plots were set up to evaluate mangrove trees, and within each quadrat, a 2 m × 2 m regeneration plot was established. The study calculated the diversity indices, such as relative frequency, relative density, and relative dominance to determine the species importance value. A total of four mangrove species and two associated plants were identified, representing three mangrove families and three genera, as well as three plant families and three genera for associated plants. The recorded species included *Avicennia marina, Nypa fruticans, Rhizophora mucronata, Sonneratia caseolaris, Acanthus ebracteatus*, and *Acrostichum speciosum*. The overall diversity value of the mangroves and associated plants was 0.87, indicating relatively low species richness. The true mangroves, *Rhizophora mucronata* exhibited the highest values for relative density (68.07%), while *Nypa fruticans* is the highest in terms of relative dominance (42.20%). Both have the same highest value in relative frequency (32.43%). All in all, the highest species importance value for true mangroves is *Rhizophora mucronata* with 126.23%. In associated plants, highest value of relative density and relative frequency belongs to *Acanthus ebracteatus* with 58% and 60%, respectively. Subsequently, the highest species importance value for associated plants is 118% for *Acanthus ebracteatus*. The study concluded that the Mandangisiao Estuary in Jasaan, Misamis Oriental has a limited species diversity, contrary to the initial hypothesis. Furthermore, the mangrove forest in the estuary faces potential threats from garbage dumping, tree cutting, boat mooring, and human encroachment, despite all the recorded species having a Least Concern conservation status.

Key words: *Avicennia*, conservation, mangrove, Mindanao, *Nypa*, *Rhizophora*.

ABSTRAK

SITOY, W. B. O. & BUENAVISTA, D. P. 2024. Keanekaragaman mangrove dan tumbuhan terkait di Muara Mandangisiao, Misamis Oriental, Filipina. *Reinwardtia* 23(1): 1–14. — Penelitian ini bertujuan untuk mengkaji status keanekaragaman mangrove dan asosiasinya. Empat garis transek dibuat tegak lurus terhadap garis pantai, berkisar antara 20 hingga 100 meter berdasarkan ukuran tegakan mangrove. Sepanjang transek ini, dibuat tiga plot kuadrat berukuran 10 m × 10 m untuk mengevaluasi pohon bakau, dan di setiap kuadrat, dibuat plot regenerasi berukuran 2 m × 2 m. Penelitian ini menghitung indeks keanekaragaman, seperti frekuensi relatif, kepadatan relatif, dominasi relatif untuk menentukan nilai kepentingan jenis. Sebanyak empat jenis mangrove dan dua tumbuhan berasosiasi telah diidentifikasi, mewakili tiga suku mangrove dan tiga marga, serta tiga suku tumbuhan dan tiga marga tumbuhan berasosiasi. Jenis yang tercatat termasuk *Avicennia marina, Nypa fruticans, Rhizophora mucronata, Sonneratia caseolaris, Acanthus ebracteatus,* dan *Acrostichum speciosum*. Nilai keanekaragaman mangrove dan tumbuhan terkait secara keseluruhan adalah 0,87, yang menunjukkan kekayaan jenis yang relatif rendah. Mangrove sejati, *Rhizophora mucronata* menunjukkan nilai kepadatan relatif tertinggi (68,07%), sedangkan *Nypa fruticans* memiliki nilai dominansi relatif tertinggi (42,20%). Keduanya mempunyai nilai frekuensi relatif tertinggi yang sama (32,43%). Secara keseluruhan, nilai penting jenis tertinggi bagi mangrove sejati adalah *Rhizophora mucronata* sebesar 126,23%. Pada tumbuhan ber-asosiasi, nilai kerapatan relatif dan frekuensi relatif tertinggi dimiliki oleh *Acanthus ebracteatus* masing-masing sebesar 58% dan 60%. Selanjutnya, nilai penting jenis tertinggi untuk tumbuhan berasosiasi adalah 118% untuk *Acanthus ebracteatus*. Penelitian menyimpulkan bahwa Muara Mandisiao di Jasaan, Misamis Oriental memiliki keanekaragaman jenis yang terbatas, bertentangan dengan hipotesis awal. Selain itu, hutan mangrove di muara juga menghadapi potensi ancaman dari pembuangan sampah, penebangan pohon, tambatan kapal, dan perambahan manusia, meskipun semua jenis yang tercatat memiliki status konservasi risiko rendah.

Kata kunci: *Avicennia,* konservasi, Mindanao, mangrove, *Nypa*, *Rhizophora*.

INTRODUCTION

Along the tropical, subtropical, and some temperate coasts, intertidal mangrove forests can be found, frequently coexisting with dense human populations (Friess *et al.*, 2019). The mangrove forest is referred to as the "rainforest of the sea", and like the upland rainforest, it supports the coasts economically and ecologically (Mendoza, 2017). Mangroves are essential components of an ecosystem because they provide food for numerous fish, insects, and birds as well as protection from coastal hazards (Alongi, 2002). It also offers crucial ecological services to hundreds of millions of people, including fish, lumber, fuelwood, coastal protection, pollution management, and cultural and spiritual values (Barbier *et al.*, 2010; Buenavista & Purnobasuki, 2023). Mangroves are now firmly on the international agenda for climate mitigation and adaptation as a result of the recent vigorous promotion of their role in carbon sequestration (Howard *et al.*, 2017).

However, due to human activities that pose a serious threat to the environment and the variety of life in mangrove areas, the number of mangroves worldwide has been declining at an alarming rate (Cudiamat & Rodriguez, 2017). Mangroves are also seriously threatened throughout a significant portion of their range due to their location in an area with rising human population concentrations and competing coastal management goals. Large-scale mangrove destruction is a result of nearby factors like aquaculture, agriculture, and urban expansion (Richards & Friess, 2016; Thomas *et al.*, 2017), while pollution and resource over exploitation further harm mangroves (Lee *et al.*, 2006). At larger scales, mangroves are affected by long-term processes such as relative sea-level rise and sea-level variations connected to climate oscillations (Lovelock *et al.*, 2015; Duke *et al.*, 2017). These effects have significant repercussions for the vulnerability of coastal populations who depend on mangrove resources.

Approximately 70 species of mangrove (Polidoro *et al.*, 2010) and 60 species of mangrove associates are known worldwide (Tomlinson, 1986). In the Philippines, 39 species of mangroves are known to exist (Nieves & Bradecina, 2020). Unfortunately, the Philippines has lost over 75% of its mangrove habitat during the past few decades, with the majority disappearing between 1950 and 1990 (Primavera, 2000; Samson & Rollon, 2008). In a nation where more than half of its 1,500 municipalities and 42,000 towns rely on coastal resources, the loss of mangrove habitat directly affects its populace (Primavera, 2000). Presently, the Philippines has a 0.5% annual mangrove loss estimated (Fries *et al.*, 2019). As such, the need for conservation is increasingly important as a result of anthropogenic alterations to the natural environment that have caused disturbing rates of biodiversity loss (Beger *et al.*, 2014). Due to the Philippines' reputation as a biodiversity hotspot, identifying the gaps and biases in the country's biodiversity record can be a crucial first step in determining the most important research area for conservation applications (Berba & Matias, 2022).

The Municipality of Jasaan in the province of Misamis Oriental, Mindanao Island is one of the mangrove areas that is still ecologically understudied. Some of the mangroves in the area are vulnerable to hazards, such as being cut down for various purposes that could endanger nearby species. Moreover, there is no published information on studies on mangroves and their plant associates in Mandangisiao Estuary, Jasaan. Thus, this research is being carried out.

MATERIALS AND METHODS

The Municipality of Jasaan, Misamis Oriental, Mindanao, Philippines is geographically located at 8°38'56.4"N 124°45'20.7"E with an elevation of 25.9 meters (85.0 feet) above sea level (m asl). The study was carried out in the natural mangrove stands in Mandangisiao Estuary in Jasaan. The study was conducted from February to April 2023 (Figs. 1 & 2).

The field sampling followed the Participatory Coastal Resource Assessment Training Guide by Deguit *et al.* (2004) wherein four (4) transect lines were laid perpendicular to the shoreline ranging from 20 to 100 meters, depending on the size of the mangrove stands. The transect lines were placed where the mangrove forest begins and end where the forest ends. After which, a series of three (3) 10 m × 10 m quadrat plots were established along the transect line, for the assessment of mangrove trees (DENR-EMB Guidelines on the Assessment of Coastal and Marine Ecosystems, 2017). In each quadrat, a 2 m × 2 m regeneration plot were also established, this is to measure the seedlings and saplings (less than 3 cm DBH) in each plot. The 10 m × 10 m quadrats plots were laid with 50 m distance in between depending on vegetation characteristics, landscape, and extend of mangrove (Fig. 3).

The voucher plant specimens were collected and preserved using the method of Morse (2000). Using a pruning shear, three to five representative specimens bearing flowers and/or fruits material were clipped off from the mangroves during collection. The acquired sample specimens were placed in a clean container or plastic bag with their field information to avoid damage and dehydration. Using the field data sheet, characters of the specimen were recorded including the coordinates, elevation, and seasonal characters. Tags with accompanying specimen number were attached to the plant collected. Relevant information such as plot

Fig. 1. Location map of the study site. A. Map of the Philippines. B. Map of the Municipality of Jasaan, Misamis Oriental. C. Map of the Mandangisiao Estuary, Upper Jasaan, Jasaan, Misamis Oriental.
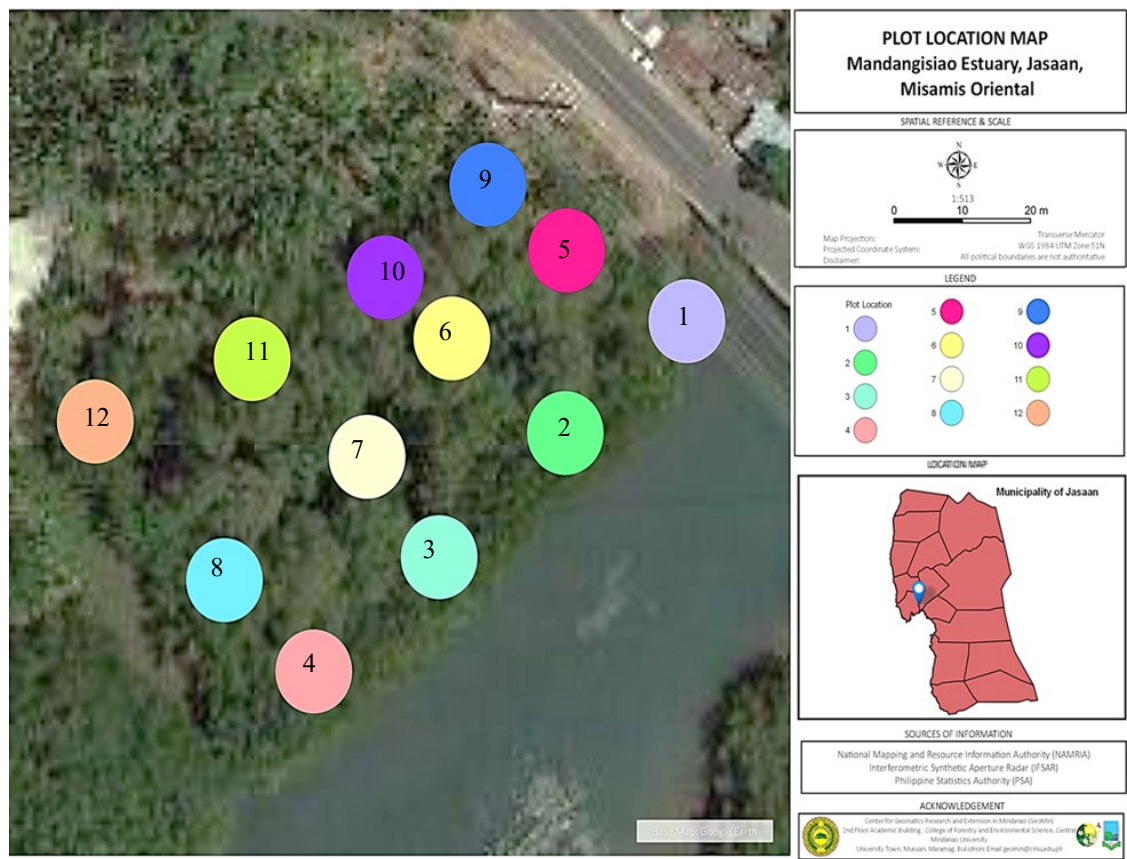

Fig. 2. Location map of the study site showing the twelve (12) sampling plots.
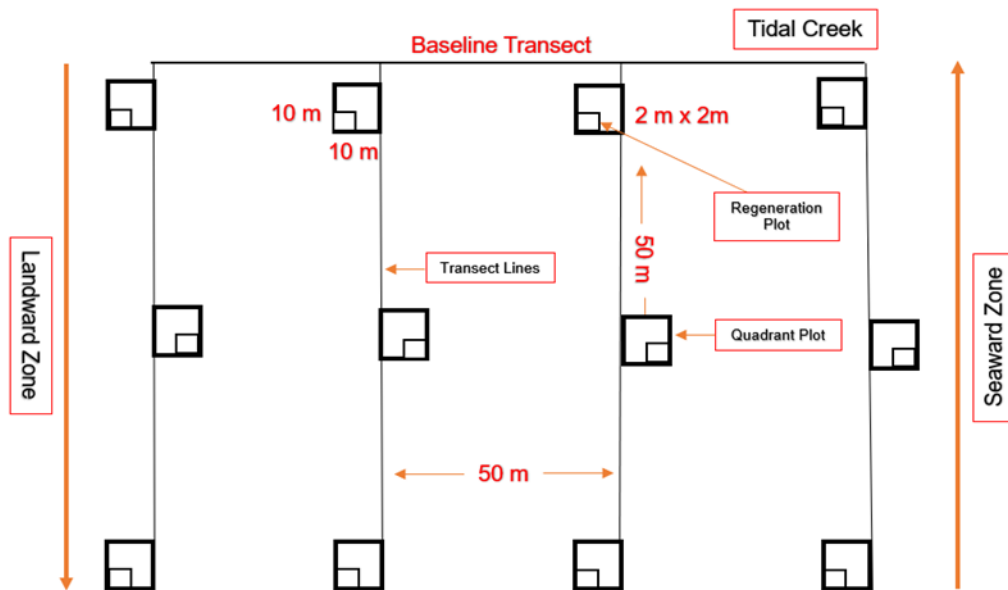
Fig. 3. Diagram showing the layout of the transect lines and plots modified from Deguit *et al.* (2004).

number and date were recorded in the field note-book and photos of plant parts were also taken. Mangroves were counted inside the plot, and measurements of their diameter at breast height (dbh), basal area, and density were taken. The specimens that were collected are subjected to wet mounting, which involves treating plants with denatured alcohol to preserve and destroy organisms present in the plant samples. Collected flowers were then preserved in spirit collection. The pile of sample specimens was pressed using normal size wooden presser with straw rope to tighten the presser after the mounting technique was done. Plant samples were then sundried. Voucher specimens were deposited in Central Mindanao University Museum.

Mangroves were initially taxonomically identified and classified by examining its vegetative and reproductive morphological structures such as the leaves, roots, flowers, and even fruit using the field guide of Primavera *et al.* (2004) and Primavera & Dianala (2009). The pre-identified mangroves were taxonomically verified and confirmed by Forester Lowell G. Aribal of Central Mindanao University and Dr. Jurgenne Primavera, Chief Mangrove Scientific Advisor of the Zoological Society of London. The collected data within the 10 m × 10 m sampling plots was used in the computation of the following diversity indices (Barbour *et al.*, 1987). The Species Importance Value (SIV) index shows how each species contributes to the community. In this study, the relative density,

relative frequency, and relative dominance data were added to determine the SIV of the mangrove trees, which have a maximum value of 300 (Cintrón & Schaeffer-Novelli, 1984). On the other hand, for understory mangrove associates, the data on relative density and relative frequency were summed up to determine the SIV. The diversity index value provides a quantitative analysis of the species richness and distribution within the mangrove habitat. The diversity values were classified based on a scale of Gevaña & Pampolina (2009). In the assessment of the conservation status, the IUCN Red List of Threatened Species (Version 2022-1) and DENR Administrative Order No. 11 series of 2017 known as the Updated List of Threatened Philippine Plants and their Categories were used.

RESULTS

Species Composition

A total of four mangrove species and two mangrove associates were recorded in the mangrove forest of Mandangisiao Estuary in Jasaan, Misamis Oriental (Table 1). These mangrove species and mangrove associates belonged to five botanical families namely, Acanthaceae (2 species), Arecaceae (1 species), Lythraceae (1 species), Rhizophoraceae (1 species), and Pteridaceae (1 species) (Table 1). The four mangrove species found in the Mandangisiao Estuary are clearly

Table 1. List of mangroves and associated plants observed in Mandangisiao Estuary, Jasaan, Misamis Oriental.

Family	Scientific name	Common name
I. Mangroves		
Acanthaceae	*Avicennia marina* (Forssk.) Vierh.	Piapi
Arecaceae	*Nypa fruticans* Wurmb	Nipa
Lythraceae	*Sonneratia caseolaris* (L.) Engl.	Pedada
Rhizophoraceae	*Rhizophora mucronata* Lam.	Bakhaw babae
II. Associated Plants		
Acanthaceae	*Acanthus ebracteatus* Vahl.	Lagiwliw
Pteridaceae	*Acrostichum speciosum* Willd.	Palaypay

Table 2. Occurrence of mangrove species and associated plants in twelve sampling plots of Mandangisiao Estuary, Jasaan, Misamis Oriental.

Family and Species	Plots											
	1	2	3	4	5	6	7	8	9	10	11	12
I. Mangroves												
A. Acanthaceae												
Avicennia marina (Forssk.)	+					+			+	+	+	+
B. Arecaceae												
Nypa fruticans Wurmb	+	+	+	+	+	+	+	+	+	+	+	+
C. Lythraceae												
Sonneratia caseolaris (L.) Engl.					+	+	+	+	+		+	+
D. Rhizophoraceae												
Rhizophora mucronata Lam.	+	+	+	+	+	+	+	+	+	+	+	+
II. Associated Plants												
A. Acanthaceae												
Acanthus ebracteatus Vahl					+	+		+		+	+	+
B. Pteridaceae												
Acrostichum speciosum Willd.					+		+		+	+		

fewer than the eight mangrove species found in the entire municipality of Jasaan, which include three species of the genus *Rhizophora*, two species each of the genus *Avicennia* and *Sonneratia*, and one species of the genus *Bruguiera*.

Among the recorded species of mangroves and associated plants, the family Acanthaceae was the most represented plant group with two species namely, *Avicennia marina* and *Acanthus ebracteatus*. Only one species was recorded to belong to the Arecaceae, namely *Nypa fruticans*. Likewise, in the families Lythraceae, Rhizophoraceae, and Pteridaceae, each with a single species: *Sonneratia caseolaris, Rhizophora mucronata,* and *Acrostichum speciosum*, respectively (Table 2).
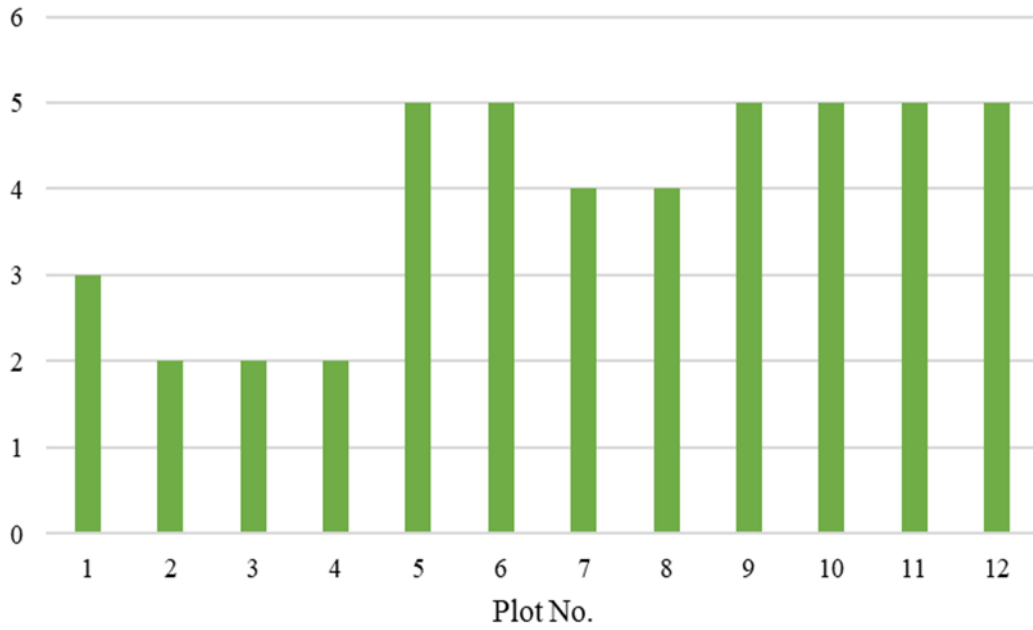
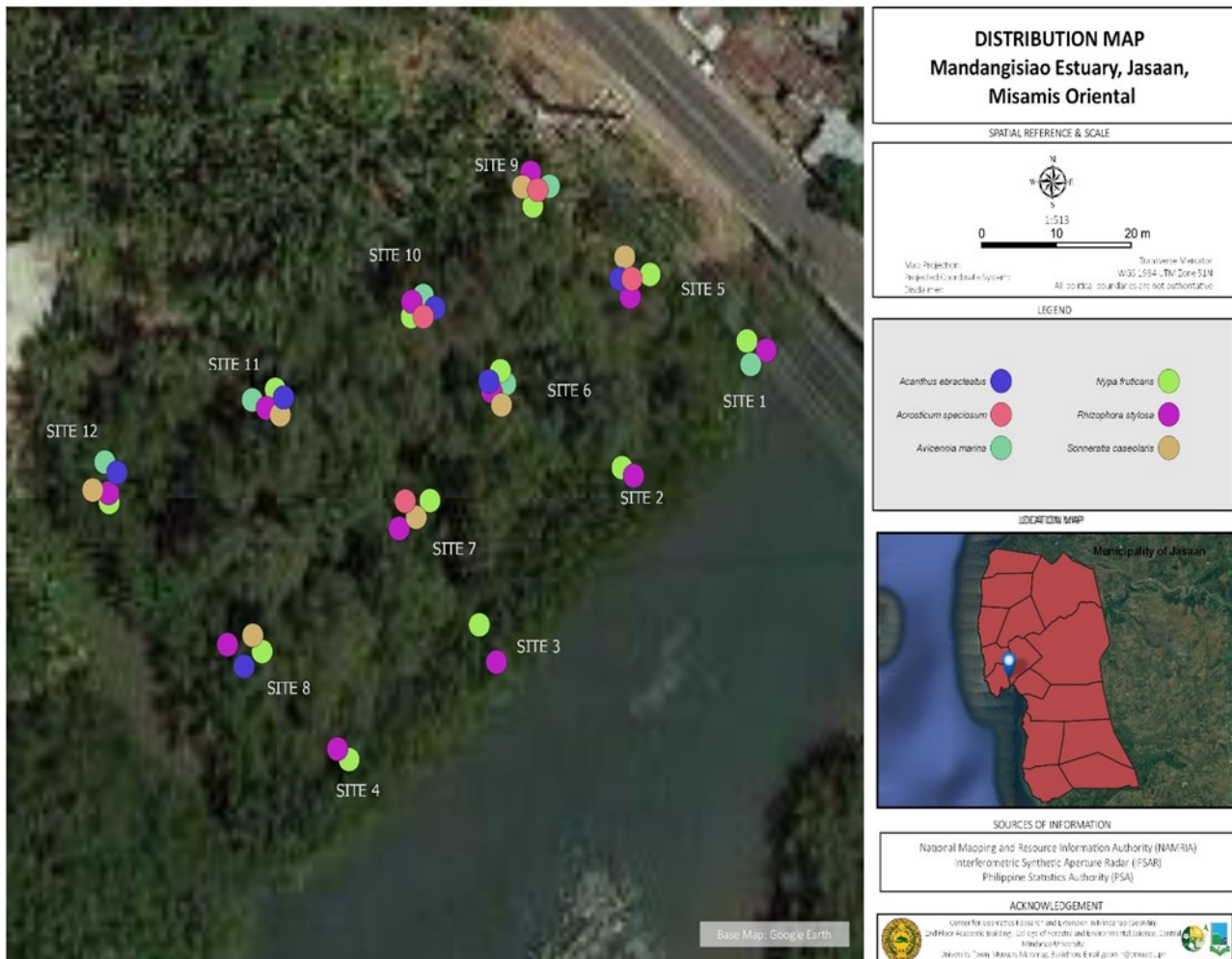Fig. 4. Bar graph showing the number of species found in plots.

Fig. 5. Distribution map of species found in each sampling plot in Mandangisiao Estuary, Jasaan, Misamis Oriental.
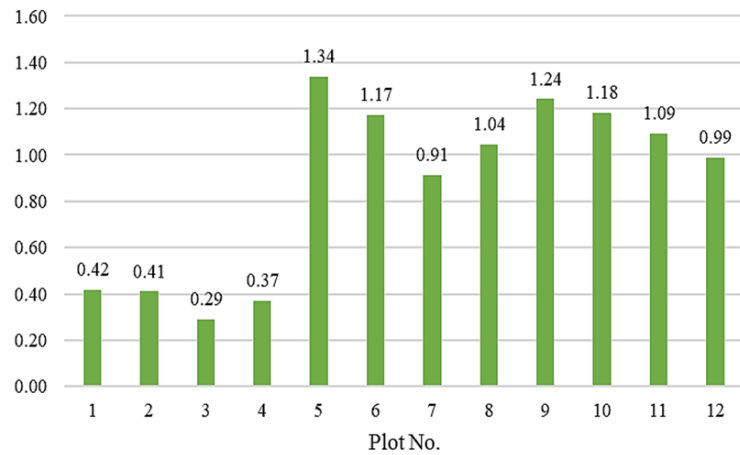
Fig. 6. Shannon-Weiner Diversity Index of mangroves and associates found in Mandangisiao Estuary, Jasaan, Misamis Oriental.
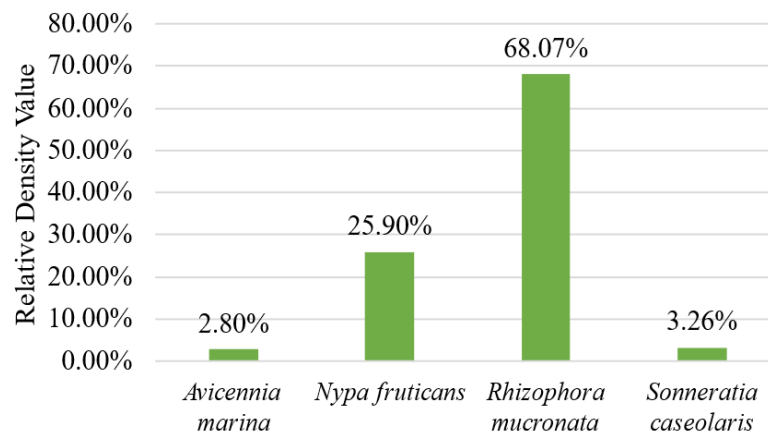

Fig. 7. Relative Density Index result of true mangrove species found in Mandangisiao Estuary, Jasaan, Misamis Oriental.
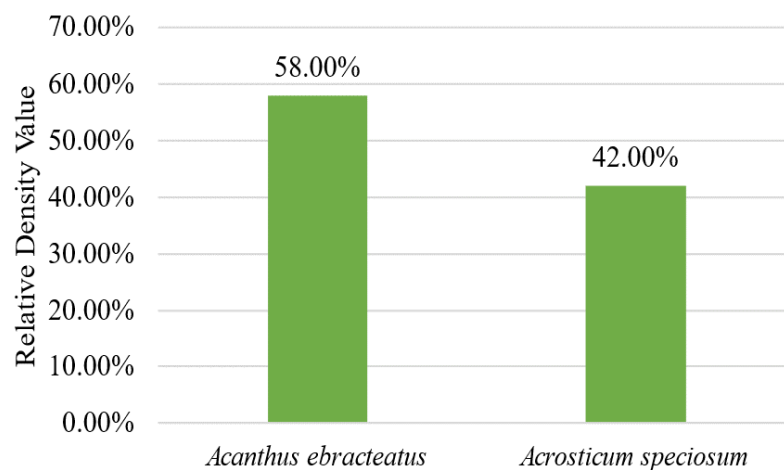

Fig. 8. Relative Density Index result of associated plants found in Mandangisiao Estuary, Jasaan, Misamis Oriental.

The species of mangroves namely *Rhizophora mucronata* and *Nypa fruticans*, were observed in all twelve plots, while *Avicennia marina* was recorded in plots 1, 6, 9, 10, 11, and 12. Furthermore, *Sonneratia caseolaris* was observed in plots 5, 6, 7, 8, 9, 11, and 12. For the associated plants, individual species of *Acanthus ebracteatus* were observed in plots 5, 6, 8, 10, 11, and 12. While the *Acrostichum speciosum* was observed in plots 5, 7, 9, and 10 (Fig. 4, Table 2).

Plots 5, 6, 9, 10, 11, and 12 have equally five species of mangroves and associates present, which consist of five different families and five genera. On the other hand, plots 2, 3, and 4 have the lowest number of different species observed, consisting of two families and two genera. While plots 7 and 8 have four species that can be found in each plot. Lastly, plot 1 has 3 species of mangroves and associated plants observed .

Mangroves and Associated Plants Diversity Indices

A. Mangrove and Associated Plants Diversity
The species diversity of mangroves in Mandangisiao Estuary, Jasaan has H' value of 0.87. Plots 9, 10, 11, and 12 (landward zone) has the highest average result of diversity index of 1.13, followed by plots 5, 6, 7, and 8 in the intermediate zone with 1.12 diversity index value; and lastly, plots 1, 2, 3, and 4 in the seaward zone evidently has the lowest average diversity value of 0.37 (Fig. 6). The result of this study shows that Mandangisiao Estuary in Jasaan has a relatively low species diversity.

This is due to low species richness and abundance of mangrove species. The dominance of few species is another factor affecting the diversity estimate of mangroves, notably the dominance of *Nypa fruticans* and *Rhizophora mucronata*, while other species are rare and few in number of individuals .

B. Mangrove Vegetation Structure
The community structure of mangroves has been measured using the relative values for density, frequency, and dominance. The Species Importance Value (SIV) for the entire sampling area was calculated using these values added together.

The species *Rhizophora mucronata* was noted to have the highest population density of 68.07%, which indicates that this species of mangrove has the highest count per unit area. This is followed by the species *Nypa fruticans* with 25.90%, *Sonneratia caseolaris* with 3.26%, and *Avicennia marina* with 2.80% (Fig. 7). The associated plants, *Acanthus ebracteatus* and *Acrostichum speciosum,* have 58.00% and 42.00%, respectively (Fig. 8). The species of *Rhizophora mucronata* are abundant in the seaward zone of the mangrove forest due to its massive stilt roots and adaptability to saline wa-

ters. Furthermore, its viviparity reproduction helps in the density of species in an area.

It has been discovered that the vegetation density reduces as one moves farther into the mangrove forest in the case of *Rhizophora mucronata* compared to other mangrove species (Ismail *et al.*, 2019).

The highest relative frequency is *Rhizophora mucronata* and *Nypa fruitcans* with 32.43%, followed by *Sonneratia caseolaris* with 18.92% and *Avicennia marina* with 16.22% (Fig. 9). The associated plants *Acanthus ebracteatus* has the highest relative frequency for the associated plants with 60.00% value, followed by the *Acrostichum speciosum* (40.00%) (Fig. 10). The high frequency of both *Rhizophora mucronata* and *Nypa fruticans* is due to their adaptability to saline waters and the dispersal of their saplings, that is also due to their mode of reproduction.

The species *Nypa fruticans* tops the relative dominance index result with 42.20%, followed by, *Rhizophora mucronata* with 25.73%, *Sonneratia caseolaris* with 22.94%, and lastly, *Avicennia marina* with 9.12%. (Fig. 11).

Conservation Status of Mangroves and Associated Plants
The assessment of conservation status showed that all species in the Mandangisiao Estuary are listed as Least Concern in the IUCN Red List. Nonetheless, the Mandangisao Estuary is currently experiencing human exploitation. Anthropogenic activities were observed in the area such as logging of *Rhizophora* trees, improper disposal of waste by the locals, building of houses in the nearby areas and the estuary become a docking site for fishing boats.

DISCUSSION

Mangrove forests are frequently zoned. Within the ecosystem, specific species inhabit niches that are only accessible to them. Other mangrove species are located farther inland, in estuaries affected by tidal action. Some mangrove species are found near shore, fringing islands, and sheltered bays (Mangrove Action Project, 2019).

As shown in Fig. 5, plots 1, 2, 3, and 4 were established in the tidal creek and more to the seaward side, and it was observed that *Rhizophora mucronata* mangroves dominated the area which may be explained by their physiological adaptations to saline conditions and are usually found growing in groups near or on the banks of tidal creeks. Stilted mangroves, like genus *Rhizophora*, can withstand a variety of intertidal environments, including salinity ranging from close to freshwater to fully concentrated seawater. They can withstand a variety of soil types, water patterns, and other
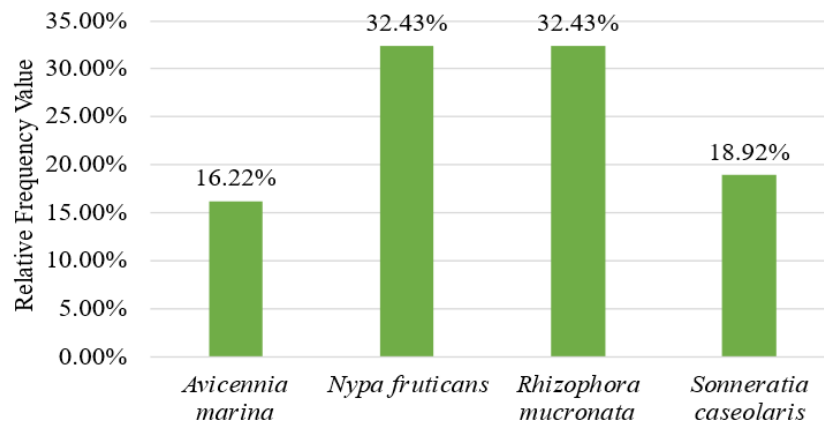
Fig. 9. Relative Frequency Index result of true mangroves species found in Mandangisiao Estuary, Jasaan, Misamis Oriental.
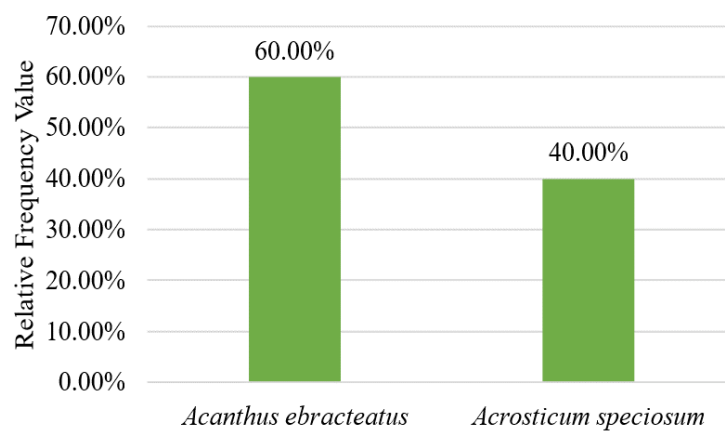

Fig. 10. Relative Frequency Index result of tassociated plants found in Mandangisiao Estuary, Jasaan, Misamis Oriental.
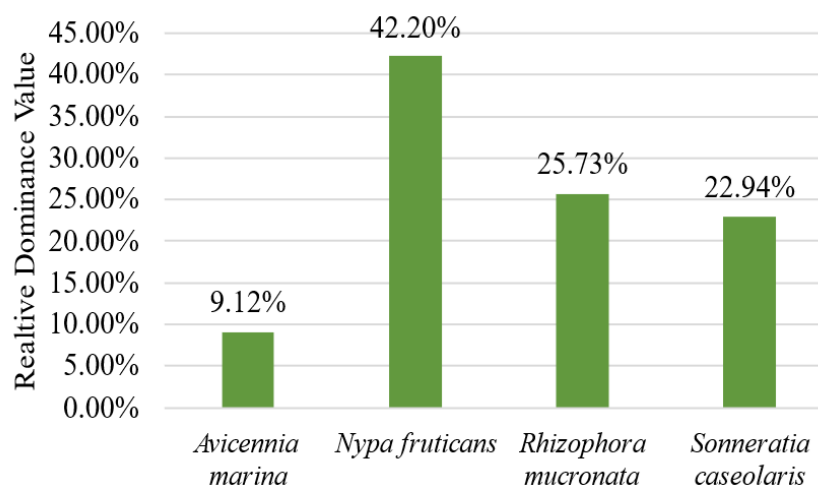

Fig. 11. Relative Dominance Index result of true mangrove species found in Mandangisiao Estuary, Jasaan, Misamis Oriental.
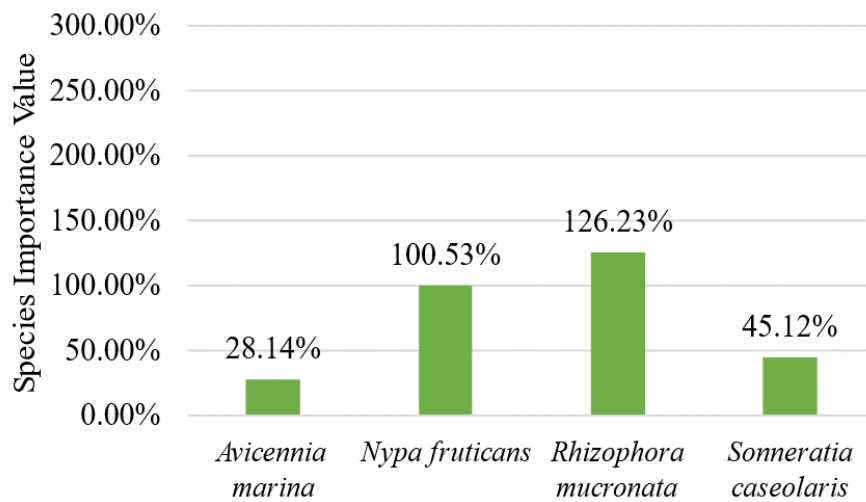
Fig. 12. Species Importance Value result of true mangrove species found in Mandangisiao Estuary, Jasaan, Misamis Oriental.
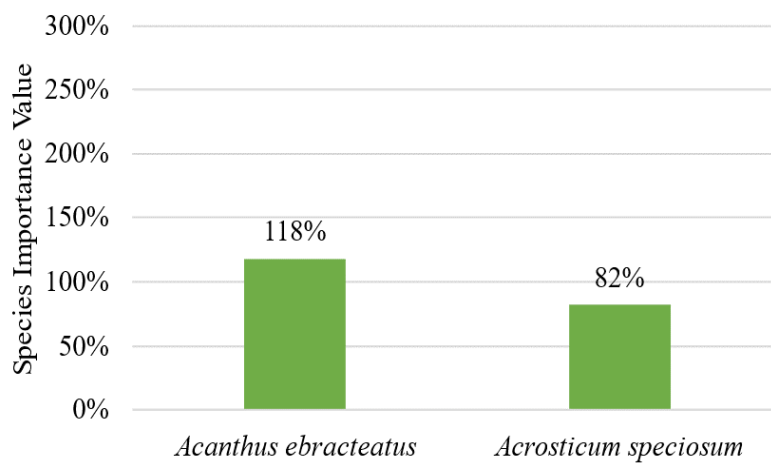

Fig. 13. Species Importance Value result of mangrove associates found in Mandangisiao Estuary, Jasaan, Misamis Oriental.

physical conditions. These mangroves are typically found in the middle of the intertidal zone, especially near the seaward edge of tropical mangrove stands (Duke, 2006). The mangroves and associated plants in the seaward zone also include the saplings of *Avicennia marina* and *Nypa fruticans*. The mangroves species *Avicennia marina* and associated plant *Nypa fruticans* were reported to be abundant in exposed shoreline locations as well as estuarine banks and have a robust tolerance for hypersaline conditions (Melana *et al.*, 2000).

The plots established in the intermediate zone of the mangrove forest (Fig. 5) harbors three species of true mangroves which includes the *Avicennia marina, Rhizophora mucronata,* and *Sonneratia caseolaris.* One of the native mangrove plants that can grow in mangrove forests on deeply muddy soil and tidal areas with mud banks is *Sonneratia caseolaris*, which is a member of the

Lythraceae family. This tree has occasionally even been observed thriving in freshwater (Rahim & Bakar, 2018). The mangroves species in this area were associated by species *Acanthus ebracteatus* from Acanthaceae family and *Acrostichum speciosum* of family Pteridaceae in which few species can thrive well in coastal environments as it also tolerates salinity and waterlogging. The associated species differ according to geographic areas, latitude, soil types, estuarine upstream location, and tidal position (Duke, 2006).

In the transect near the landward zone (Fig. 5), *Nypa fruticans* dominated the area with the greatest number of individuals. Despite having the ability to grow in saltwater, their production increased in less salty environments, particularly those close to landward zones, with species showing different levels of water tolerance (Ball, 1998). It also includes the saplings and small trees of *Rhizophora*

mucronata and *Avicennia marina* also a few tree species of *Sonneratia caseolaris* that were observed in each plot. The mangroves in this zone were also associated with species of *Acanthus ebracteatus* and *Acrostichum speciosum*. The growth and number of some associated plants increased in less saline environments as per observed in this study. Salty soils are not conducive to the growth of the majority of plants. Because salt reduces the rate and quantity of water that plant roots can absorb from the soil. Additionally, when present in high concentrations, some salts are poisonous to plants (Glenn *et al.*, 1999). Therefore, changes in coastal environments' salinity brought on by variations in precipitation, river flows, soil type, and evaporative demand are expected to have significant impacts on both the growth and species composition of mangroves and associates. Moreover, the geographic distribution of mangroves is mostly influenced by changes in sea level. Air temperature, salinity, ocean currents, storms, shore slope, and soil substrate are additional secondary influences. Mangroves can grow on sand, peat, and coral rock, but they typically developed on muddy soils (Bitantos *et al.*, 2017).

Species richness revealed a total of four true mangroves, and two associated plants. Evidently, the species richness of mangroves in Mandangisiao Estuary, Jasaan, is just half the number of mangroves recorded in the entire Municipality of Jasaan, with eight species of mangroves identified and other neighboring municipalities and city in Misamis Oriental (Mangroves in Macajalar Bay, 2019). However, the findings of this study are consistent with Bitantos *et al.* (2017) in which they also recorded four species of mangroves in Pamintayan, Damaquillas Bay, Zamboanga, Sibugay, Philippines. Moreover, mangrove forests frequently exhibit zonation, or spatial variation, both horizontally and vertically. Some species can be found in mosaics or in monospecific bands parallel to the shore; however, distribution patterns differ depending on the locality, both locally and regionally. Interspecific variation is also extremely considerable in the low species richness in each zone.

The diversity index result is attributed to a lack of species variation in the mangrove forest. Numerous studies have determined that mangrove forests have very low diversity indices compared to other tropical forest ecosystems because of their distinctive stand construction and their need for adaptability to harsh saline environments (Gevana & Pampolina, 2009). Furthermore, deforestation and other human activities alter the mangrove ecosystem, which causes several natural changes. This modification eventually leads to changes in species richness and composition. Presumably, among the four species of mangroves observed in the area, *Nypa fruticans* makes up the largest mangrove biomass and has a large basal area for the entire sampling area. This is due to the large number of individuals recorded for each species and the large area covered if combined. The density and girth of mangroves in an area are both factors that affect basal area. Smaller basal areas typically imply fewer trees, whereas larger basal areas suggest dense forests. A mangrove area could, however, be dense and still have a relatively small basal area because of the small tree diameter (Manual *et al.*, 2022).

Furthermore, among the four species of true mangroves and two species of associated plants documented, *Rhizophora mucronata* was noted to have the highest species importance value percen-tage of 126.23%, followed by *Nypa fruticans* (100.53%), *Sonneratia caseolaris* (71.99%), *Avicennia marina* (43.59%) (Fig. 12). Further, associated plants, *Acanthus ebracteatus* has the highest species importance value with 118%, followed by *Acrostichum speciosum* (82%) (Fig. 13). The result can be interpreted that *Rhizophora mucronata* had the most significant role in the mangrove ecosystem of the study site. A high species importance value index indicates the significant function and contribution that mangroves make to the wider ecosystem. Mangroves provide a significant supply of construction supplies, charcoal, and firewood for coastal populations (Nicolau *et al.*, 2017). Additionally, numerous organisms in this ecosystem, such as fish, shrimp, crabs, and mollusks, depend on mangrove waste for food and vegetation for shelter, foraging, and even spawning (Njana, 2020).

The expansion and concentration of the human population have a negative impact on mangrove forests. There will be increased anthropogenic effects on the forests as there are more people living in or close to mangroves (Alongi, 2002). Many mangrove habitats in big cities throughout the world have observed rapid loss and deterioration of forest cover (Branoff, 2017). Human activity had a significant impact on the structure of mangrove forests, but despite of this, people can work together to manage them (Walters *et al.*, 2008).

CONCLUSION

A total of four true mangrove species and two associated plants were recorded in Mandangisiao Estuary, Jasaan, Misamis Oriental under three families and three genera of mangroves and three families and three genera for the associated plants. The mangrove species that can be found in the Mandangisiao Estuary include *Avicennia marina, Nypa fruticans, Rhizophora mucronata*, and *Sonneratia caseolaris*. Associated plants comprise *Acanthus ebracteatus* and *Acrostichum speciosum*. Moreover, the diversity value of mangroves and associated plants in Mandangisiao

Estuary, Jasaan, Misamis Oriental is 0.87, which is considered to have a very low relative value. Moreover, for true mangroves *Rhizophora mucronata* had the highest relative density and species importance, while *Nypa fruticans* is the highest in terms of relative dominance. Both have the same highest value in relative frequency. All in all, the highest species importance value for true mangroves is *Rhizophora mucronata* with 126.23%. For associated plants, *Acanthus ebracteatus* has the highest values of relative density, relative frequency, and species importance. Mangrove vegetation varies in its adaptability depending on its zonation, versatility, or level of resistance. *Nypa fruticans* and *Rhizophora mucronata* species are more zonation-adaptive than other plant species, and they can be restored more rapidly. A conservation status assessment showed that all six species of mangroves and associated plants are of Least Concern according to the IUCN Red List. However, the adept dumping of garbage, frequent tree cutting, the docking of fishing boats, and the spread of human occupants were all possible dangers to the estuary's mangrove forest.

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