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Mangrove Ecosystem Biodiversity in Malacca Strait and Its Economic Values to Local Community: A Case Study in Riau Coastline

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ABSTRACT

The mangrove ecosystem holds a lot of potentials to be utilized by local communities in the Riau Coastline. Therefore, this study was carried out to assess the biodiversity of flora and fauna in the Riau Coastline mangrove ecosystem and its impacts on local communities. The transect was performed to identify soil conditions, distribution, and the dominance of flora species, while field observations and interviews with residents were conducted to determine the presence of fauna and discover the ecosystem's benefit to the local community's economy. Based on the results, *Rhizophora mucronata* and *Rhizophora apiculata* has the highest relative dominance (RDC) and important value index in all observed stations. On the other hand, the fish/water biota species has the highest diversity and have economic that mostly serve as a catch for local fishermen. Ecotourism is also encouraged to boost the community's economy and aid ecological learning for sustainability purposes. The mangrove ecosystem's existence remains sustainable because fisheries are the main commodity, however, logging is less desirable as a source of income.

1. INTRODUCTION

The mangrove ecosystem is a unique ecosystem with characteristic fauna and flora morphology [1] and grows in river mouths, tidal areas, or seasides [1-3] as a transition of terrestrial species [4]. Furthermore, the morphology of mangrove plants is a combination of the characteristics of aquatic and terrestrial plants and has a root system generally in the form of pneumatophores or breath roots [1] as well as stilt roots [3]. This type of rooting is a technique used by plants to adapt to poorly oxygenated or even anaerobic substrate conditions [5]. According to Sukuryadi et al. [6] and Mahmood et al. [7], the mangrove ecosystem does support not only the growth of flora but also fauna, therefore, suitable habitat for various kinds of biota due to the wide coverage area [6, 8]. Meanwhile, the fauna present in this ecosystem includes endemic, protected, and commodity animals, especially fish, serving as a source of livelihood for the surrounding community [8, 9].

Indonesia has a large mangrove ecosystem, comprising almost 23% of the world's total mangrove area, at 3,489,140.68 Ha [10]. However, only 1,671,140.75 Ha of this area is in good condition, while 1,817,999.93. The Riau Coastline, situated in Malacca Strait, is an area with unique edaphic environmental conditions due to the presence of mangrove vegetation growing on peatlands [1], and with consequently high biodiversity. Previous studies by Ono et al., [11], and Sukendi and Mariana [1], described biodiversity as natural wealth with economic, social, and ecological value.

In the last two decades, the mangrove ecosystem's existence has drastically decreased in quality and is now generally found around river estuaries with a thickness of 10-100 meters. This is caused by mangrove deforestation and human activities such as land-use development, agriculture expansion, overexploitation, and natural disaster such as tsunami [4]. This condition certainly needs to be evaluated to ensure improvements in the future.

Mangroves are defined as vegetation growing in coastal estuarine environments, in this case, areas with socio-economic and environmental significance [9, 12-14]. Thus, the socio-economic benefits of mangroves for local communities, particularly coastal communities, must be known while assessing the ecosystem's management [12]. Coastal communities are directly exposed to harsh ecosystem conditions and depend on the use of coastal and marine resources as sources of livelihoods and are, therefore, unique. Fishermen are the dominant coastal community and are categorized as poorer compared to the families of farmers or craftsmen. Therefore, social and economic aspects must be discussed in the assessment of coastal area management to obtain further information.

Mangrove's ecosystem resources provide various benefits at both the local, national, and global levels [2, 6, 8]. The mangrove forest ecosystem offers a range of ecosystem services such as supporting, provisioning, cultural, and regulating services to the livelihood of millions of people [4]. These consist of tangible benefits in the form of mangrove ecosystem products, non-timber ecosystem products including fruit, and latex, as well as intangible benefits, including environmental protection, and genetic diversity [13]. Also, the mangroves ecosystem adapts to the growth of flora and fauna in addition to compensating for the influence of seawater intrusion on the soil [3, 5]. This ecosystem is a habitat for various fish species, and is, therefore, a source of livelihood for local fishermen [15-17].

The transect method is a common method used in assessing the existence of mangrove vegetation [4]. Also, the characteristics of tropical mangrove soil correlate with the forest structural attributes [5]. The existence of the mangrove ecosystem is also influenced by the local community participation and awareness in preserving mangrove ecosystem sustainability [6]. The collaboration in physical observation and local social condition assessment in mangrove forest utilization could summarize the sustainability of the mangrove ecosystem [7].

Riau coastline has a large mangrove ecosystem located in Malacca Strait which supports the livelihood of local communities. The present mangrove ecosystem has economic values such as the source of fisheries, woods, and ecotourism. Several researches have been conducted on mangrove biodiversity in the Indonesian coastline [1, 2, 6, 8]. On the other hand, the study of the impact of mangrove ecosystem biodiversity on the local community especially on the Sumatra Coastline is still lacking.

Since it has had a great impact on the local community economy, the presence of the mangrove ecosystem in Riau coastline, it is important to assess mangrove biodiversity so that it can be utilized sustainably. This study, therefore, aims to collect data on the condition of the Riau Coastline area's mangrove ecosystem. An assessment was carried out on the soil, flora, and fauna conditions and the impact on the lives of the surrounding community, comprising mostly fishermen. This study's results are expected to be a benchmark for mangrove conservation in supporting the economic life of coastal communities, both at the local and regional levels.

2. MATERIALS AND METHODS

2.1 Sampling area

Figure 1 shows the four observation stations within the Riau Coastline area used in this study. Each observation station was located close to a fishing village dependent on the mangrove ecosystem as a source of livelihood. The four observation stations are related to economic, socio-cultural, and ecological activities. Also, the observation stations have the highest access for the community activities, such as ecotourism, fisheries, and conservation activities organized by stakeholders.

2.2 Methodology

Figure 2 shows the summary of the research methodology conducted in this work. Contentious transect methods are used on assessing the mangrove vegetation, while fields were performed to obtain information on the fauna species. An interview was done to collect data on ecological aspects, supporting the field observations data.

Figure 1. Sampling locations

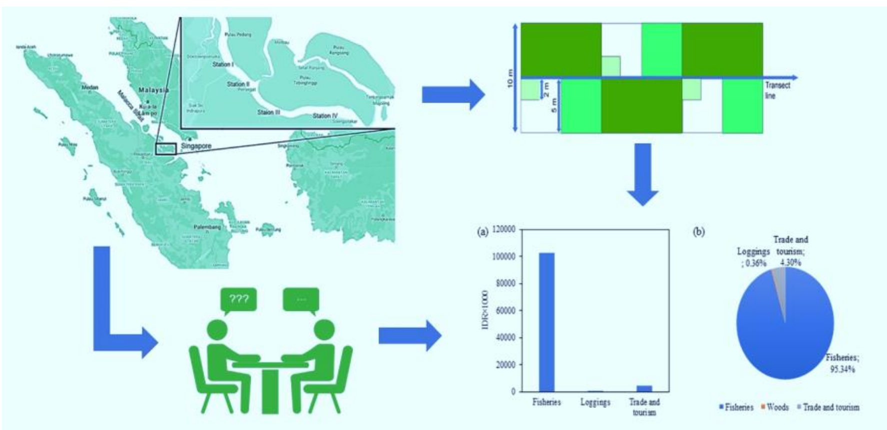

Figure 2. Research methodology summary

2.2.1 Transect

Figure 3 shows a series of sample plots, referred to as a cluster. The transects were formed using sample plots or sample units with an area expected to represent the condition of the entire population in question. Sample plots were created in this stage, with each largest plot measuring 10 m × 10 m since the observation area has a high density of mangrove trees. The measuring plot was lined up lengthwise to form a cluster of plotted lines perpendicular to the coastline, starting from the coast towards the land, according to the mangrove's thickness. Subsequently, an inventory of the mangrove vegetation was conducted using the plotted path method [8].

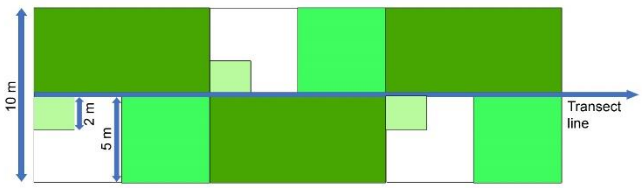

Figure 3. Plotted path transect method for floristic inventory

Although the plotting path method can become very tedious in assessing the separated individual species, this method has advantages to more effectively study the changes of vegetation according to the density of mangroves from the coastline. Meanwhile, the cluster design was placed in a pioneering direction cutting perpendicular to the shoreline, with a width of 10 m and a length depending on field conditions. The tree strata were then classified based on previous studies [8, 18, 19]. In addition, seedlings as well as undergrowth seedlings (h ≤1.5 m), saplings (height 1 m to < 4 cm in diameter), and the tree strata (stem diameter 4 cm) were verified within a 2×2 m subplot, a 5×5 m subplot, and a 10×10 m subplot, respectively.

The mangrove vegetation parameter was chosen because it is assumed to be able to contribute to the key value of the ecological dimension, one dimension of which is assessed and analyzed for its position against other dimensions in the concept of sustainability. The parameters used to describe the condition of mangrove vegetation at each research station are based on previous studies [20, 21] and include the percentage density of a species to the total density of all species (relative density (RD)), the percentage of the frequency of a species to the sum of the frequencies of all species (relative frequency (RF)), percentage of the dominance of a species to the total dominance of all species (relative dominance (RDC)), important value index (IVI), which is the sum of the calculated parameters (RD, RF, and RDC). The values of RD, RF, RDC, and IVI are calculated using Eq. (1), Eq. (2), Eq. (3), and Eq. (4) respectively. In this study, the RDC was not calculated at the seedling level because only the number of species was counted during data collection. However, at the sapling and tree levels, the number of species, as well as the stem circumference, were recorded.

$$RD = \frac{sum\ of\ individual\ species}{transect\ area} \quad (1)$$

$$RF = \frac{sum\ of\ transect\ area\ that\ species\ found}{suum\ of\ transect\ area} \quad (2)$$

$$RDC = \frac{dominance\ of\ calculated\ species}{dominance\ of\ all\ sepcies} \quad (3)$$

$$IVI = RD + RF + RDC \quad (4)$$

2.2.2 Soil salinity measurement

Soil parameters were chosen because they are assumed to contribute key values to the ecological dimension. To assess the ecological dimension, various parameters are needed, not only the condition of the vegetation but also the physical condition of the edaphic and various other biotic factors. The soil EC analysis method is done by the principle of the electrical effect of an electrolyte, is a concise and most universal analytical method for a soil salinity assessment [22]. The soil samples located 500 m behind the mangrove ecosystem sample were collected by digging 30 cm at 3 points, with a 100 m distance between points. Subsequently, the soil samples from the three points were mixed and analyzed. During determining soil salinity using EC, several probable factors will distract soil salinity measurements to a certain extent, such as electrophoretic mobility, soil salt composition, soil-water ratio, solution total salinity, solution temperature, and constant of the cell conductance [22].

2.2.3 Field observation

Field observations were performed to obtain information on the fauna species in the mangrove ecosystem area. Data were obtained through direct observation as well as information from literature and residents (regarding the types of fish caught by fishermen). Subsequently, the mangrove's economic value for the surrounding community was determined by calculating the value of direct benefits, in the form of products, for instance, capture fisheries, wood, food, recreation, and medicine. Meanwhile, an interview was performed to collect data on ecological aspects, to support the data obtained by field observations.

Animal data collection is done by direct observation. This was done with the support of literature studies, in which several parties had made observations as well. Direct observation is intended to find out the latest real conditions because literature studies were carried out on previous documents. While the literature study in this study is intended as a compliment, where if there are species of animals that have not been found but are found in the document, the researchers make observations once again by focusing on species that have not been recorded in direct observation.

3. RESULTS AND DISCUSSIONS

3.1 Mangrove ecosystem conditions

The Riau coastline mangrove ecosystem's ecological condition is influenced by the condition of the environmental physical parameters. This is also indirectly related to the vegetation's composition and structure, as well the life within, including fauna, especially fish, crabs, and other fishery commodities**.**

3.1.1 Soil salinity

Figure 4 shows the soil salinity in the mangrove vegetation areas. Based on the results, stations III and I had the highest and least salinity levels, respectively. Stations I, II, and IV have relatively high soil salinity, while station III's counterpart is very high. According to a previous study, soil salinity has a positive correlation with several mangrove vegetation biomass (i.e., tree size and flowering) [23], and the other [5, 24].

Furthermore, at station III, the dominant plant species on the coast was the Avicennia marina, while at station I, the dominant composition on the coast was *Rhizophora mucronata* (White Mangroves). Stations III and I were observed using a measuring plot for up to 20 and 40 meters across the coastline, respectively. Previous studies by Banerjee et al. [5] and Cooray et al. [25] showed *Avicennia marina* grows on high salinity soils and acts as a pioneer on the coast because the strong roots can withstand the waves.

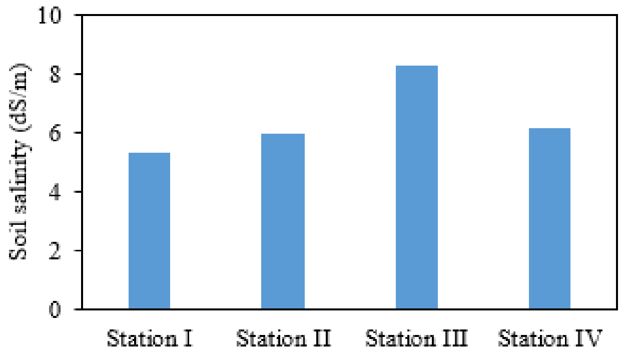

Figure 4. Soil salinity of observation stations in Riau coastlines' mangrove vegetation area

In addition, the type of substrate found in the two observation stations differed, with station I having a dark sandy mud substrate, and station III having more light-colored sand. This type of substrate corresponds to the type of plant growing. At station 1, the mud substrate is overgrown with the more stenohaline stilt root plants [26]. Meanwhile, the mud substrate at station III is overgrown, with more euryhaline pneumatophores or prop root vegetation [25, 27]. Thus, the soil condition behind the coastline is related to the type and thickness of the plant species growing and affects the land salinity level [26, 27]. The thick mangrove ecosystem with root types adaptive to the influence of seawater and the substrate conditions [25], affects reducing the seawater intrusion on the land behind the shoreline [3, 5].

The soil variables have a pairwise correlation with the structural variables for linking the mangrove vegetation with the environment [24]. The soil salinity is likely to be reduced with the increasing distance from the coastline to the upland [5]. An increase in soil salinity was found to be having a great impact on the vegetation community and structure [20, 5]. Also, the presence of mangrove leaves and litter inland could decrease the soil salinity because of the enhanced addition of fresh organic carbon [20, 27].

3.1.2 Mangrove vegetation composition and structure

Table 1 shows the composition of mangrove species found in the Riau coastline. A total of 17 species belonging to 11 families, were identified. The vegetation is mostly dominated by the *Rhizophoraceae* family, comprising *Rhizophora mucronata*, *Rhizophora apiculata*, *Bruguiera gymnorhiza*, and *Bruguiera sexangulata*. Meanwhile, the least dominant vegetation belongs to the *Lythraceae* family and comprises the *Sonneratia alba* species. This is in line with the previous study [21] stating *Rhizophoraceae* dominate the mangrove species on the Sumatra coast, followed by *Meliaceae* and *Avicenniaceae*.

Mangrove vegetation data at each research station has a varied composition and structure of values. Therefore, there are differences in the character of each plant species at each observation station (Figure 5). Based on the results, 11 species were identified at station I, dominated by the *Rhizophoraceae* family in all growth strata, especially *Rhizophora mucronata*. This species had the highest RDC and IVI in all mangrove growth strata, compared to other species (IVI tree: 123). The species with the highest RDC and IVI, in this case, *Rhizophora mucronata*, played an important role in maintaining the mangrove community's stability at station I. Furthermore, the seedling strata comprised only *Rhizophora mucronata*, indicating the regeneration of other species are experiencing obstacles probably due to natural or human factors.

Table 1. Mangrove species found in Riau coastline

Family	Local names	Species	Abb.
Rhizoporaceae	*Bakau putih*	*Rhizophora mucronata*	RM
	bakau merah	*Rhizopora apiculata*	RA
	putut	*Brugueira qymnoriza*	BG
	Temusing	*Brugueira sexangulata*	BS
Acanthaceae	*Api-api putih*	*Avicenia marina*	AM
Meliaceae	*Nyirih*	*Xylocarpus granatum*	XG
Malvaceae	*Baru-baru*	*Thespesia popylnea*	TP
	Dungun	*Heritiera littoralis*	HL
	Dungun	*Heritiera globasa*	HG
Pandanaceae	*Pandan duri*	*Pandanus tectonus*	PT
Rubiaceae	*Cingam*	*Scyphiphora hyropylacea*	SH
Icanaceae	*Bedaru*	*Canteyla corniculata*	CC
Combretaceae	*Teruntum*	*Lumnitzera racemosa*	LR
	Ketapang	*Terminalia catappa*	TC
Euphorbiaceae	*Bebatak*	*Excoecaria agallocha*	EA
Lynthraceae	*Perepat*	*Sonneratia alba*	SA
Arecaceae	*Nipah*	*Nypa fruticans*	NF

A total of 6 species were identified at station II, dominated by *Rhizophora apiculata* at the tree strata and Avicennia marina at the sapling strata. The results showed *Rhizophora apiculata* species had the highest RDC and IVI (95). In addition to contributing significantly to the mangrove vegetation community, this species also shows adaptability to the environmental conditions at station II. This is similar to the report by Hanggara et al. [21] stating *Rhizophora apiculata* plays an important role in the North Sumatra coast. A study by Yudha et al. [8] also reported similar results for similar studies in Guinea Island.

A total of 12 species were identified at station III, dominated by the *Rhizophoraceae* family, comprising *Rhizophora mucronata*, *Rhizophora apiculata*, and *Bruguiera gymnorhiza*. The results showed Avicennia marina and *Rhizophora mucronata* had the highest RDC and IVI at the sapling (IVI: 46) and tree (IVI: 80), respectively. *Avicennia marina* species also had lower regeneration, compared to *Rhizophora mucronata* and *Rhizophora apiculata*.

The existence of this species is directly affected by seawater with constantly inundated conditions. Therefore, the species' location at the end of the beach poses a challenge to the regeneration process. However, *Rhizophora mucronata* and *Rhizophora apiculata* are located behind the *Avicennia marina* and have a regeneration process hindered by exposure to destructive seawater. These two species can grow in the polyhaline zone [28], and are, therefore, able to dominate the ecosystem.

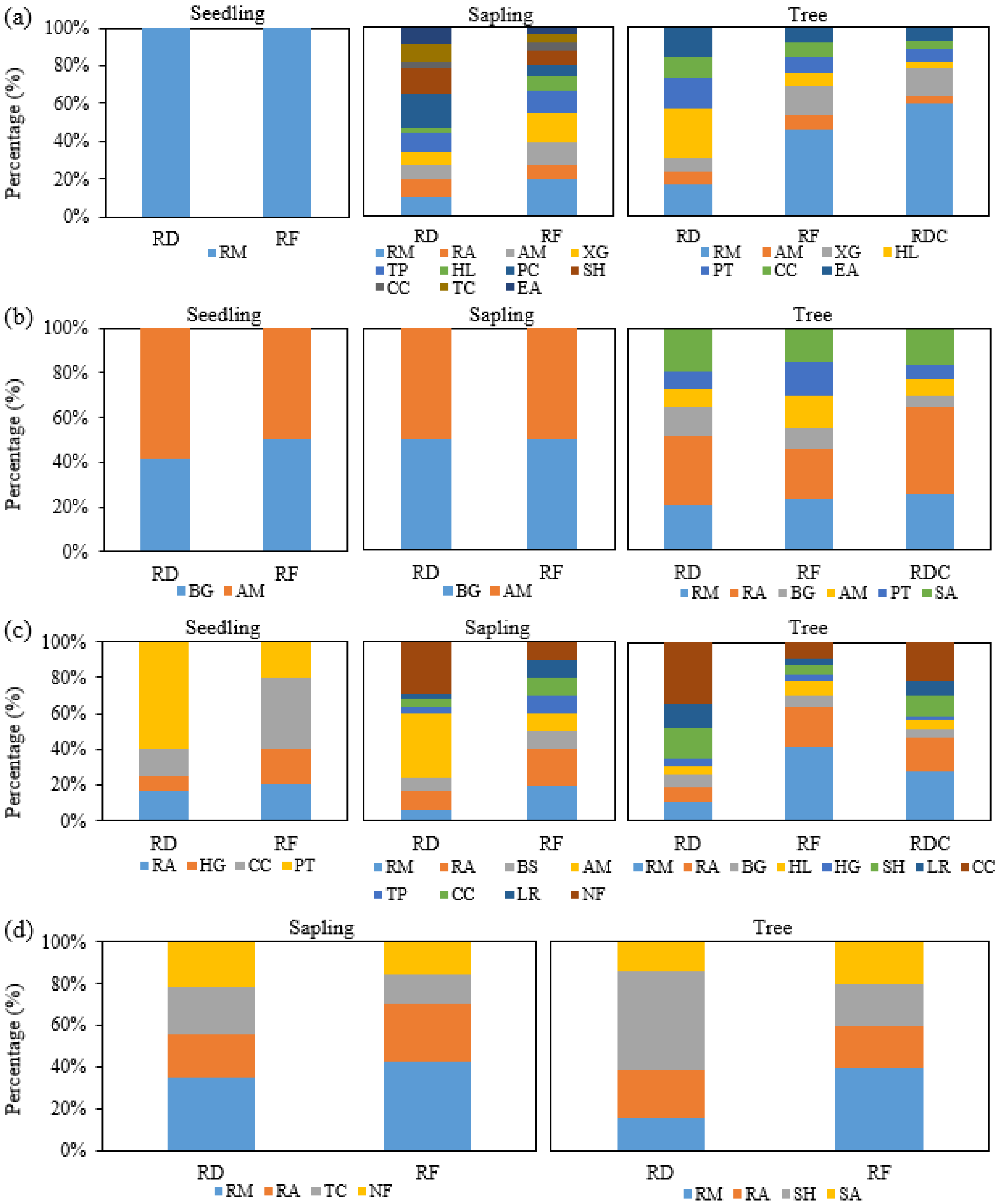

Figure 5. Mangrove condition parameters of tree strata in each observation station: (a) Station I, (b) Station II, (c) Station III, and (d) Station IV

Meanwhile, a total of 7 species were identified at station IV, also dominated by *Rhizophora mucronata* at the sapling strata (IVI: 46). The tree strata in this station are dominated by other species from the *Rubiaceae* family, particularly *Scyphiphora hydrohyllacea* (VI: 40), a unique monotypic genus in India, Indochina Malay Archipelago [29].

3.1.3 Diversity index (H') of mangrove species

The Shanon-Wienner species diversity index describes the condition of the mangrove vegetation population, where is H' 1, 1<H'<3, and H'>3 indicate low, moderate, and high diversity, respectively [30, 31]. Figure 6 shows a comparison of each station's H' value. Based on the results, stations I and II had the least and highest H' in all strata, respectively. This indicates the vegetation in station I tend to be homogeneous, despite having the largest number of individuals, because the diversity is low. The seedling strata at the station I had H'0 because the vegetation at station II tended to be the most varied or heterogeneous. Station IV also has a 0 value H', because no seedling strata individuals were present in the research plot.

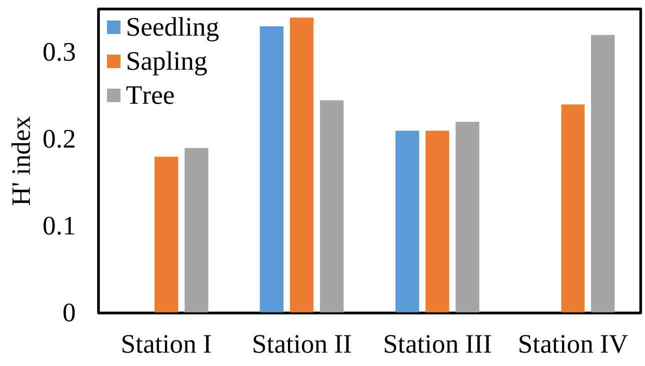

Figure 6. Diversity index (H') of mangrove species in the observation station

Suitable environmental conditions, including a muddy substrate, less inundation, and insignificant land conversion activity, enable the *Rhizophoraceae* family to thrive naturally at station I. This makes the vegetation in this station homogeneous, and consequently, with the least H' value. This vegetation family, especially *Rhizophora mucronata* grows widely and is found everywhere in the mangrove ecosystem [32]. Meanwhile, environmental conditions at station II are more significantly affected by human activities, for instance, past logging, planting activities, and efforts to conserve species collections, as well as the presence of a shipping port, and these lead to changes in the flora's structure and diversity [33].

Station III has a low H' after station I, because the substrate tends to be suitable for growing *Avicennia marina*, and these species are directly affected by seawater and waves. Therefore, the homogeneity is more for the *Avicennia marina* because the species has a great survival rate [34], but grows mostly in the sapling strata. Meanwhile, station IV has a high H' after station II because, apart from the true mangrove groups, *Rhizophora mucronata*, and *Rhizophora Apiculata*, the area is also overgrown with the associated mangrove groups, *Pandanus tectonus*, *Thespesia populnea*, *Nypa fruticans*, as well as *Terminalia catappa*.

Interestingly, this study discovered a globally rare and vulnerable mangrove species existing as a single species, with no variations. However, special attention is required for the species' management. The *Scyphiphora hydrophyllacea*, locally referred to as *Cingam*, is an endangered species classified into the Least Concern (LC) category with the 20% global loss criteria of the International Union for the Conservation of Nature (IUCN) Red List of Threatened Species [35, 36].

3.1.4 Fauna conditions

Figure 7 shows the diversity of fauna species found in Riau Coastline's mangrove ecosystem and the surroundings. A total of 12, 2, 5, 5, and 3 species of fish/water biota, amphibians, birds, reptiles, as well as mammals, respectively, were identified, with the most diverse and least diverse fauna group being fish/water biota, and amphibians, respectively.

Meanwhile, Table 2 shows the fauna species found in Riau Coastlines' mangrove ecosystem and the respective conservation statuses. The fish/water biota species present have economic value, and, therefore, mostly serve as a catch for local fishermen [37-39]. However, the existence of fish/water biota is maintained, provided the mangrove ecosystem exists. The ecosystem serves as a settling or spawning habitat for fish/water biota before going to deeper seas, and acts as a complex provider of nutrients and protection. For instance, the *Scomberomorus* fish has a diet of *Engraulidae* fish, particularly *Ilisha elongata* as well as Stolephorus dubious, and was found in this study. *Stolephorus dubious*, *phytoplankton*, and *zooplankton* often found in the mangrove ecosystem due to the abundance of detritus and other nutritional sources within were also found [40].

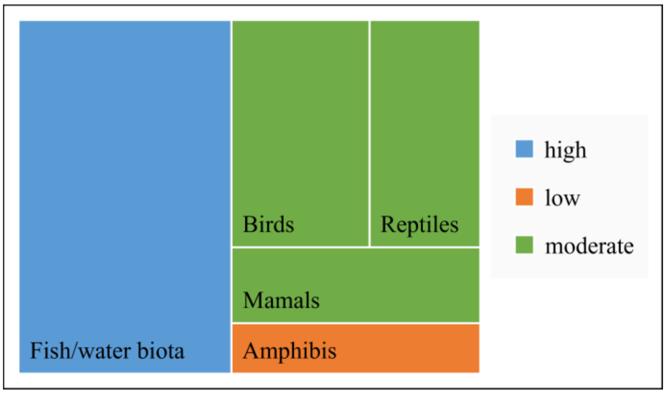

Figure 7. The diversity of fauna species

A total of 2 amphibian species, both from the same family, were found. The two species, *Rana limnocharis* (Swamp Frog) and *Rana cancrivora* (Mangrove Frog) are commonly found in mangrove ecosystems with unprotected status and low species diversity. *Ranidae* frogs are present in a wide variety of forests, however, only a few species survive in mangrove ecosystems [41]. This is because the water's salinity is probably unsuitable for the frog's relatively permeable skin [42].

Meanwhile, a total of 5 bird species from 4 different phyla with high diversity, were identified. According to the IUCN, these birds are protected species classified as low risk in the category of heading for extinction, particularly the white-collared Kingfisher *Halcyon chloris* and *Butorides striata*. These species tend to be solitary or live in small colonies within mangrove trees and are also found in the mangrove forest of Papua Island [8]. The birds prey on smaller animals, including small fish, shrimp, as well as insects, and forage in the sea through exposed rocks and coral reefs, after the sea recedes. *Corvus enda* and *Merops philipphinus* are common insectivorous species found in swamps, open forests, and mangrove forests, while *Haliaeetus cirrhatus*, a large eagle, lives on the coast and eats smaller birds, fish, as well as snakes. This ecosystem is a good food provider for birds, especially for these species, and is, therefore, suitable habitat for all types of birds [8].

In this study, 4 reptile species from 4 different phyla with moderate diversity, were also identified. The snake species found in the mangrove ecosystem use the environment as their primary habitat. *Boiga dendrophila*, a snake, is commonly found in the canopy seeking for birds to prey on [43], while *Enhydris enhydris*, a water snake, preys on fish [44]. Meanwhile, the lizard species found were *Varanus salvator* and *Mabouya multifasciata*. Large lizards, for instance, Varanus salvator are found on riverbanks as well as in mangrove vegetation [7].

In addition, a total of 3 mammal species from 2 families with moderate diversity, were identified in this study. *Macaca fascicularis*, one of these species, is included in the Appendix II category of CITES (Convention on International Trade in

Endangered Species of Wild Fauna and Flora), particularly in the vulnerability status, based on the convention on international trade in endangered species of wild plants and animals. The Appendix II category is a list of species not threatened with extinction, but have the potential to be threatened with extinction, provided unregulated trade ensues. *Macaca fascicularis* utilizes the mangrove ecosystem only to find food and lives in coastal forests or associated groups with higher vegetation types than the original vegetation.

3.2 Economic values

The mangrove ecosystem's existence provides benefits for the local community, especially fishermen [1, 2]. In addition to catching fish, shrimp, and crabs within and around the area, the community also uses mangroves as a source of daily needs, including firewood for boiling water, to sell around the area, mostly developed for ecotourism. The ecotourism strategy provides benefits for the local community and aids ecological learning for sustainability [45].

Figure 8 shows the average value of the direct benefits enjoyed per person, in Riau Coastline. Based on this study, the total direct benefit value of the mangrove ecosystem obtainable by each person is IDR. 107,501,195, per year, from fish catches, indicating the ecosystem has a high economic value. Fishing as an occupation has a greater intensity in accessing this ecosystem, compared to other occupations.

Furthermore, ecotourism has attracted the interest of other environmentalists, including academics, Non-Governmental Organizations (NGOs), local governments, and the general public. This attractiveness has made various parties unite to organize activities, including counseling on the importance of mangrove conservation, marketing training for ecotourism destinations, and developing tourism products, for instance, tour packages, fishing tours, and producing snacks (syrup and sweets), as well as medicine, from mangroves. These training activities have a positive impact on the community and promote the establishment of mangrove ecotourism destinations.

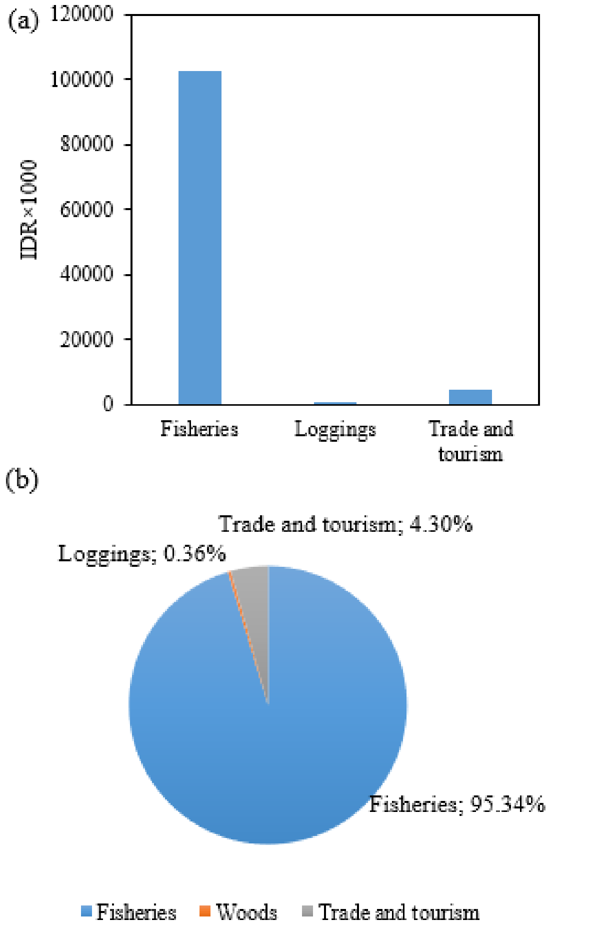

Figure 8. The benefit values of mangrove ecosystem per person: (a) Benefit per persons in a year, and (b) Percentage

Table 2. The fauna species found in Riau Coastlines' mangrove ecosystem and its conservation status

Fauna	Species	Family	Endemic	Conservation status
Fish/ water biota	*Harpodon nehereus*	*Synodotidae*	Endemic	Not protected
	Otolithoides pama	*Sciaenidae*	Endemic	Not protected
	Ilisha elongata	*Engraulidae*	Endemic	Not protected
	Scomberomorus	*Sombridae*	Endemic	Not protected
	Muraenesox talaban	*Muraenesocidae*	Endemic	Not protected
	Stolephorus duboisus	*Engraulidae*	Endemic	Not protected
	Pumpus sp	*Bramidae*	Not endemic	Not protected
	Aphases sp	*Palinuridae*	Endemic	Not protected
	Oratosquila oratoria	*Squillidae*	Endemic	Not protected
	Penaeus merquensis	*Panaeidae*	Not endemic	Not protected
	Parapenaeiis perezfarato	*Parapenaeidae*	Not endemic	Not protected
	Charybdis annulata	*Portunidae*	Not endemic	Not protected
Amphibi	*Rana limnocharis*	*Ranindae*	Not endemic	Not protected
	Rana cancrivora	*Ranindae*	Not endemic	Not protected
Birds	*Halcyon chloris*	*Alcedinidae*	Not endemic	Protected
	Butorides striata	*Alcedinidae*	Not endemic	Protected
	Corvus anea	*Corvidae*	Not endemic	Not protected
	Merops philippinus	*Meropidae*	Not endemic	Not protected
	Haliaeeius cirrhatus	*Accipitridea*	Not endemic	Protected
Reptiles	*Boiga dendropila*	*Colubridae*	Not endemic	Not protected
	Enhydris en hydris	*Homolopsidae*	Not endemic	Not protected
	Varamus salvator	*Varanidae*	Not endemic	Not protected
	Mabouya multifaciata	*Scincidae*	Not endemic	Not protected
Mamals	*Macaca fascucilaris*	*Ceropithecidae*	Not endemic	Not protected
	Cynopterus	*Pteropodidae*	Not endemic	Not protected
	Rattus	*Muridae*	Not endemic	Not protected

This research has assessed the impact of local community activities on the sustainability of the mangrove ecosystem. On the other hand, details of all aspects of community life that depend on mangrove ecosystems such as fisheries, logging, and ecotourism are still needed. The impact of the times and the development of technology, as well as land development on the mangrove ecosystem, also needs to be investigated further.

4. CONCLUSIONS

The mangrove species in the Riau coastline comprise 17 species from 11 families, dominated by the *Rhizophoraceae* family, consisting of Rhizophora mucronata, *Rhizophora apiculata*, *Bruguiera gymnorhiza*, and *Bruguiera sexangulata*, with a low species diversity index of 0.10-0.37 and a mangrove area of 6,840.4 ha. Meanwhile, the fishery biota, including fish, shrimp, and crabs, are the main commodities traded by the local community, because logging of mangrove forests is a less attractive source of income. In addition, the promotion of ecotourism also increases public awareness of sustainability and serves as an economic booster.

This research only assessed the impact of local community activity on the sustainability of the mangrove ecosystem. Even though it is sustainable, community activities in utilizing the mangrove ecosystem must continue to be monitored to ensure sustainability. Further research is needed on strategies for developing mangrove ecosystems to keep pace with technological developments and community needs in the future.

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