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Ecoregional Site Study on Small Islands: A Case Study of The Significance of Flora For Fisheries in the Anambas Islands

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ABSTRACT
In terms of geological formation, the Anambas Islands were included in the Bunguran Formation category. It can be seen from the complex of seabed rocks millions of years ago, which were then exposed to the surface and formed the islands in the Anambas Islands arch. The natural process created a unique coastal ecosystem type, with large rocky beaches and high cliffs on some of its coastlines. Meanwhile, sloping locations protected from wind and waves allow the soil substrate to be mixed with sand to create thin mud and become a habitat for mangrove forests to grow. Today, development in various sectors in Anambas is carried out to grow the economy. Some of the most prominent are the fisheries, tourism, and oil and gas mining sectors. This massive development threatens the existence of forests in this region, especially forests located in coastal areas, both mangrove forests and coastal forests. In fact, forests play a very important role in maintaining the balance of the ecosystem, which can guarantee the sustainability of natural resource stocks such as fishery resources. The continuity between these natural components needs to be studied to estimate the role of forests in fisheries. This study examines the significance of forests for fisheries in the Anambas Islands. The methods used consist of two approaches, namely biology and socio-economics. Biological surveys were conducted by analyzing forest vegetation to display the Anambas flora profile. Fisheries surveys were conducted by interviewing fishermen directly in the field and with representatives of fishermen groups. The study was conducted in nine sample locations spread throughout the Anambas ecoregion. The study results found 23 species of flora in coastal forests and seven in mangrove forests. The identified fisheries consisted of five species of large pelagic fish, five species of small pelagic fish, six species of demersal fish, two species of reef fish, three species of shrimp, and mollusks such as squid. These fish species have a symbiosis with the forest, either directly or indirectly (multilevel). The relationship between these components is reflected in the association between components, so maintaining the forest in Anambas will help balance fisheries stocks.

Keywords: Ecoregion, Coastal Ecosystem, Anambas Islands, Mangrove, Capture Fisheries.

INTRODUCTION

The formation of the Anambas islands is a form of earth's surface dynamics that occurred over millions of years. Initially, Anambas was a continent of origin where the continental shelf of the Sunda shelf was in this zone. Then the movement of tectonic plates forced this zone to sink into the ocean which occurred 300 million years ago (Devonian geological period). This causes the surrounding zones to seek balance and gradually the surface of the earth emerges above sea level. So that slowly the land that appeared and sank created the surface of the earth as it exists today (Sisca, 2018).

In the process, Sisca (2018) stated that there were at least eight land formations on the Sunda shelf. This evolution of the earth's surface has led to the emergence of large islands on the Sunda shelf along with small islands around them. This also makes the Sundanese shelf part of the volcanic route of the volcano. On a micro scale in the Anambas Islands, geological evidence states that this group of islands belongs to the Bunguran formation (Haile, 1970, Hakim and Suryono 1994).

Based on a study by Budiono and Latuputty (2013), the Bunguran formation is a bedrock complex, which is thought to originate from deep sea deposits of Jurassic-Cretaceous age. The age of the rocks is quite old, indicating that this formation was exposed to the surface and formed islands in the arc of the Anambas Islands group. Incongruously, this formation is overlain by the

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Oligocene-Middle Miocene lining sandstone and the Upper Miocene-Pliocene Raharjapura Sandstone. Then, incongruously, Resen Alluvium was deposited on top of these units (Budiono and Latuputty 2013).

All of these natural processes create a unique type of ecosystem, namely a rocky beach ecosystem, where the rocks at the study location are large rocks with cliffs on some of the coastlines. Some other beaches are sloping locations and create sandy beaches. The sand found along the site is also white sand which is the result of the breakdown of coral reefs and meta-sedimentary rocks around it. Apart from that, the sand formed is also influenced by longshore currents (Budiono and Latuputty 2013). Meanwhile, sloping and protected locations allow the dust substrate to mix with sand to create a thin mud that allows mangrove forests to grow.

Mangrove forests usually consist of trees and/or shrubs consisting of one of 12 or more tree genera that have adapted to habitats that are affected by sea tides. Mangrove forests usually grow flowering plants such as *Avicennia spp.*, *Sonneratia sp.*, *Rhizophora sp.*, *Bruguiera sp.*, *Ceriops sp.*, *Xylocarpus sp.*, *Lumnitzera sp.*, *Laguncularia sp.*, *Aegiceras sp.*, *Aegiatilis sp.*, *Snaeda sp.*, dan *Conocarpus sp.* which belong to eight families (Bengen, 2004). It is estimated that 51% or 38 mangrove species live in Indonesia out of a total of 89 mangrove species that grow in the world (Supriharyono, 2007).

The composition of flora found in mangrove ecosystems is determined by several important factors such as soil type conditions and tidal inundation (Nontji, 2007). The area closest to the sea, with a slightly sandy substrate, is often grown by *Avicennia* spp. This zone is usually marked by the presence of *Sonneratia* sp. which predominantly grows in mud rich in organic matter. Further on land, mangrove forests are generally dominated by *Rhizophora* sp. In this zone, *Bruguiera* sp. and *Xylocarpus* sp. The next zone is dominated by *Bruguiera* sp. Meanwhile, the transition zone between mangrove forests and lowland forests usually grows Nypa fruticans and several other palm species (Bengen, 2001).

Today, development in various sectors in Anambas is carried out to grow the economy. Some of the most prominent are the fisheries, tourism, and oil and gas mining sectors. Development in Anambas was carried out to grow the economy in this region. The Regional Government consistently carries out development in various fields. Some that stand out are the fisheries, tourism and oil and gas sectors. Based on the Regulation of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia, No.18/Permen-KP/2014, concerning the State Fisheries Management Area of the Republic of Indonesia, the Anambas Region is within the State Fisheries Management Area of the Republic of Indonesia 711 (WPPNRI-711) which includes the waters of the Karimata Strait, Natuna Sea and Sea North Natuna. In this Fisheries Management Area (WPP), it is necessary to pay attention to the study of coastal flora. This is related to the availability of fisheries stocks in this Fisheries Management Area (WPP), especially for fish located around the coast. Apart from that, the presence of mangroves will really help the breeding location for fish species that require large areas in mangrove forests.

This massive development threatens the existence of forests in this region, especially forests located in coastal areas, both mangrove forests and coastal forests. In fact, forests play a very important role in maintaining the balance of the ecosystem, which can guarantee the sustainability of natural resource stocks such as fishery resources. The continuity between these natural components needs to be studied to estimate the role of forests in fisheries. This study examines the significance of forests for fisheries in the Anambas Islands.

METHODS

Observations were carried out along the northern side of the Anambas Islands group. Along the northern side, the studies carried out can be used to see the direct influence of the ecosystem which is closely related to the North Natuna Sea (South China Sea). The observation locations are spread across two ecosystem types, namely mangrove and beach types. Observation locations for the beach type were carried out at seven locations, while for the mangrove type they were carried out at two locations. This was done because the mangrove locations that were found and represented the type of ecosystem of the northern coast of the Anambas Islands were only found in two locations, namely on Jemaja Island and on Matak Island. The flora study location was only carried out on the northern coast of the Anambas Islands, and was taken from nine sampling points, namely Pahat Island, Semut Island, Telaga Kecil Island, Linggai Island, Siantan Island, Keramut Island, and Jemaja Island. Tabularly, the observation location points are shown in Table 1. A map of the observation locations is shown in Figure 1.

Table 1. Location codes and observation points.

Location Code	Location Name	Coordinate Point	Ecosystem Type
P01	Pahat Island	N 03 23' 31,7" E 106 08' 43,3"	Coastal Forest
P02	Semut Island	N 03 23' 45,9" E 106 16' 20,1"	Coastal Forest
P03	Telaga Kecil Island	N 03 05' 31,1" E 105 58' 12,1"	Coastal Forest
P04	Lingai Island	N 03 09' 07,7" E 106 05' 10,6"	Coastal Forest
P05	Siantan Island	N 03 13' 42,3" E 106 12' 06,5"	Coastal Forest
P06	Keramut Island	N 03 06' 03,6" E 105 39' 50,2"	Coastal Forest & Mangrove Forest (side-by-side location)
P07	Jemaja Island	N 03 03' 40,5" E 105 41' 42,3"	Coastal Forest
M01	Matak Island	N 03 23' 45,9" E 106 16' 20,1"	Mangrove Forest
M02	Keramut Island	N 03 06' 03,6" E 105 39' 50,2"	Mangrove Forest

Source: Field Survey, 2020

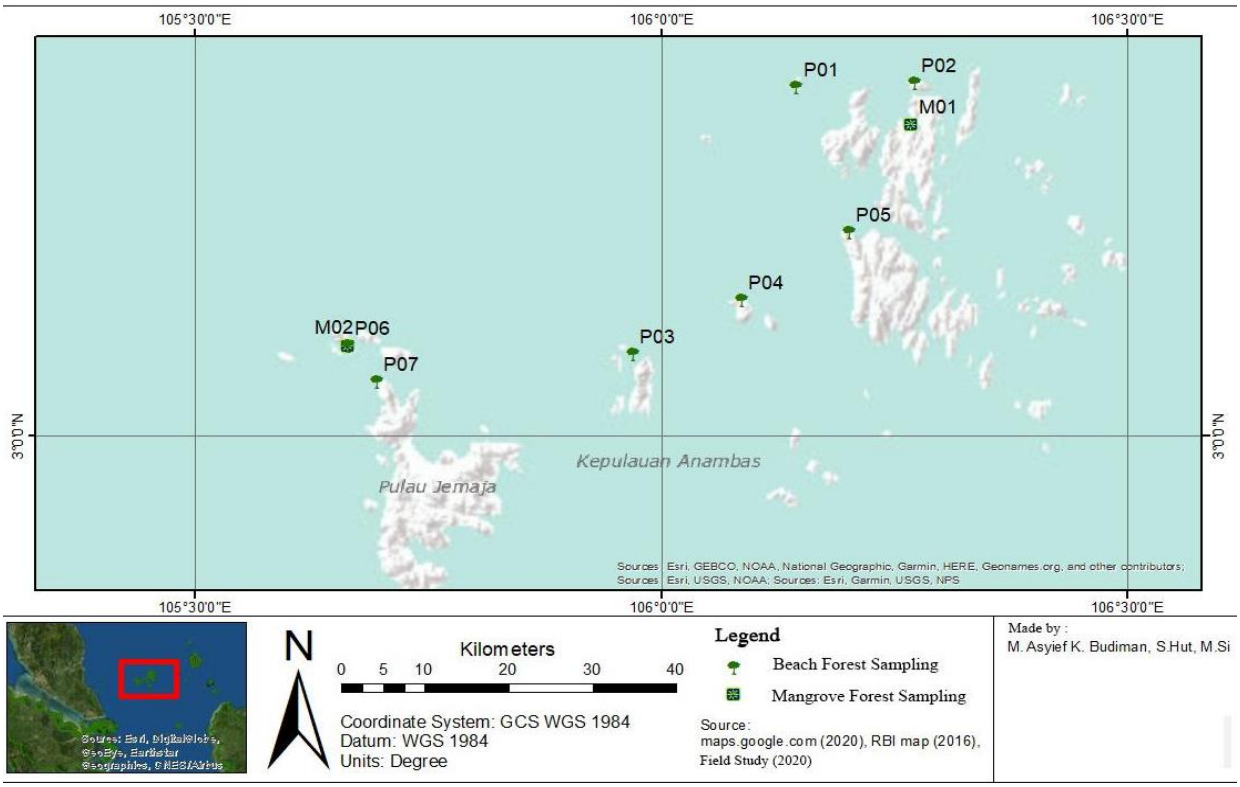


Figure 1. Map of observation locations.

The materials used in observing flora are observation tally sheets and leaf cuttings taken directly in the field. Tools in the form of a sewing meter to measure the circumference of a tree, a tape measure to make flora analysis plots. Apart from that, another tool used is the mangrove identification guidebook by Noor *et al.* (2006) and a digital camera to document research activities. The object of study is the flora that grows in the Anambas Islands area on the north side.

The observation technique used is a field survey where the observer goes directly to the field to conduct a survey directly. Observers determine observation locations based on sampling locations that have been determined based on planning by looking at the representation of forest types. Locations designated as pilot routes are locations that represent coastal types, namely mangrove forests and coastal forests. Vegetation analysis is a method used to analyze the composition and structure of flora in an ecosystem. Vegetation analysis was carried out using the plotted path method, where one path consists of three plots as the minimum scale for representing one location. The specified plot size is 20 x 20 m for coastal forests and 10 x 10 m for mangrove forests. In mangrove forest measurement plots, the distance between plots is set at 10 m. The substrate of the sampling location is also recorded to indicate the type of substrate where the flora grows. Data collection was also carried out by documenting leaf specimens for further identification at the Forest Ecology Laboratory, Faculty of Forestry and Environment, IPB University. An illustration of the data collection method used for flora analysis is presented in Figure 2.

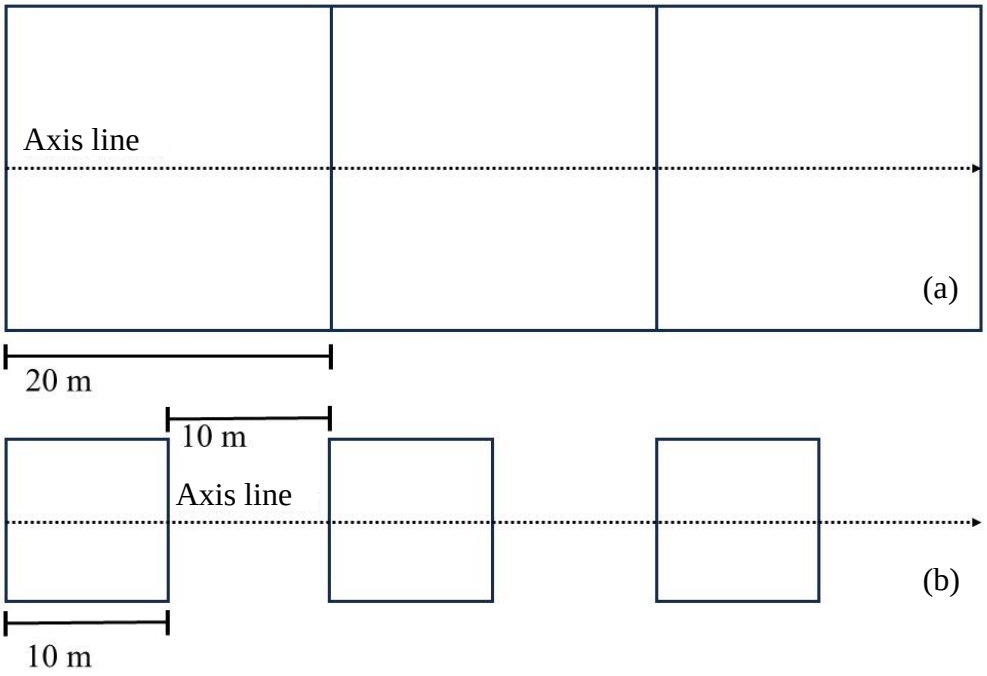


Figure 2. Illustration of data collection methods for flora analysis in: (a) coastal forests and (b) mangrove forests.

Fisheries data was obtained by conducting surveys of fishermen directly in the field and also conducting interviews with representatives of fishing groups. Information related to fisheries is also obtained by conducting surveys at fish landing ports. In addition, data completeness was carried out using secondary data from previous research (journals and other publications) as well as from related agencies (Anambas Islands Regency Fisheries, Agriculture and Food Service).

Analysis of flora data is calculated using the Important Value Index. This index is used to determine species composition and the dominance of a species in a stand. In order to obtain the Important Value Index value, the equation used according to Soerianegara and Indrawan (2002) is as follows:

$$K = \sum \frac{n}{L} \quad (1)$$

$$F = \sum \frac{p}{P} \quad (2)$$

$$D = \sum \frac{lbds}{L} \quad (3)$$

where K is the population density (ind/ha), n is the number of individuals of a species, L is the area of sample plots, F is the frequency of encounters, p is the number of plots found for a species, P is the total number of plots, lbds is the basal area of a species, and D is the dominance of a species. The formula for getting lbds is to use the principle of the circle equation using the dimensions of an individual tree, namely:

$$lbds = \frac{1}{4}\pi d^2 \quad (4)$$

where d is the diameter of an individual tree as a result of field measurements. Analysis was also carried out to obtain the dominance index (C) value. This index is used to determine the dominance of species in a community to determine where dominance is concentrated (Soerianegara and Indrawan 2002). The dominance index is determined using the following equation:

$$C = \sum \left(\frac{N_i}{N}\right)^2 \quad (5)$$

where C is the dominance index, Ni is the Important Value Index for each species, and N is the total Important Value Index for all species.

Analysis of fisheries data is grouped based on fishery type. This grouping is intended to make it easier to see the significance of forests for fisheries.

RESULTS AND DISCUSSION

Results

The type of flora that grows in coastal forests is a lowland forest type characterized by hard woody plants without supporting roots (Figure 3). Meanwhile, in some locations, mangroves can still grow with mangrove types that can survive on rocky beaches with sandy mud or rocky mud substrates (Figure 4). These two types of forests are found on the coast of the Anambas Islands and can represent any type of coastal flora that can characterize the Anambas ecoregion.

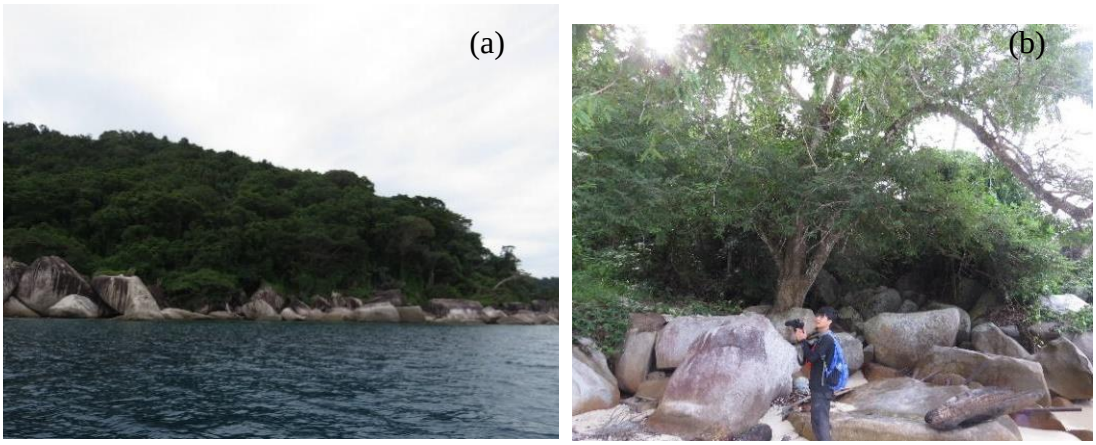


Figure 3. Rocky coastal forest ecosystem types. (a) Semut Island, (b) Siantan Island.

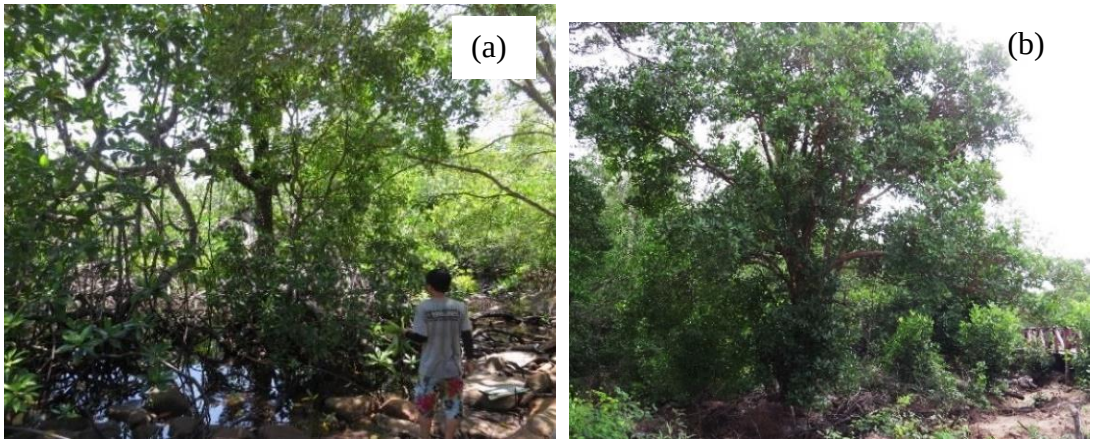


Figure 4. Mangrove forests growing on the north side of the Anambas Islands. (a) Keramut Island, (b) Matak Island

Substrate data collection was carried out by recording the type of substrate at each sample location. This data is used to display the location of vegetation growth at the study location. The substrate types and beach types that have been observed at each sample location are shown in Table 2.

Beach flora is found on the northern coast of the Anambas Islands, namely Pahat Island, Semut Island, Telaga Kecil Island, Lingai Island, Siantan Island, Keramut Island and Jemaja Island. Compared to mangrove vegetation, coastal flora is relatively more common on the north coast of the Anambas Islands. Below in Table 3 is a list of species found at the study location in the coastal ecosystem at the study location on the northern coast of the Anambas Islands. Exploration carried out in coastal forests is to identify species from seedling to tree level in order to illustrate the diversity of species in the Anambas Islands.

Table 4 presents the species composition and Important Value Index level of trees generally found on the northern coast of the Anambas Islands.

Table 2. Substrate and beach type for each sample location

Location code	Location name	Substrate	Beach type
P01	Pahat Island	Sand	Rocky sand beach
P02	Semut Island	Sand	Rocky beach
P03	Telaga Kecil Island	Sand	Rocky sand beach
P04	Lingai Island	Sand	Sand beach
P05	Siantan Island	Sand	Rocky beach
P06	Keramut Island	Sand	Sand beach
P07	Jemaja Island	Sand	Sand beach
M01	Matak Island	Sandy mud	Rocky mud beach
M02	Keramut Island	Sandy mud	Muddy stone beach

Source: Field Survey, 2020

Table 3. List of coastal ecosystem plant types at the study location

No	Species	Family
1	*Guettarda speciosa*	Rubiaceae
2	*Pongamia pinnata*	Fabaceae
3	*Derris trifoliata*	Fabaceae
4	*Terminalia catappa*	Combretaceae
5	*Pandanus tectorius*	Pandanaceae
6	*Ochrosia oppositifolia*	Apocynaceae
7	*Ipomea pes-caprae*	Convolvulaceae
8	*Scaevola taccada*	Goodeniaceae
9	*Melastoma candidum*	Melastomataceae
10	*Thespesia populnea*	Malvaceae
11	*Milletia pinnata*	Fabaceae
12	*Heritiera littoralis*	Malvaceae
13	*Macaraga sp.*	Euphorbiaceae
14	*Ficus hipsida*	Moraceae
15	*Cocos nucifera*	Arecaceae
16	*Carbera manghas*	Apocynaceae
17	*Calophyllum inophyllum*	Clusiaceae
18	*Artocarpus heterophyllus*	Moraceae
19	*Ficus caulocarpa*	Moraceae
20	*Baringtonia asiatica*	Lecythidaceae
21	*Mangifera indica*	Anacardiaceae
22	*Caesalpinia sappan*	Fabaceae
23	*Cathormion umbrellatum*	Fabaceae

Source: Field Survey and Data Analysis (2020)

Table 4. Composition and Important Value Index of each type of tree-level coastal flora at the study location

Location	Number	Species	Family	Important Value Index
Pahat Island	1	*Cocos nucifera*	Arecaceae	205.50
	2	*Terminalia catappa*	Combretaceae	30.40
	3	*Carbera manghas*	Apocynaceae	33.25
	4	*Heritiera littoralis*	Sterculiaceae	30.85
	Total			300,00
Semut Island	1	*Terminalia catappa*	Combretaceae	95.14
	2	*Thespesia populnea*	Malvaceae	32.29
	3	*Cocos nucifera*	Arecaceae	137.90
	4	*Pongamia pinnata*	Fabaceae	34.67
	Total			300.00
Telaga Kecil Island	1	*Terminalia catappa*	Combretaceae	194.65
	2	*Pongamia pinnata*	Fabaceae	105.35
	Total			300.00
Lingai Island	1	*Terminalia catappa*	Combretaceae	115.52
	2	*Baringtonia asiatica*	Lecythidaceae	79.47
	3	*Calophyllum inophyllum*	Clusiaceae	42.29
	4	*Pongamia pinnata*	Fabaceae	62.73
	Total			300.00
Siantan Island	1	*Cocos nucifera*	Arecaceae	136.95
	2	*Caesalpinia sappan*	Fabaceae	47.40
	3	*Calophyllum inophyllum*	Clusiaceae	68.26
	4	*Artocarpus heterophyllus*	Moraceae	47.40
	Total			300.00
Keramut Island	1	*Ficus caulocarpa*	Moraceae	175.48
	2	*Terminalia catappa*	Combretaceae	71.89
	3	*Cocos nucifera*	Arecaceae	52.63
	Total			300.00
Jemaja Island	1	*Terminalia catappa*	Combretaceae	39.27
	2	*Baringtonia asiatica*	Lecythidaceae	12.28
	3	*Thespesia populnea*	Malvaceae	13.21
	4	*Ficus caulocarpa*	Moraceae	24.53
	5	*Cerbera indica*	Apocynaceae	12.13
	6	*Cocos nucifera*	Arecaceae	12.31
	7	*Arthocarphus heterophyllus*	Moraceae	30.61
	8	*Caesalpinia sappan*	Fabaceae	71.03
	9	*Cathormion umbrellatum*	Fabaceae	84.64
	Total			300.00

Source: Data Analysis (2020)

The results of flora analysis carried out on the northern part of the coast of the Anambas Islands, and carried out on nine islands, mangrove ecosystems were only found on two islands, namely Matak Island and Keramut Island. Table 5 presents the types of mangroves found in the mangrove forest ecosystem on the two islands. Fishing data and feeding behavior are shown in Table 6.

Discussion

General Conditions of the Study Location

In general, based on the results of flora analysis, the Anambas Islands ecoregion has terrestrial flora cover in the form of mangrove forest and beach forest flora. This area is an unstable area because it is strongly influenced by wave and current conditions. In the north wind season, waves will directly hit the coastal area, causing erosion. This condition is caused by the relatively steep morphology of the seabed around the coastal waters. So the rocky and sandy coastlines that are formed tend to be more stable than muddy coastlines. These naturally occurring natural processes occur gradually over a period of time (Budiono and Latuputty 2013). The initial succession process of coastal forests can still be seen in several locations, with the massive growth of pioneer plants such as crown flower (*Calatropis gigantea*).

Table 5. Composition of mangrove species at tree level on the north coast of Matak Island and Keramut Island, Anambas Islands

Location	Number	Species	Family
Matak Island	1	*Xylocarpus granatum*	Meliaceae
	2	*Ceriops tagal*	Rhizophoraceae
	3	*Bruguiera gymnorrhiza*	Rhizophoraceae
	4	*Rhizophora stylosa*	Rhizophoraceae
	5	*Scyphiphora hydrophyllaceae*	Rubiaceae
Keramut Island	1	*Rizophora stylosa*	Rhizophoraceae
	2	*Rhizhophora mucronata*	Rhizophoraceae
	3	*Bruguiera gymnorrhiza*	Rhizophoraceae
	4	*Avicennia alba*	Avicenniaceae

Source: Field Survey and Data Analysis (2020)

Table 6. Identified fish and their feeding behavior

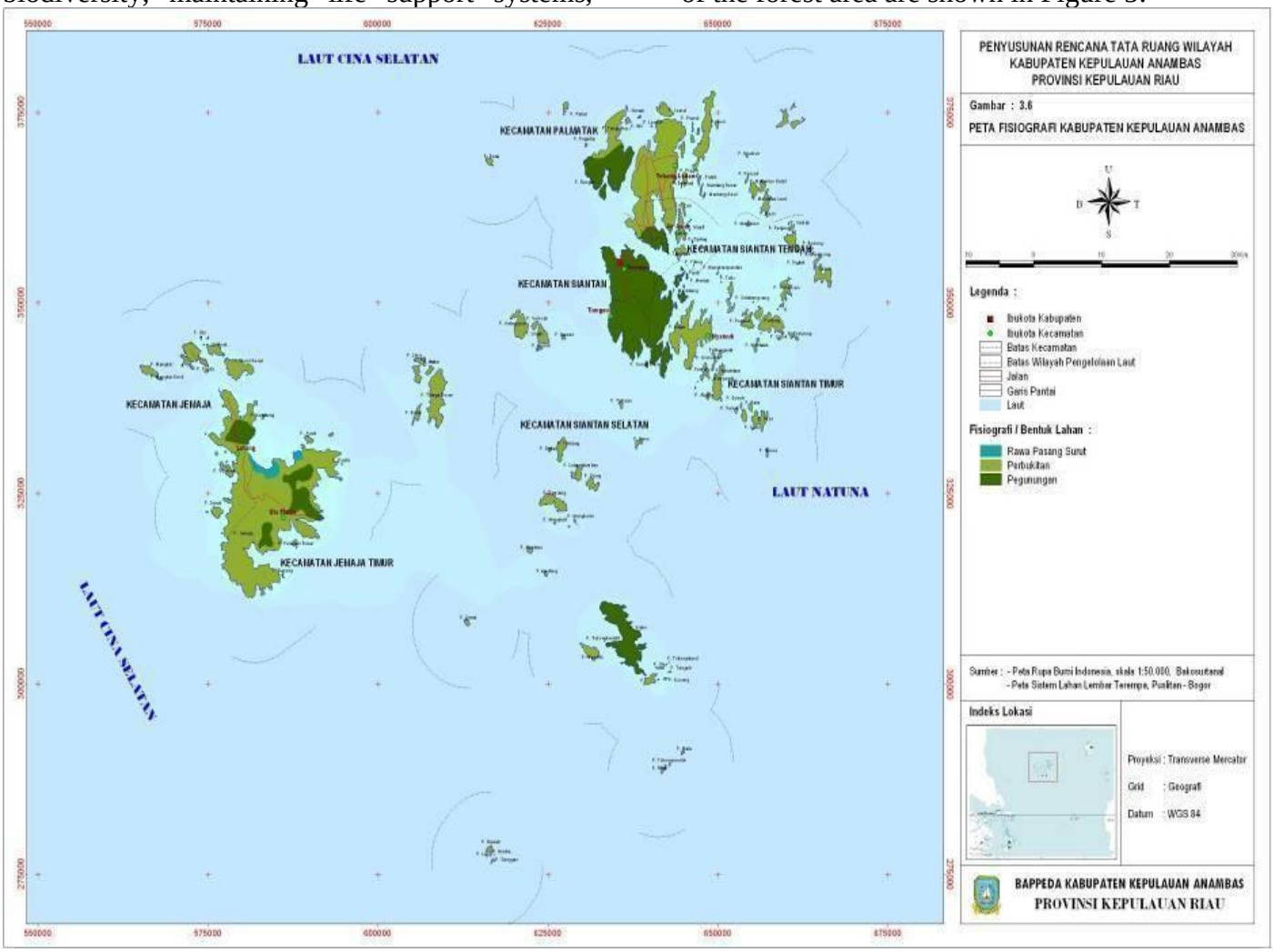
Group of fish	Species	Eating behavior	References
Large pelagic fish	Mackerel tuna (*Euthynnus affinis*)	Eat small fish, shrimp and shellfish	Lelono dan Bintoro (2019)
	Skipjack tuna (*Katsuwonus pelamis*)	Eat everything (not picky)	Susaniati et al Pemakan pelagis kecil. (2019)
	Narrow-barred Spanish mackerel (*Scomberomorus commerson*)	Eat small pelagic	Rajesh *et al.* (2017)
	Frigate tuna (*Auxis thazard*)	Eat fish	Agustina *et al.* (2023)
	Longtail tuna (*Thunnus tonggol*)	Eat anchovy, shrimp and squid	Risti *et al.* (2019)
Small pelagic fish	Northern mackerel scad (*Decapterus russelli*)	Eat shrimp and crab	Poojary *et al.* (2010)
	Indian mackerel (*Rastreliger kanagurta*)	Eat plankton	Bhendarkar *et al.* (2014)
	Herrings (*Sardinella* spp.)	Eat plankton	Pertami *et al.* (2014)
	Trevally fish (*Caranx* spp.)	Eat small fish and shrimp	Maherung *et al.* (2018)
	Herrings (*Clupea* spp.)	Eat plankton	Sulistiono *et al.* (2010)
Demersal fish	Bombay duck (*Harpodon nehereus*)	Eat Acetes shrimp	Ghosh (2012)
	Marine ray-finned (*Nemipterus* spp.)	Eat shrimp, crabs and fish	Sjafei dan Robiani (2001)
	Snappers (Lutjanidae)	Eat fish and crabs	Prihatiningsih *et al.* (2017)
	Trevallies (*Carangoides* spp.)	Eat fish and plankton	Honebrink (2000)
	Threadfin (Polynemidae)	Eat small fish and shrimp	Pane *et al.* (2020)
	Spotted scat (*Scathophagus argus*)	Omnivorous (majority of detritus and algae)	Allen dan Erdmann (2012)
Coral fish	Blackspot emperor (*Lethrinus harax*)	Eat shrimp, fish, crabs and squid	Tampi *et al.* (2023)
	Checkered snapper (*Lutjanus decussatus*)	Eat crabs, shrimp, fish, lobsters, detritus	Rapi *et al.* (2022)

Forest areas are certain areas in the form of forests or non-forests, which are designated and/or

determined by the government to be maintained as permanent forests. This is to ensure legal certainty regarding the status of forest areas, the location of the boundaries and the area of a particular area that has been designated as a permanent forest area. The designation of a forest area also includes the designation of a water conservation area whose area is calculated within the forest area. This is based on all conservation areas, including Nature Reserve Areas, Nature Conservation Areas, and Buru Park as a whole, including forest areas. However, in practice in the field, forest areas that have a physical sea form are managed by the Ministry or Forestry Service in collaboration with the Ministry or Maritime Service.

Forest is an expanse of land with a minimum area of 0.25 ha which contains natural units with biotic and abiotic components in them with physical dominance in the form of trees and their natural associations. The existence of forests in an ecosystem is important because forests can perform various functions, including protecting biodiversity, maintaining life support systems, recreation, and providing other benefits both directly and indirectly. Therefore, the existence of forests in an ecosystem is very important for the balance of the ecosystem. Especially if an ecosystem is connected to a water system such as watershed. So the existence of good forests will greatly influence the quality of the coastal and marine environment in one ecoregional unit.

Based on references found in the Anambas Regency area, no forest areas were found. However, physically there are primary forests, both coastal forests, lowland forests and mangrove forests. In this study, the focus of forest studies is on the mangrove forests and coastal forests located at the location. This is based on a study of basic environmental baseline data to describe coastal conditions on the islands of Anambas Islands Regency. In general, physiographic conditions can provide predictions of forests in the study area. It can be seen that tidal swamps are usually occupied by mangrove forests, the rest can be coastal forests or lowland forests. The physiographic conditions of the forest area are shown in Figure 5.



Source: BAPPEDA Anambas Islands District (2014)

Figure 5. Map of physiographic conditions of Anambas Islands Regency.

Mangrove exploration was carried out in two locations, namely on Matak Island and on Keramut Island. These two locations are mangrove locations on the north side of the Anambas Islands group. This is done because these two locations are locations that directly face the North Natuna Sea (South China Sea), where the northern side of the Anambas Islands group is the closest area to the border with other countries and is also close to international sea transportation routes. So if one day an accident occurs on this mode of international sea transportation, this area will automatically be the first to be affected. This is the basis for choosing a location only on the north side of the Anambas Islands.

In general, the two locations where mangrove exploration was carried out had clusters of mangrove formations that were not intact. Figure 6 shows a general illustration of a group of mangrove formations that are still intact. The mangrove formations formed at the study location have colonies that are not too thick with a relatively short coastline coverage area. This happens because the study area is located around a bay which has a substrate in the form of a sandy and slightly muddy beach. Apart from that, in general mangroves grow in bays or estuaries which are protected from the open sea. So it will not be directly hit by waves during the north/west wind season. Meanwhile, the beaches in the Anambas Islands group are generally coastal forests, both sandy and rocky beaches (Figure 7).

Mangroves that grow on the north side of the Anambas Islands group have a narrow distribution (Figure 8). The lack of suitable substrate for mangrove growth means that the dynamics of the coastline on the north side tends to be more stable than the dynamics of the coastline in mangrove forested areas. Cita and Budiman (2019) have proven that dense mangrove forests will have higher diversity. It has been proven that mangrove formations are more complete in thick mangrove forests. Apart from that, the age class of mangroves also greatly influences the biodiversity that lives in them (Cita and Budiman 2019). The mangrove study map is shown in Figure 9.

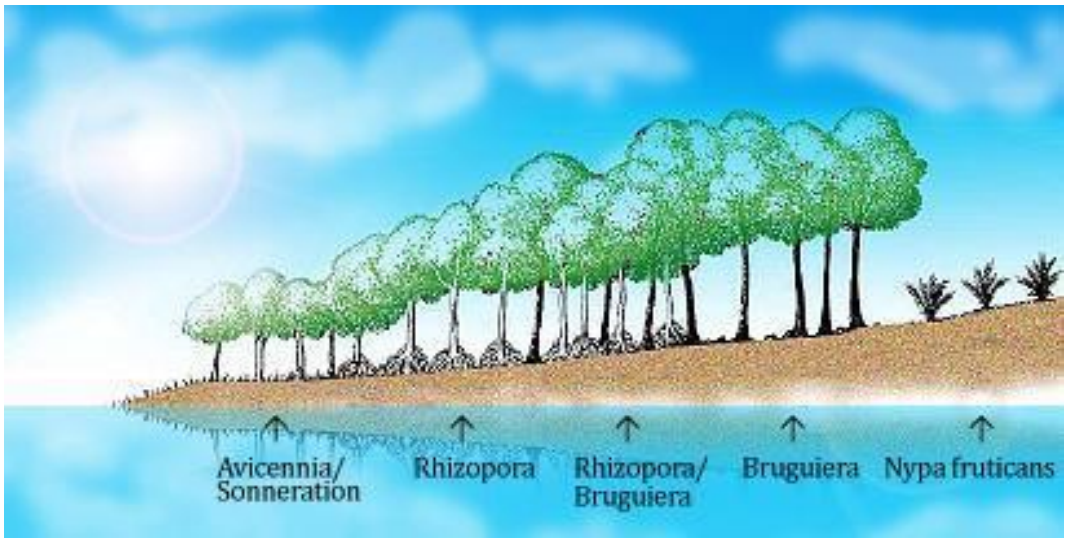


Figure 6. One type of mangrove forest zoning in Indonesia (Bengen 2004).

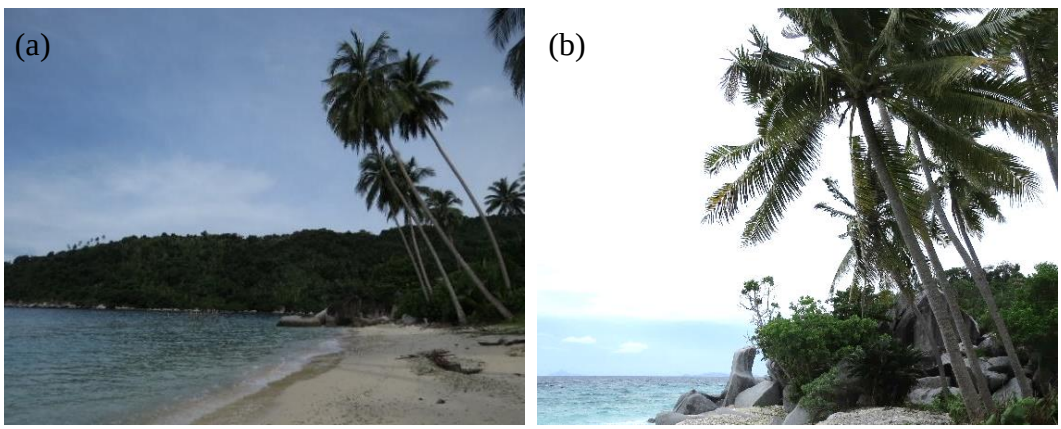


Figure 7. General condition of beaches in the Anambas Islands. (a) Sandy beach, or (b) Rocky beach.

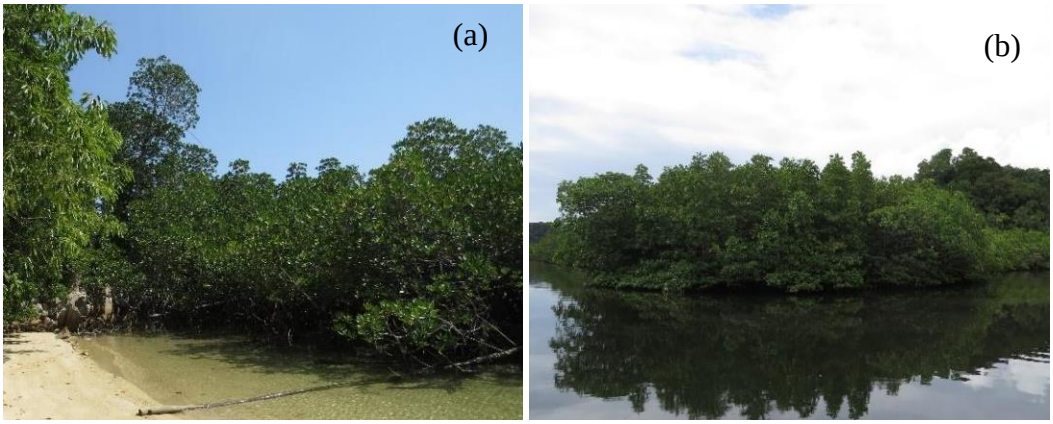
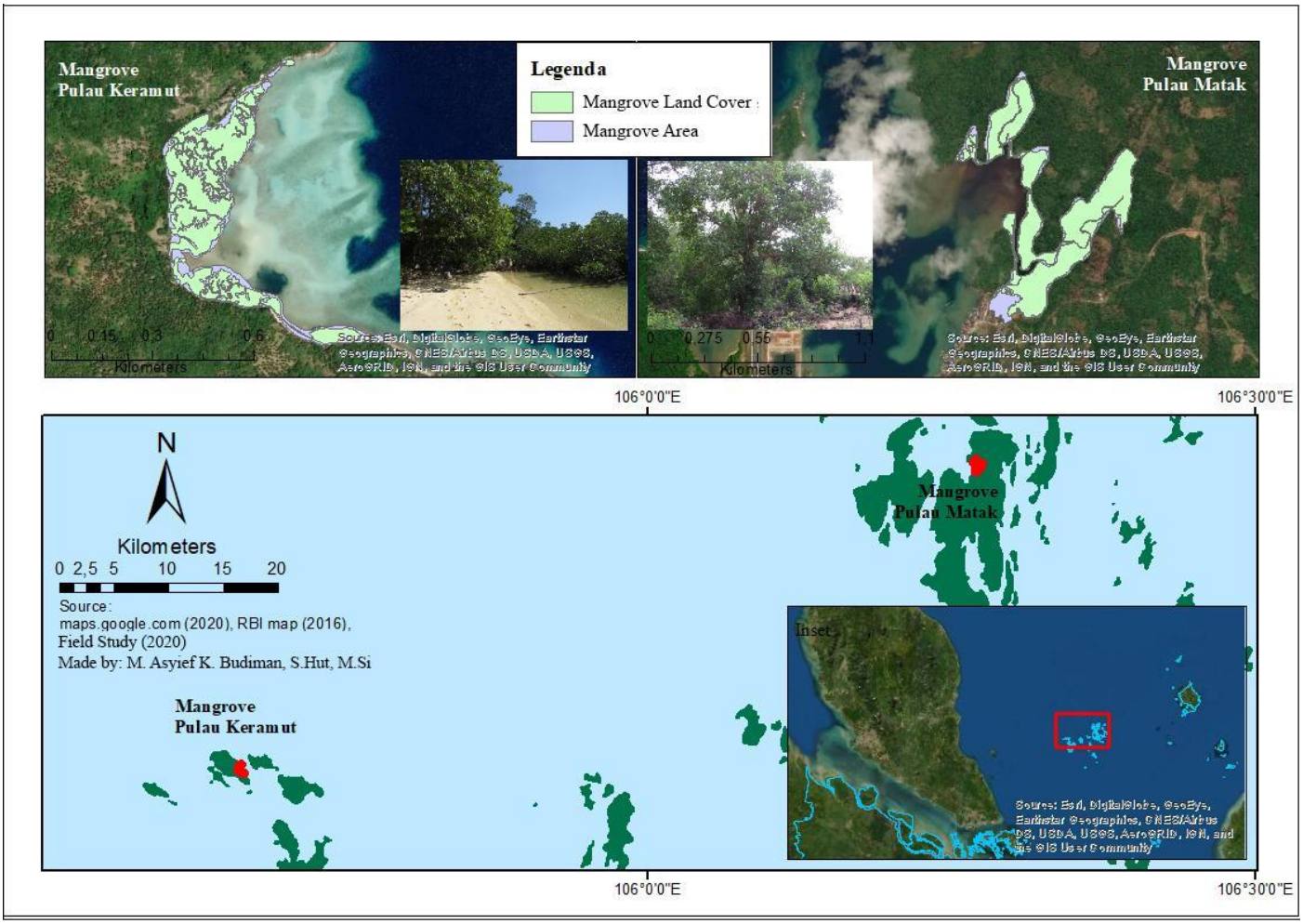


Figure 8. Condition of mangroves at the study location. (a) Keramut Island, (b) Matak Island



Source: Field Survey and Data Analysis (2020)

Figure 9. Map of Mangrove study locations.

Forest Ecosystem

Based on the survey conducted, it is known that several types of tree-level coastal flora dominate the study location, including: *Cocos nucifera*, *Terminalia catappa*, *Ficus caulocarpa*, *Caesalpinia sappan*, and *Cathomion umbrellatum*. In general, the families that dominate and are often found in the northern coastal area of each island that is the study location in the Anambas Islands, include family Arecaceae, Combretaceae, Fabaceae, dan Moraceae. The types of this family are thought to be adaptive types that are able to grow in the study location, which has characteristics ranging from sandy to rocky beaches. The existence of coastal flora is very important for the stability of the coastal ecosystem, because of its very important role. The role of coastal flora indirectly influences the biota in the sea. Flora that functions as producers (food sources) and habitat for other living creatures such as birds or mammals is at the beginning of the predation chain. Furthermore, land fauna that lives

or uses coastal flora will play a role in fisheries resources, especially in the carbon cycle. Coastal forests also play a direct role in marine biota such as sea turtles (Cheloniidae) as nesting areas (Roemantyo *et al*. 2012). Another role of flora is in the life support system around the coast, such as controlling erosion or coastal abrasion.

Mangroves can refer to a form of forest ecosystem or individual plants that grow in brackish areas and are affected by tides. Dahuri (2003) states that mangroves are a type of forest typical of tropical and subtropical areas that grow along beaches or estuaries, and are influenced by the tides. Soerianegara (1987) stated that there are several types of mangroves that can be found growing in a mangrove forest ecosystem, including *Avicennia spp.*, *Rhizhopora sp.*, *Bruguiera sp.*, *Ceriops sp.*, *Xylocarpus sp.*, *Scyphyphora sp.*, *Lumnitzera sp.*, *Sonneratia sp.*, and *Nypa sp*. In general, mangroves are found in coastal areas that are protected from waves (Pramudji 2001).

On the north coast of the Anambas Islands, especially on Matak Island and Keramut Island, several types of mangroves from three families are found, namely Meliaceae, Rhizophoraceae, Rubiaceae and Avicenniaceae. Based on the species, the mangroves found consist of several species, namely *Xylocarpus granatum*, *Ceriops tagal*, *Bruguiera gymnorrhiza*, *Rhizophora stylosa*, *R. mucronata*, *Scyphiphora hydrophyllaceae*, and *Avicennia alba*. One of the parameters considered in the study of flora composition and structure is the Important Value Index. Important Value Index is one of the parameters that determines the dominance of a species (Kusmana 2017). Figure 10 presents the Important Value Index values for each type of mangrove at tree level on Matak Island.

Rhizophora stylosa and *Xylocarpus granatum* are species of mangrove that have the highest Important Value Index in the mangrove community on Matak Island. This indicates that these two species are the most dominant types in this location. Apart from that, there are also *Scyphipora hydrophyllaceae* which is relatively common in this location. The Important Value Index values for each type of mangrove at tree level on Keramut Island are presented in Figure 11.

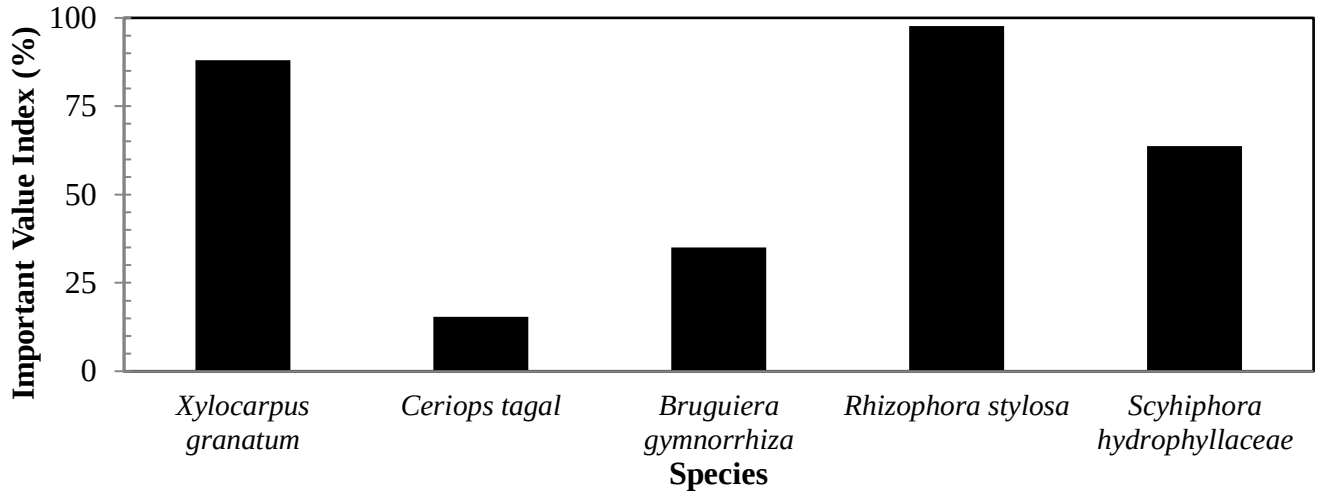


Figure 10. Importance index of mangrove species at tree level on the north coast of Matak Island

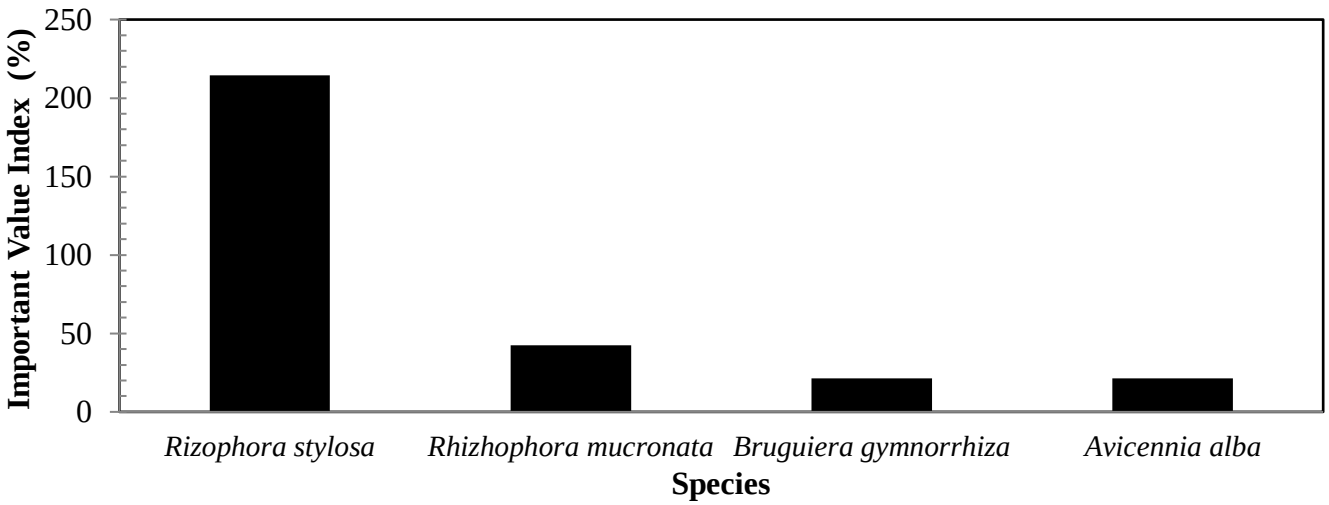


Figure 11. Importance index of mangrove species at tree level on the north coast of Keramut Island

In Keramut Island, the most dominant species of mangrove are *Rhizophora stylosa* and then *Rhizhophora mucronata*. In general, *Rhizhopora stylosa* is often found on Matak Island and Keramut Island, and relatively dominates the mangrove communities on the north coast of these two islands. Data collected by Christian *et al.* (2019) also showed the influence of the presence of mangrove forests on coastline dynamics. The existence of these mangroves functions as a natural trap for sedimentary material which allows soil to emerge. As at Ujung Pangkah Beach, which is on the north coast of Gresik Regency, it is experiencing quite fast dynamics. This condition is because mangrove forested areas have experienced a significant increase in area, however, areas where mangrove forests have been lost and cut down have experienced quite severe coastal erosion (Christian *et al.* 2019). The dynamics of the coastline cannot be separated from physical environmental factors such as substrate (beach type), amount of sedimentation material, direction of sea waves, tides and also the presence of mangrove forests. Considering the conditions in Ujung Pangkah, which has a muddy beach, it will be very different from the conditions in the Anambas Islands. Because, in this group of islands, most of the beaches are rocky or sandy. So only a few mangroves were found.

Significance of Forest Ecosystems in Fisheries

In general, the fish found in the study location are offshore water resources consisting of pelagic, demersal/coral fish groups, as well as several types of shrimp and molluscs. Based on data from the Department of Fisheries, Agriculture and Food, Anambas Islands Regency (2019), supported by the results of interviews and surveys of fish landing ports, several types of fish resources caught by fishermen identified include:

1. Large pelagic fish consists of Mackerel tuna (*Euthynnus affinis*), Skipjack tuna (*Katsuwonus pelamis*), Narrow-barred Spanish mackerel (*Scomberomorus commerson*), Frigate tuna (*Auxis thazard*), and Longtail tuna (*Thunnus tonggol*).
2. Small pelagic fish consists of northern mackerel scad (*Decapterus russelli*), indian mackerel (*Rastrelliger kanagurta*), herrings (*Sardinella spp*.), trevallies (*Caranx spp*.), dan herrings (*Clupea spp*).
3. Demersal fish consists of bombay duck (*Harpodon nehereus*), marine ray-finned (*Nemipterus spp*.), snappers (Lutjanidae), trevallies (*Carangoides spp*.), threadfin (Polynemidae), and spotted scat (*Scathophagus argus*).
4. Coral fish consists of blackspot emperor (*Lethrinus harax*), and checkered snapper (*Lutjanus decussatus*).
5. Shrimp species identified are giant tiger prawn, cat prawn, dan white shrimp. Meanwhile, species of mollusks include squid.

All types of fish have a symbiotic relationship directly or indirectly (multilevel). This is related to the dynamics of the ecosystem where several fish species migrate to mangroves or reproduce. Adult fish can leave the mangrove and then become prey for carnivorous fish. This symbiosis runs and the dynamics in the aquatic ecosystem will be maintained.

The role of forests on the coast of the Anambas Islands is very large in fisheries, especially for fish around the coast. Moreover, mangrove forests also play a role in maintaining the stability of ecosystems on coral reefs. The role of mangroves in relation to coral reefs is to protect coastlines, provide adequate nutrition for coral reef associations, and provide conditions for balance in biological cycles. Another role produced is in several mangrove species such as *Rhizophora sp*., *Avicennia sp*., and *Sonneratia sp*. along with forest conditions provide benefits for the spawning of marine biota larvae. Another important thing is the provision of fish spawning, spawning and rearing places for fish and shrimp. Fish and shrimp in mangroves also take advantage to protect themselves from prey. Among the fish that live in mangroves are fish with high economic value (Karimah, 2017).

Lokbere *et al.* (2019) explained that there are fish species in mangrove areas that function as eaters of crustaceans, mollusks, polychaetes and small fish. Apart from that, several species of fish when they are still juveniles prefer to consume crustaceans and small fish rather than other food. However, when they grow up they become piscivorous. There are also fish that are categorized as omnivores or all-eaters. The observation results compare the type data with data from previous research literature on fisheries. The identified species are tabulated and then their eating behavior (food habits) is identified by comparing with previous research.

According to Doll (2013), the factors that usually influence the determination of feed include::

1. Availability, this factor can be said to be the main factor in selecting feed resources,
2. Accessibility or convenience, foraging behavior is also related to the ease of accessing food resources,
3. Palability, this will determine the fish's preferences in choosing food that suits their tastes.

In mangrove areas there are also many invertebrate associations that function as prey for predatory fish. Boneka and Laleleh (2010) have shown that the fish commonly caught by fishermen around the coast usually eat invertebrates, mollusks, crustaceans and polychaetes. This has been proven by surgery on fish where the largest food in the fish's stomach is biota which generally comes from mangrove areas. The relationship between these components is reflected in the association between components, so maintaining the forest in Anambas will help balance fisheries stocks.

CONCLUSION

The Anambas Islands ecoregion has two types of ecosystems, namely coastal forest ecosystems and mangrove forests. 23 types of flora were found in the coastal forest dominated by five types of flora. Seven types of mangroves were found and dominated by *Rhizhopora stylosa*. The existence of these forests both beach and mangrove greatly help the existence of fishery resources in the Anambas Islands, for example, as spawning areas of fish. Several species were found that can support life in the future in the Anambas Islands ecoregion, such as various types of pelagic fish. The presentation of this general condition can be used as a database that can be used as a reference in sustainable landscape management. The relationship between these components is reflected in the association between components so that maintaining the forest in Anambas will help balance fishery stocks.

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