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# High Diversity of Mangrove Ecosystem on the North Coast of Bangkalan, East Java, Indonesia

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## ABSTRACT

Mangrove ecosystems play an important role in supporting the preservation of coastal resources and providing ecosystem services for coastal and marine communities in coastal areas. Given the role of mangroves, this study was conducted to know the composition of mangrove species and the health condition of mangrove forests based on community structure, species diversity, and mangrove canopy cover on the North Coast of Bangkalan Regency, Indonesia. Due to the lack of supporting literature on the health of mangroves along the north coast of Bangkalan, this study was conducted in that location. The assessment of the mangrove ecosystem's condition was carried out by analyzing the critical value index, which includes parameters such as frequency, dominance, and density within the mangrove population. The sampling method was employed to gather the necessary data for this analysis. The mangrove species sampling method used a 10 x 10m squared transect with three transects at each of the fourteen stations. The canopy cover was taken using the hemispherical photography method. The results showed that the composition of mangrove species on the north coast of Bangkalan Regency consisted of 17 species and ten genera. The results indicated that the mangrove ecosystem along the north coast of Bangkalan Regency is in good condition and exhibits low vulnerability to degradation.

## INTRODUCTION

Indonesia is a country with the largest mangrove ecosystem area in the world. Based on the National Mangrove Map released by the Ministry of Environment and Forestry in 2021, Indonesia's total mangrove area reaches 3,364,076 ha or equivalent to 20.37% of the total mangrove forest area in the world. The distribution of mangrove in Indonesia is influenced by the geographical position in the tropics and the length of the Indonesian coastline, designated as the second longest coastline in the world **(Puryono, 2018)**. This is the leading supporter of mangroves growing well and can be found not only on large islands but also on small islands in Indonesia.

Mangroves have high productivity and decomposition of organic matter compared to other ecosystems, making them an essential ecological link for the life of living things around them **(Imran, 2016)**. Mangroves support the survival of marine life by acting as a

producer of nutrients and a nursery ground for marine life that has economic value, such as shrimp, fish, and shellfish **(Ajai & Chauhan, 2017)**. A robust mangrove root system can be a barrier to coastal abrasion, reducing waves. Mangroves also act as carbon sinks in the atmosphere and are stored in sediments and organic waste processors **(Hermon *et al.*, 2018)**. Mangroves also have aesthetic value that can be utilized as educational and recreational ecotourism areas **(Hutchison *et al.*, 2014)**. The functionality of mangrove ecosystems is related to the structure of stands and the quality of mangroves as providers of ecosystem services and high economic value. Apart from their enormous ecological and socio-economic functions, mangrove ecosystems are highly sensitive to change and are undoubtedly at risk due to extreme climate change, land conversion into settlements and ponds, excessive exploitation of mangrove resources, pollution, and various other land use activities. These factors contribute to habitat destruction, biodiversity loss, and a decline in marine resources. Persistent environmental pressures can lead to rapid degradation of mangrove ecosystems. This condition makes it essential to assess the condition of mangrove ecosystem communities **(Schmitt & Duke, 2015)**.

Assessment of the health condition of mangrove ecosystems is carried out to determine the condition of mangroves and to become one of the efforts to maintain their function and sustainability. There is no specific method for assessing mangrove conditions because mangroves have many unique characteristics that make various methods inappropriate in some categories of mangroves in an area. The comprehensive assessment is determined from the complex and integrated interaction of factors at the ecosystem level to be the right indicator to reflect a good, actual health status **(Faridah-Hanum *et al.*, 2019)**. This assessment can be done by calculating the important value index and community structure and measuring the percent of mangrove canopy cover.

The study site located in Bangkalan Regency has a total mangrove forest area of 1,508.1 Ha **(Muhsoni, 2014)**. Bangkalan Regency is known to have mangrove forests in poor condition reaching an area of 1,200.2 Ha or 66.3% of the total land area **(Iqbal *et al.*, 2014)**; degradation can occur due to land use change for settlements, shrimp ponds, and salt ponds, and a decrease in the quality of mangrove forests due to plastic waste that fills mangrove forest areas. This condition makes Bangkalan Regency chosen as a study location, especially in the northern coastal area. Therefore, this study was conducted to determine the condition of mangrove ecosystem communities on the north coast of Bangkalan. This study would enrich information about the species composition and health of mangrove in Bangkalan, especially in areas along the north coast of Bangkalan Regency.

## MATERIALS AND METHODS

### 1. Study Area

This study was conducted along the north coast of Bangkalan Regency, East Java Province. The time for data collection in the field was from September to November 2022. The data collection location was divided into 14 stations in detail located in 6 districts: Kamal, Socah, Bangkalan, Arosbaya, Sepulu, and Tanjungbumi Districts. A

map of the data retrieval location can be seen in Fig. (1). The tools and materials used in this study were Global Positioning System (GPS), roller meter, raffia rope, camera, scissors, stationery, sewing meter, and mangrove identification book.

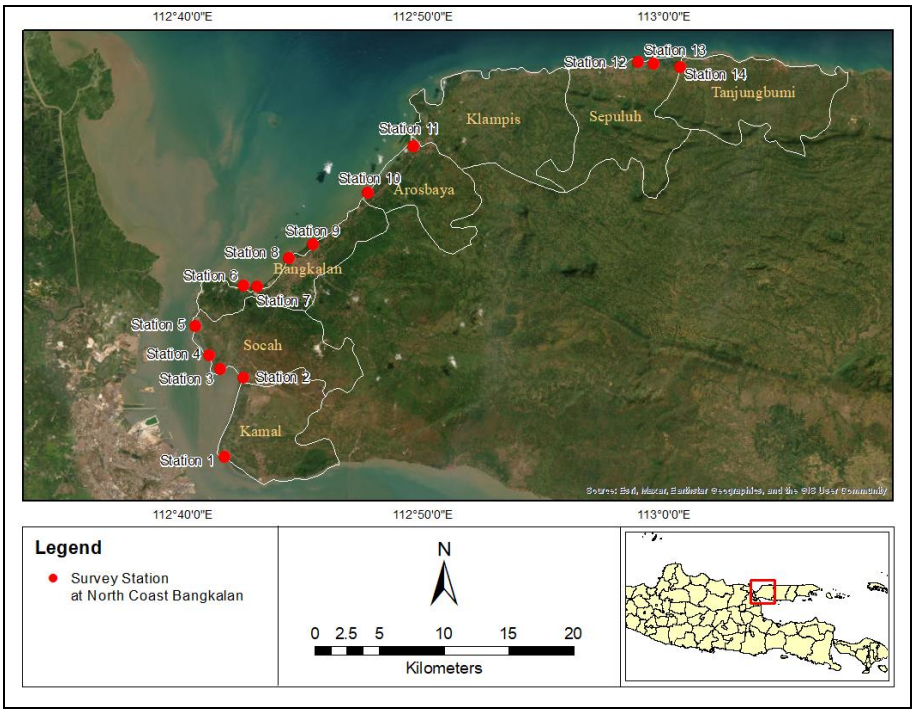


**Fig. 1.** Mangrove study location in the north coast of Bangkalan, Indonesia

## 2. Sampling

Study on the condition of mangrove communities includes mangrove identification, calculation of important value index, community structure, and percent canopy cover. Data collection of type identification, important value index, and community structure using plot method or square measuring 10x10m$^2$ were conducted at 14 study stations with each station consisting of three plots (squares) so that there are as many as 42 study plots. Mangroves were identified by looking at the general characteristics or characteristics of tree shapes, roots, leaves, flowers, and fruits. Moreover, they were identified using references from books or literature on mangrove species. Data collection on the importance value index and community structure involved measuring the circumference of the tree trunk at chest height using a sewing meter. Trees with a trunk diameter of at least 16cm were analyzed.

Data collection of percent mangrove canopy cover was conducted using the hemispherical photography method (**Bianchi *et al.*, 2017**). This data was carried out using the phone's front camera, which is directed perpendicular to the sky. Five photos were taken in each plot, hence 210 photo samples were obtained. The method of taking pictures and determining the point of taking photos follows the guidelines in **Dharmawan and Pramudji (2014)**. Photos were analyzed using ImageJ software to determine the number of pixels in the photo that represent the canopy. The hemispherical

photography method analyzes the separation of white sky pixels and black mangrove vegetation pixels **(Dharmawan & Widyastuti, 2017)**. Taking photos with this method must meet the terms and conditions with several things that need to be avoided, including avoiding taking multiple photos, shooting next to tree trunks, and avoiding photos from the sun **(Febriyanto & Suryanti, 2019)**.

## 3. Analysis

The calculation of the importance value index and structure of mangrove communities followed the equations of **Bengen (2004)**, as follows:

### *3.1 Relative density (RDi)*

The relative density of the type is the ratio between the number of i stand types and the total stands of all types. The relative density of the type is calculated using the equation:

$$RDi=\left[\frac{ni}{\Sigma n}\right]x100$$

Ni = number of individual of the species
Σn = total number of stands of all the species

### *3.2 Relative frequency (RFi)*

The relative frequency of a type is the ratio between the frequency of type i and the sum of the frequencies of all types.

$$RFi=\left[\frac{Fi}{\Sigma F}\right]x100$$

Fi = number of occurrence of the species
ΣF = number of occurrence of all the species

### *3.3 Relative closure (RCi)*

The relative closure of the type is the ratio between the closure of type i and the total area of closure for all types.

$$RCi=\left[\frac{Ci}{\Sigma C}\right]x100$$

Ci = number of closure of the species
ΣC = number of closure of all the speciess

### *3.4 Importance value index (IVI)*

The important value index is the sum of relative density (RDi), relative frequency (RFi), and relative closure (RCi) that shows the dominance and role of each species in a community **(Abino *et al*., 2014)**. The importance index of a type ranges from 0 to 300.

$$IVI = RDi + RFi + RCi$$

RDi = Relative density
RFi = Relative frequency
RCi = Relative closure

### *3.5 Diversity index*

The calculation of the diversity index in mangroves uses the Shanon-Wiener equation. The diversity index calculates the number and distribution of species. The value of the diversity index shows that the greater the value of H', the greater the diversity of species, and vice versa **(Njana, 2020)**. Shannon-Wiener calculations use calculations:

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

H' = diversity index
S = number of species/species richness
Pi = fraction of the entire population

The Shannon-Wiener diversity index has a range of 0.0 to 4.6. The value describes the quality of a habitat. A value of 0.0 indicates that the diversity in the habitat is low, while a value of 4.6 means that the total distribution of each species is evenly distributed **(Zhila *et al.*, 2013)**.

### *3.6 Evenness index*

Evenness index is the spread of the number of individuals of each species by calculating the ratio of the diversity index value with maximum diversity. The evenness index describes the pattern of individual distribution of a species in the ecosystem,

$$J = \frac{H'}{H\ maks} = \frac{H'}{log 2s}$$

J = evennes index
H' = diversity index
H' maks= 3,3219 logS
S = number of species/species richness

The evenness index has a range between 0 and 1. If the index value is close to 0, it means evenness among species in a low community, reflecting that the number of individuals of each species is different or low evenness. Conversely, if the index value is close to 1, evenness between species is evenly distributed, and the number of individuals in each species is relatively the same or has high evenness **(Yunus *et al.*, 2020)**.

### *3.7 Simpson's dominance index*

The Simpson's dominance index is calculated to describe the most common species found in a mangrove ecosystem. Dominance can be expressed in terms of the Simpson dominance index using the equation:

$$C = \frac{N\,(N-1)}{\sum ni\ (ni-1)}$$

C = Simpson's index of dominance
Ni = number of individual of the species
N = number of individual of all the species

The Simpson's dominance index has a range between 0 and 1 with understanding that if the value is close to 0, then no species dominates in a community, indicating stable environmental conditions without any ecological pressure on a species. Conversely, if the index value is close to 1, a dominating species is found and ecological pressure occurs on the mangrove ecosystem community **(Singh, 2020)**.

### *3.8 Percentage canopy cover*

The percentage of mangrove canopy cover refers to C in the following binner image analysis **(Chianucci & Andrea, 2012)**:

$$C=\frac{P255}{Ptotal}x100\%$$

P255 = number of pixels that has a value of 255 as an interpretation of the mangrove canopy cover

Ptotal = total number of pixels

According to the Decree of the State Minister of Environment No. 201 of 2004, concerning the standard category of mangrove damage are divided into three categories, as shown in Table (1).

**Tabel 1.** Mangrove forest damage standard based on the Decree of the Minister of Environment No. 201 of 2004

| Category | | Coverage (%) | Density |
|---|---|---|---|
| Good | Dense | ≥75% | ≥1500 |
| | Moderate | 50-75% | 1000-1500 |
| Damaged | Rare | <50% | <1000 |

## RESULTS

### 1. Mangrove composition

The results showed that the composition of mangroves found in the study transects at fourteen stations identified a total of 17 species and 10 genera. The results of the study revealed that, across the fourteen sampled stations, a total of 17 species from 10 genera were identified in the mangrove composition. Among these species, *Rhizophora apiculata* was the most frequently encountered, recorded in twelve study transects, followed by *Rhizophora mucronat*a and *Sonneratia alba*, which were observed in eleven transects each. *Avicennia marina* was found in eight transects. Additionally, *Aegiceras corniculatum, Avicennia rumphiana, Avicennia officialis*, *Ceriops decandra, Xylocarpus granatum*, and *Xylorcarpus molucensis* were each observed at one station.

**Table 2.** Distribution of true mangrove species identified on transects at the study site

| Genus | Species | Station | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| *Aegiceras* | *Aegiceras corniculatum* | | | | | | ✓ | | | | | | | | |
| *Avicennia* | *Avicennia alba* | | | | | | | ✓ | | ✓ | | | | | |
| | *Avicennia marina* | ✓ | ✓ | ✓ | ✓ | | | | | ✓ | | ✓ | | ✓ | ✓ |
| | *Avicennia officinalis* | | | | | | | | | ✓ | | | | | |
| | *Avicennia rumphiana* | | | ✓ | | | | | | | | | | | |
| *Bruguiera* | *Bruguiera cylindrica* | | | | | | | ✓ | | | | | | | |
| *Ceriops* | *Ceriops decandra* | | | | | | | | | | ✓ | | | | |
| | *Ceriops tagal* | | | | ✓ | | ✓ | | | | | | | | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Rhizophora* | *Rhizophora apiculata* | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ |
| | *Rhizophora mucronata* | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ |
| | *Rhizophora stylosa* | | | | | | | | ✓ | | ✓ | | | ✓ | ✓ |
| *Excoecaria* | *Excoecaria agallocha* | | | | | | | ✓ | | | | | | | |
| *Lumnitzera* | *Lumnitzera racemosa* | | | | | | ✓ | ✓ | | | | | | | |
| *Pemphis* | *Pemphis acidula* | | | | | | | ✓ | | | | | | | |
| *Sonneratia* | *Sonneratia alba* | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ |
| *Xylocarpus* | *Xylocarpus granatum* | | | | | | | | | | ✓ | | | | |
| | *Xylocarpus moluccensis* | | | | | | | | | | | ✓ | | | |

## 2. Important value index

Based on the calculation of the importance value index at the study site, it shows that *Avicennia marina* is the species with the highest importance value index of 234.17 precisely at station 2. *Rhizophora mucronata* is the dominant species with the highest importance value index at most study stations, reaching 205.37 at station 11. It is followed by *Rhizophora stylosa*, which has a value of 135.84 at station 13. Mangroves categorized as minor are found on the edges of the study site and do not form pure stands. These include *Excoecaria agallocha*, with an important value index of 22.52 at station 7; *Xylocarpus granatum*, with a value of 38.18 at station 10; and *Xylocarpus moluccensis*, with a value of 24.05 at station 11.

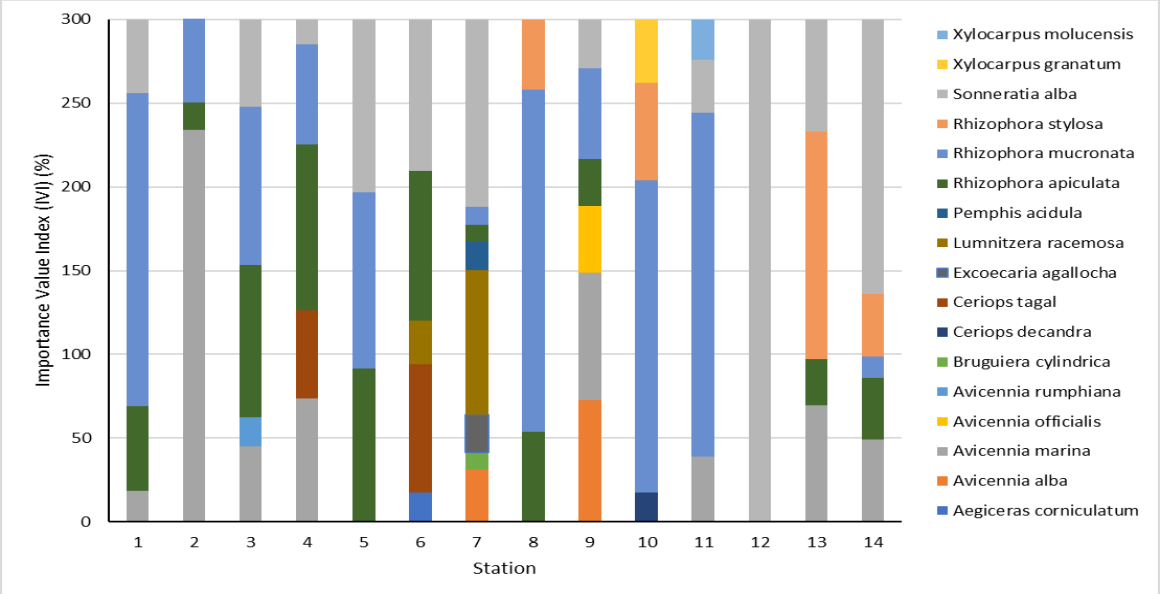


**Fig. 2.** Important value index (IVI) of true mangrove in the north coast of Bangkalan, Indonesia

### 3. Community structure

The results showed the diversity index shown in Table (3) has the highest diversity value of 1.648 at station 9, with species evenness index of 0.920 and dominance of 0.213. The lowest diversity index value is 0 at station 12, with an evenness value of 0 and dominance of 1.

**Table 3.** Community structure

| Station | Diversity (H') | | Evenness (J) | | Dominance (C) | |
|---|---|---|---|---|---|---|
| | H' | Category | J | Category | C | Category |
| 1 | 0.795 | Low | 0.573 | Moderate | 0.594 | Moderate |
| 2 | 0.183 | Low | 0.167 | Low | 0.926 | High |
| 3 | 1.347 | Moderate | 0.837 | High | 0.288 | Low |
| 4 | 1.406 | Moderate | 0.874 | High | 0.274 | Low |
| 5 | 1.072 | Low | 0.976 | High | 0.350 | Low |
| 6 | 1.295 | Moderate | 0.805 | High | 0.313 | Low |
| 7 | 1.156 | Low | 0.556 | Moderate | 0.427 | Low |
| 8 | 0.839 | Low | 0.763 | High | 0.518 | Moderate |
| 9 | 1.648 | Moderate | 0.920 | High | 0.213 | Low |
| 10 | 0.757 | Low | 0.546 | Moderate | 0.614 | High |
| 11 | 0.637 | Low | 0.459 | Moderate | 0.695 | High |
| 12 | 0 | Low | 0 | Low | 1 | High |
| 13 | 1.120 | Low | 0.808 | High | 0.399 | Low |
| 14 | 1.146 | Low | 0.712 | High | 0.426 | Low |
| Average | 0.957 | Low | 0643 | Moderate | 0503 | Moderate |

### 4. Percentage of mangrove canopy cover

The results of study and data processing, percent canopy cover is shown in Table (4). Mangrove canopy cover on the north coast of Bangkalan ranged from 58.82-86.97%. The highest percent canopy cover of 86.97% was at station 2 and station 3, while the lowest percent cover was at station 14, which amounted to 58.83%. Station 2 to station 6 have a good percentage of mangrove canopy cover category because they have *Rhizophora apiculata* and *Rhizophora mucronata* species as the most species in the study transect.

**Table 4**. Percentage of mangrove canopy cover in the north coast of Bangkalan, Indonesia

| Station | Coverage (%) | Category* |
|---|---|---|
| 1 | 68.70 | Moderate |
| 2 | 86.97 | Good |
| 3 | 86.97 | Good |
| 4 | 84.35 | Good |
| 5 | 80.43 | Good |
| 6 | 78.51 | Good |
| 7 | 63.19 | Moderate |
| 8 | 73.79 | Moderate |
| 9 | 73.88 | Moderate |
| 10 | 71.34 | Moderate |
| 11 | 66.15 | Moderate |
| 12 | 64.78 | Moderate |
| 13 | 68.50 | Moderate |
| 14 | 58.82 | Moderate |
| Average | 73.31 | Moderate |

## DISCUSSION

There were 17 mangrove species found at the study site on the north coast of Bangkalan. The most common species found were *Rhizophora apiculata, Rhizophora mucronata, Avicennia marina* and *Sonneratia alba* which were recorded at almost all study stations. In this study, most mangroves grow in the intertidal area. The composition of mangroves in this study is different from the results of **Sholiqin *et al*. (2021)** in Pacitan Coast, East Java which has a smaller total species of 10 mangrove species including *Rhizophora mucronata*, *Avicennia marina*, and *Sonneratia alba*. Furthermore, study conducted by **Mughofar *et al*. (2018)** recorded a smaller species composition of 12 species, with *Sonneratia alba* and *Avicennia alba* being the dominant species at the study site at Cengkrong Beach, Karanggandu Village, Trenggalek Regency, East Java. Mangroves derived from the genera *Rhizophora, Avicennia*, and *Sonneratia* are commonly found throughout the north coast of Java. Not only on the north coast of Java, in a study by **Shah *et al*. (2016)** in Sarawak, Malaysia, a mangrove composition of 9 species and 8 families were identified, *R. apiculata* was the dominant species at that location. The same species composition and diversity can be attributed to the study location in the tropics.

The results of the important value index of the dominant species were calculated at 234.17 for *Avicennia marina*, 205.37 for *Rhizophora mucronata* and 135.84 for *Rhizophora stylosa*. Based on these results, it is known that mangrove species of the

genera *Rhizophora*, *Avicennia*, and *Sonneratia* which are categorized as major mangroves become dominant species that grow in tidal areas and form pure stands at the study site, on the north coast of Bangkalan Regency. This finding aligns with that of **Zhilla and Hossain (2014)**, who stated that *Avicennia marina* is known to thrive and survive in high salinity conditions and windy environments. *Rhizophora* is the largest genus found on the north coast of Bangkalan; this genus is also very adaptable in extreme environments. According to **Nisari *et al*. (2021)**, the *Rhizophora* genus exhibits superior tolerance to salinity compared to other genera, supported by its distinctive breathing root system. The important value index describes the influence and role of a species in a mangrove community; this index also states the level of dominance of species in the community. **Rani *et al*. (2016)**, in thier study on the southwest coast of India, obtained the highest importance value index results for *Avicennia oficinalis* species, namely 154.89. While the results of **Renta *et al*. (2016)** in Mojo Village, Pemalang Regency, Central Java, obtained the highest importance index of 153.24 for *Avicennia marina* species and the lowest value of 5.528 for *Avicennia alba* species. Based on the importance value index of each study, it can be seen that each study location has a different species dominance according to its environmental conditions.

Shannon-Wiener species diversity on the north coast of Bangkalan, based on the results of the study, is in the range between 0-1.648 with an average of 0.957; this value is considered low category based on the Shannon-Wiener scale used by **Abino *et al*. (2014)**. This value can be attributed to the important value index in some species, especially in mangroves with the genus *Rhizophora*, which has a higher frequency and density than other mangrove genera. Low diversity values indicate unstable conditions due to ecological pressures both naturally and owing to human activities. In this study, the lowest value was recorded by station 12 with a species diversity value of 0, this is because only one mangrove species was found, namely *Sonneratia alba* which was identified as a mangrove in the tree category; station 12 is a mangrove rehabilitation area so that most of the mangroves found are still in the size of <10 cm in diameter or are in the sapling category. The highest diversity value recorded at station 9 with 1.648 and categorized as moderate; this is influenced by the location of station 9, which is far from settlements or cultivation sites and has less anthropogenic impact, so it is undisturbed and still natural. Vegetation indicators such as density, frequency, closure and importance index were an evidence that the mangrove forest at station 9 is still well maintained. The dominance value at station 9 is 0.213, indicating a low level of species dominance at this station, which suggests that there is no single species overwhelming others and thus no significant decrease was recorded in diversity. The same study was also conducted by **Setyadi *et al*. (2021)** in Mimika Regency, Papua, which obtained a species diversity value in the range of 0.62-1.19, which is also in the low category. According to **Ellinson (2005)** mangrove adaptation depends on the ability of mangroves to survive in salt water, because differences in salinity are a factor that affects mangrove diversity.

The evenness index in this study is in the range of 0-0.976 with an average of 0.643 which is in the moderate category. The highest evenness value is found at station 5, which is 0.976, while the lowest is at station 12. The high evenness index value at station 5 shows that the location has diverse mangroves with relatively the same distribution of each species, on the other hand, the grouping of mangrove species makes the evenness index low as in station 12 which only found 1 species group, namely *Sonneratia alba*. These results differ from the study of **Sholiqin *et al*. (2021)** in Pacitan Coast, East Java which has a range of evenness index values between 0.23-078 which is included in the low category. Factors affecting low evenness include weather, locations with advanced conservation systems, and geological conditions **(Sannigrahi *et al*., 2020)**.

The results showed that the dominance index on the north coast of Bangkalan was in the range of 0.213-1 with an average of 0.503, which was in the moderate category. Based on these results it can be stated that the north coast of Bangkalan has a good dominance with the distribution of species that tends to be evenly distributed, there are no species that extremely dominate a mangrove ecosystem. This illustrates the absence of high ecological pressure on the study site. Station 12 has the highest dominance because only 1 mangrove species was found in the tree category. The same study was conducted by **Ragavan *et al*. (2015)** on Andaman and Nicobar Islands, India, which had a dominance value in the range of 0.07-0.10, with a total of 38 mangrove species spread evenly across 8 study stations.

Based on the percent mangrove canopy cover categories outlined in Indonesian Ministry of Environment Decree No. 201 of 2004, the mangrove canopy cover on the north coast of Bangkalan is classified as moderate to good, with an average canopy cover of 73.31% in the moderate category. This percentage suggests that the mangrove ecosystems in this region are generally in good condition. The percent canopy cover reflects the state of the ecosystem at each study station, with stations exhibiting a good canopy cover, indicating the presence of mature mangroves, with tree diameters exceeding 16 cm, which form a dense canopy. Variations in canopy cover are influenced by tree size, canopy formation ability, and the number of species at each station. The moderate to good canopy cover percentages observed in this study indicate that the mangroves are well-maintained and thriving. Differences in canopy cover can be attributed to varying tree sizes and species at each location. Sediment characteristics also play a crucial role in mangrove growth. For example, West Tongas in Probolinggo, characterized by deep mud layers, is dominated by *Rhizophora mucronata* with an IVI value of 221, while Sumberasih in Probolinggo, with sand deposits, is dominated by *Avicennia marina* with an IVI value of 174 **(Saputra *et al*., 2022)**. The same study was conducted by **Baksir *et al*. (2018)** on the coast of Minaluli Village, North Mangoli District, Sula Islands Regency, North Maluku Province, with the condition of the mangrove community area classified as good and a percentage of canopy cover value of 72-82%, which indicates the ecological conditions of the environment supporting the

existence of mangroves and in accordance with mangrove health quality standards. Furthermore, **Pratama *et al.* (2022)** found the percentage of mangrove canopy cover value of 61.46-70.71% in Pantai Bahagia Village, Muara Gembong District, Bekasi Regency. Meanwhile, **Schaduw (2020)** obtained mangrove canopy cover results of 77.80-88.97% on Batanta Island and Salawati Island, Raja Ampat Regency, West Papua Province. The differences in the results obtained in each study occur because each study location has different environmental characteristics, as well as the level of ecological pressure and diversity of mangrove species distribution are factors that influence the results of the study.

Mangrove health conditions on the north coast of Bangkalan Regency based on Kepmen LH no 201 of 2004 are in the moderate to good category. The large number of species identified is also an evidence of good mangrove health, with an abundant distribution of species in each study site. These results overall indicate that the mangrove ecosystem on the north coast of Bangkalan Regency is in good condition and has a low vulnerability to degradation. Therefore, further management involving local communities and stakeholders is needed to improve mangrove sustainability for the north coast of Bangkalan.

## CONCLUSION

The results showed that the condition of mangrove ecosystems on the north coast of Bangkalan was in the excellent category. *Rhizophora, Sonneratia,* and *Avicennia* became the most commonly found genera. Based on the calculation of the important value index from the study location, the highest value was recorded by *Avicennia marina* (234.17). The species diversity results show high diversity (1.648), relatively even distribution, and low dominance, indicating stable environmental conditions with low ecological pressure. This condition is also supported by the percentage of mangrove canopy cover, which is in the moderate category (73.31%), which illustrates the ability of mangroves to grow.

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