Mangrove Conservation Opportunity at Southern Coast of Bangkalan-East Java, Indonesia

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Abstract
Mangrove ecosystems are resources of landscapes, flora, fauna, and local communities that interact with each other. Mangrove ecosystems have important ecological, economic and social functions for coastal development. Conservation is a means of involving the community in mangrove recovery and management activities as a preservation effort. This paper examines the potential of mangrove ecosystems in the southern coast of Bangkalan as a conservation area. The fact, mangrove ecosystems have a pressure that decreased area significantly. Data collection used the quadratic transect method and satellite image analysis. Mangroves on the southern coast of Bangkalan have increased area over the past 10 years. Mangrove vegetation found consisted of 4 families and 8 species. There are also found fauna i.e. insects, snakes, primates and birds. The observations indicated that conservation of mangrove forests on the southern coast of Bangkalan needs to be done. This effort can be supported by ecotourism activities which are expected to improve the community welfare.

1. Introduction
Mangroves are forest ecosystems located in intertidal zones on tropical and subtropical coasts [14]. The mangrove ecosystem has a large role as a conservation, rehabilitation, disaster mitigation and education area to improve people's welfare. In addition, the existence of this ecosystem also provides economic benefits to the surrounding community from timber and fish catches [5][8][10][16][22].

Continual overexploitation of mangrove utilization such as of land conversion or resource exploitation causes much damage to ecosystems [9]. Environmental degradation both naturally and caused by various human activities also affects the existence of mangrove ecosystems, so special attention is needed to increase the environmental capacity of these ecosystems [17]. Utilization of mangrove resources that are not based on ecological interests could threaten the sustainability of the ecosystem [21].

Bangkalan Regency on Madura Island has a coastal area in the south with a potential mangrove ecosystem to be managed and developed. In general, the coastal area of Bangkalan Regency
is used as a port, fishpond, tourism, capture fisheries, mangrove reservation area and fishpond area. This can potentially lead to a conflict of interest, environmental quality degradation and pressure on existing resources for the existence of activities that have a significant environmental risk, especially on the sustainability of coastal and marine resources. Mangrove ecosystems in the southern coast of Bangkalan have control over coastal conditions, to prevent the abrasion, subsidence and sea water intrusion [21].

Planning and management of coastal areas based on environmental factors is an initial effort to achieve sustainable regional development [4][11][15]. Conservation is one of the efforts to preserve mangrove ecosystems that accommodate economic and ecological interests. The first step in the effort to conserve mangroves is to analyze the condition of mangroves in the study area, which includes changes in the extent of mangroves over the past 10 years, important value indices and their zoning. Based on the reasons above, this paper aims to analyze the condition of mangroves on the southern coast of Bangkalan Regency and its conservation opportunities.

2. Method

2.1. Time and Place
The study was conducted in the southern coastal mangrove area of Bangkalan Madura Regency with intermediate coordinates 7° 2’31.68” - 7° 9’10.62” S and 112° 49’14.94” - 113° 2’ 33.41” E (Figure 1). The location of this research administratively covers 2 districts, Kwanyar District and Modung District. This research was conducted in September to December 2019.

![Study Area](https://earthexplorer.usgs.gov)

2.2. Mangrove Vegetation Analysis
Mangrove area data obtained through image data processing to determine changes in vegetation for 10 years. Analysis of Landsat 7 satellite data in 2009 and Landsat 8 in 2019 were processed and classified according to standard image data processing procedures, which was image cutting, geometric correction, image sharpening and image classification.

Mangrove zoning was determined by perpendicular line from the coast towards the sea. Mangrove vegetation data collection was carried out in each village as a station. Vegetation data collection was carried out using the belt transect method, which is to place the transect belt using a 10
x 10 m plot method. Line transects were taken from the sea towards the land (perpendicular to the coastline along the mangrove forest zoning) along 50 meters in the intertidal area. At the field, transects were carried out using the quadratic method to determine the distribution of mangroves in the form of tree density, species dominance and other important objects related to the condition of mangrove forests based on tree classification [2]. Vegetation composition and structure data were displayed in significant values which were the sum of the cover values and relative frequencies divided by two [18]. Importance value index (IVI) was used to find out the dominant tree species at each level of regeneration. IVI values are obtained using the following vegetation analysis [2]:

\[ DR_i = \left( \frac{n_i}{\sum n} \right) \times 100 \% \]  
\[ FR_i = \left( \frac{F_i}{\sum p} \right) \times 100 \% \]  
\[ CR_i = \left( \frac{C_i}{\sum C} \right) \times 100 \% \]

a. Species Relative Density (RDi)

Description:
- \( n_i \) : Number of stands for species i
- \( \sum n \) : Number of stands for all species

b. Species Relative Frequency (RFi)

Description:
- \( F_i \) : Frequency of species i
- \( \sum p \) : Number of frequencies for all species

c. Species Relative Cover (RCi)

Description:
- \( C_i \) : Areal cover of species i
- \( \sum C \) : Total areal cover for all species

d. Importance Value Index (IVI)

Importance Value Index (IVI) is the sum of species relative density, species relative frequency and species relative cover of mangroves. The importance value index of a type ranges from 0 - 300. This importance value provides an overview of the role of each species of mangrove in the ecosystem and can also be used to determine the dominance of a species in the community [2].

3. Result and Discussion

3.1. Mangrove Area

Mangrove forests that located on the southern coast of Bangkalan Regency have various types and conditions. Sampling of mangrove vegetation cover classes based on the appearance of Landsat 7 satellite images with RGB 453 and Landsat 8 with RGB 562 with supervised classification. The existence of mangrove forests in the study area has changed in the last 10 years, from 82.26 Ha (2009) to 115.56 Ha (2019) (Figures 2).
Increasing the area of mangroves in the study area occurs naturally and attempts at forest restoration. The natural area increase occurred in the forest area of Modung Station, while the results of the restoration effort were mostly carried out in the Kwanyar Station. The expansion of the area which reached 40.48% over the past 10 years must be maintained through conservation policies. Conservation efforts can be made through the use of environmentally friendly forests, increased forest growth, prevention of damage and increased protection of forest ecosystems. This strategy has been declared successful in influencing conservation in terms of enhancing the extent and quality of ecosystems, restoring landscapes, providing environmental services and protecting species in situ and ex situ. Mangrove recovery remains based on environmental friendly management by developing innovative environmental management [7]. Integrated efforts are needed in managing, conserving and protecting mangrove forests. Lack of transparency in mangrove governance frameworks, asynchronous between management and research, and geopolitical differences play a role in reducing the efficiency of mangrove management. Therefore, the mangrove management plan requires a greater effort to connect the stakeholders [3].

Common tools for the preservation and management of mangroves and other marine ecosystems include: marine protected areas (MPAs); nature preserve; wilderness area; national monuments and national parks [3]. Human efforts through planting are one of the factors that play a role to increase mangrove land cover. Mapping mangrove areas that are currently developing can be used to select potential locations as forest rehabilitation areas [10]. Mangrove trees that had planted on the southern coast of Bangkalan Regency was one of the forest conservation measures undertaken by the local government and non-governmental organizations. Successful management of conservation and restoration of mangrove forests requires the commitment of local communities, governments and stakeholders. This is because the farther humans are from nature, the concern for nature will also

**Figure 2.** Mangrove Vegetation on 2009 and 2019
diminish. In addition, the importance of the indirect function of mangrove forests that less understood by the community would cause indifference to access to resources, and then become a threat to the existence of mangrove resources. The Threat of Mangrove Resources Conservation was the Conservation of Populations that only concentrated in coastal areas. The main factor that causing the conversion of mangrove forests was the conversion of habitats into agricultural land and aquaculture [14].

Protection of natural mangrove ecosystems in the research area was very much needed through conservation efforts. This was because the growth reached 50.78% with natural zones and planting to 92.06% over 10 years. Successful management of mangrove ecosystems on the southern coast of Bangkalan Regency required the integration of stakeholders and increasing community basic knowledge to achieve conservation goals.

3.2. The Zonation of Mangrove

Based on field observations, the expansion of mangroves at the study site was due to 2 things, which was natural progress and planting efforts. Natural expansion occurred in mangrove forests in Modung, while mangrove planting areas were often carried out in Kwayar. The mangrove forest zone on the southern coast of Bangkalan from the sea direction in general, consists of:
1. Avicennia zone consists of *Avecennia alba* and *Avicennia marina*.
2. *Sonneratia alba* zone
3. *Rhizophora apiculata* zone.
4. The mixed zone consists of *Rhizophora mucronata*, *Rhizophora apiculata*, *Bruguiera gymnorrhiza*, slightly *Nypa fruticans*. At some of these stations also found mangrove plants from the Avicenniaceae family, *Avicennia alba* and *Avicennia marina*.

Mangrove vegetation has zoning according to the character of each habitat. Mangrove zonation can be characterized by the presence of a certain mangrove species that occupy certain locations. Mangrove zones devided based on tree species into six zones: (1) the border zone with the land; (2) Ceriops bush zone; (3) the Bruguiera forest zone; (4) Rhizophora forest zone; (5) Avicennia zone leading to the sea; and (6) the Sonneratia zone [20]. Other zonation of mangrove forest is as follows (figure 3) [1].

![Figure 3. Zonation of Mangrove [1]](image)

1. The area closest to the sea with a slightly sandy substrate, often overgrown by *Avicennia spp*. Usually in this zone associated with Soneratia spp species which predominantly grow in deep mud like organic matter.
2. Zone more towards the land, generally dominated by *Rhizophora* spp. In this zone, *Bruguiera* spp and *Xylocarpus* spp.

3. The next zone is dominated by *Bruguiera* spp.

4. The transition zone between mangrove forest and lowland forest is usually overgrown by *Nypa fruiticans* and several other palm species.

The classification and zoning of mangrove communities can be based on the structural criteria of mangrove forests, physiogeographic characteristics, or coastal geomorphology. In one mangrove community not all species can be found. Zonation can also be determined by tides that reach the mangrove community, salinity and soil drainage. There are zoning variations in each mangrove area, so there are no mangrove areas that are exactly the same [6]. Mangrove zoning also helps in assessing regional diversity [19]. Restoration or artificial mangrove ecosystems usually have low diversity [13]. This can be seen in the mangrove station kwanyar with homogeneous mangrove species.

3.3. Importance Value Index (IVI)

The mangrove forest ecosystem in the study area consists of 4 families and 8 species (Table 1). The mangrove vegetation in this study area was predominantly dominated by the Rhizophoraceae family which was known through the Importance Value Index (IVI).

| Station       | Species                | D  | DRI | F  | FRI | C  | CRI | IVI  |
|---------------|------------------------|----|-----|----|-----|----|-----|------|
| Kwnyayar Tebul| *Rhizophora Stylosa*    | 0.03 | 100 | 1  | 100 | 0.54| 100 | 300  |
| Pesanggrahan  | *Bruguiera gymnorhiza*  | 0.03 | 25.0 | 0.67 | 25.0 | 2.32 | 24.3 | 74.3 |
|               | *Sonneratia alba*      | 0.05 | 41.7 | 1.00 | 37.5 | 11.6 | 11.6 | 90.7 |
|               | *Rhizophora apiculata* | 0.04 | 33.3 | 1.00 | 37.5 | 6.09 | 64.0 | 134.8 |
|               | *Sonneratia alba*      | 0.02 | 18.2 | 1.00 | 37.5 | 0.78 | 21.7 | 77.3 |
|               | *Rhizophora stylosa*    | 0.04 | 36.4 | 0.67 | 25.0 | 1.58 | 43.8 | 105.1 |
| Batah Timur   | *Rhizophora Stylosa*    | 0.05 | 45.5 | 1.00 | 37.5 | 1.25 | 34.6 | 117.5 |
|               | *Rhizophora Apiculata*  | 0.12 | 54.5 | 0.67 | 20.0 | 7.96 | 27.2 | 101.7 |
|               | *Bruguiera Gymnorhiza*  | 0.06 | 27.3 | 1.00 | 29.9 | 20.35| 34.6 | 117.5 |
|               | *Sonneratia Alba*      | 0.08 | 45.8 | 1.00 | 42.9 | 3.20 | 44.2 | 133.0 |
| Batah Barat   | *Avicennia alba*        | 0.07 | 41.8 | 0.33 | 16.67| 3.99 | 43.1 | 101.0 |
|               | *Sonneratia alba*      | 0.03 | 17.65| 1   | 50   | 0.52 | 5.6  | 73.3 |
|               | *Rhizophora stylosa*    | 0.07 | 41.8 | 0.33 | 16.67| 3.99 | 43.1 | 101.0 |
|               | *Sonneratia alba*      | 0.03 | 25   | 1   | 50   | 0.69 | 11.2 | 86.3 |
|               | *Rhizophora apiculata*  | 0.05 | 41.7 | 0.67 | 33.33| 2.21 | 36.0 | 111.0 |
|               | *Bruguiera gymnorhiza*  | 0.04 | 33.3 | 0.33 | 16.67| 3.25 | 52.8 | 102.8 |
|               | *Rhizophora Stylosa*    | 0.12 | 57.1 | 0.67 | 28.49| 8.85 | 63.3 | 148.9 |
|               | *Rhizophora Apiculata*  | 0.04 | 19.0 | 1   | 42.74| 0.81 | 5.8  | 67.6 |
|               | *Sonneratia Alba*      | 0.05 | 23.8 | 0.67 | 28.49| 4.32 | 30.9 | 83.2 |
|               | *Rhizophora stylosa*    | 0.11 | 45.8 | 1.00 | 42.9 | 3.20 | 44.2 | 133.0 |
|               | *Sonneratia alba*      | 0.06 | 25.0 | 0.33 | 14.3 | 1.18 | 16.4 | 55.7 |
|               | *Rhizophora apiculata*  | 0.07 | 29.2 | 1.00 | 42.9 | 2.85 | 39.4 | 111.5 |
|               | *Bruguiera gymnorhiza*  | 0.04 | 36.4 | 0.67 | 25.0 | 2.07 | 46.2 | 107.6 |
|               | *Rhizophora apiculata*  | 0.03 | 27.3 | 1.00 | 37.5 | 0.81 | 18.0 | 82.8 |
|               | *Rhizophora stylosa*    | 0.04 | 36.4 | 1.00 | 37.5 | 1.59 | 35.5 | 109.3 |
| Species               | Karang Anyar | Karanganyar | Modung       | Suwa’an  | Langpanggang |
|-----------------------|--------------|-------------|--------------|----------|--------------|
| **Rhizophora Stylosa** | 0.02         | 0.10        | 0.13         | 0.07     | 0.01         |
| **Rhizophora Apiculata** | 0.03         | 0.10        | 0.13         | 0.04     | 0.06         |
| **Bruguiera Gymnorhiza** | 0.05         | 0.30        | 0.15         | 0.03     | 0.01         |
| **Sonneratia alba**    | 0.08         | 0.30        | 0.14         | 0.13     | 0.15         |
| **Nypa fruticans**     | 0.02         | 0.30        | 0.14         | 0.04     | 0.06         |
| **Avicennia alba**      | 0.04         | 0.30        | 0.15         | 0.05     | 0.06         |
| **Avicennia Marina**    | 0.03         | 0.30        | 0.15         | 0.06     | 0.06         |
| **Avicennia Marina**    | 0.03         | 0.30        | 0.15         | 0.06     | 0.06         |
| **Bruguiera gymnorhiza**| 0.04         | 0.30        | 0.15         | 0.06     | 0.06         |
| **Rhizophora Stylosa** | 0.02         | 0.10        | 0.13         | 0.07     | 0.01         |
| **Bruguiera gymnorhiza**| 0.04         | 0.30        | 0.15         | 0.06     | 0.06         |
| **Sonneratia Alba**     | 0.12         | 0.30        | 0.16         | 0.05     | 0.06         |
| **Rhizophora Apiculata**| 0.05         | 0.30        | 0.16         | 0.05     | 0.06         |
| **Sonneratia Alba**     | 0.06         | 0.30        | 0.16         | 0.05     | 0.06         |
| **Avicennia Marina**    | 0.05         | 0.30        | 0.16         | 0.05     | 0.06         |
| **Rhizophora Stylosa** | 0.06         | 0.30        | 0.16         | 0.05     | 0.06         |
| **Avicennia Marina**    | 0.06         | 0.30        | 0.16         | 0.05     | 0.06         |

**Note:** The data includes growth measurements in centimeters (cm) and the species are listed in alphabetical order by genus and species.
The Importance Value Index (IVI) shows the importance of a plant species and its role in the community. Analysis of plant communities is a way of studying the composition or composition of types and shapes or structures of vegetation. In forest ecology, the vegetation units studied or investigated are plant communities which are concrete associations of all plant species that occupy a habitat. Based on the analysis of Importance Value Index (IVI) in mangrove forests on the southern coast of Bangkalan, it was dominated by *Avicennia marina*, *Rhizophora stylosa* and *Rhizophora apiculata*. The dominant species has a large productivity, and in determining a dominant species it is

| Plant Community       | Importance Value Index (IVI) |
|-----------------------|------------------------------|
|                       |                             |
| *Avicennia marina*    | 0.06 57.1 0.67 39.9 11.23 94.9 192.0 |
| *Rhizophora stylosa*  | 0.05 83.3 0.67 39.9 0.96 82.2 205.5 |
| *Avicennia marina*    | 0.05 26.3 0.67 28.5 12.13 63.7 118.5 |
| *Sonneratia Alba*    | 0.04 26.7 0.33 14.3 4.1 37.2 78.2 |
| *Avicennia marina*    | 0.01 3.85 1 33.3 0.8 9.82 47.0 |
| *Avicennia Marina*    | 0.02 12.8 1 37.5 2.43 60.9 111.1 |
| *Sonneratia Alba*    | 0.04 26.7 1 42.9 4.0 37 106.6 |
| *Avicennia marin*     | 0.06 23.1 1 33.3 0.9 10.3 66.7 |
| *Rhizophora stylosa*  | 0.14 53.8 0.67 22.2 5.2 61.5 137.6 |
| *Rhizophora stylosa*  | 0.05 19.2 0.33 11.1 1.6 18.8 49.1 |
| *Avicennia marina*    | 0.05 12.8 1 37.5 24.3 60.9 111.1 |

Source: Research Result (2019)
necessary to know the stem diameter. The existence of a dominant species at the study site becomes an indicator that the community is in an appropriate habitat and supports its growth [12].

The terrestrial fauna that found at the study site consisted of insects, snakes, primates and birds. This group lives and adapts to parts of trees that are tall and far from the reach of sea water, even though they depend on sea animals for food needs, that is during low tide. The mangrove ecosystem is one of the wild animal habitats including primates, reptiles, birds and several estuarine ecosystem components that are important in the life of waterfowl, especially those who migrate. Mangrove natural resource wealth in unique vegetation formations, animals and associations that exist in the mangrove ecosystem has the potential to be conserved as a conservation area.

4. Conclusion
Mangrove land cover on the southern coast of Bangkalan District had increased by 40.8% in a span of 10 years. The area of natural vegetation increased by 50.8% and the increase in area due to planting reached 92.1%. Based on this, the determination of mangrove conservation areas on the southern coast of Bangkalan Regency needs to be done. However, the chances of establishing mangroves as conservation areas will be successful if the management of the area is carried out in an integrated manner by stakeholders together with local communities.

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