Mangrove diversity and sustainability in karangsong village of indramayu regency, west java

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Abstract. Mangrove forests in the northern coastal region of Karangsong Village, Indramayu Regency, West Java, form a crucial component of the livelihoods of coastal communities. The objective of this research is to know the diversity of species and mangrove vegetation based on growth level. The research method is explorative survey technique method. The data collection for the research vegetation data from 10 plots divided from observed tracks. This study resulted in the observation 9 species of plants: *Avicennia marina*, *Avicennia alba*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Rhizophora apiculata*, *Terminalia catappa*, *Casuarina equisetifolia*, *Ziziphus mauritiana*, and *Thespesia populnea*. From the analysis, it is known *Rhizopora mucronata* are the dominant species in the Karangsong Village Mangrove Ecotourism area within three growth phases (seedling, sapling, and mature), which evidenced from the frequency of their presence in 7 (seven) sample plots. Based on the analysis of data obtained, the index of diversity (H') of vegetation in mangroves and coastal of study area is 1.75, which means that this area has medium vegetation diversity. The calculated Dominancy Index for Karangsong Village Mangrove Ecotourism area is 0.210, which indicates that mangrove species has scattered growth pattern, thus means moderately high in diversity.

1. Introduction

Mangrove systems form a crucial component of the livelihoods of coastal communities in developing countries, as they provide fish, crustaceans and other sea life for food and income; wood for fuel and energy; protection of shorelines from erosion, flooding and storm damage; and a filter for pollutants to help maintain water quality [1][2]. However, historical researches had stated that Indonesia’s mangrove area have experienced rapid change in the form of degradation and loss [3]–[6] due to the increase of human activity, especially from intensive and extensive commercial aquaculture in rural livelihoods [7]. It is estimated that Java Island alone had lost 75% of its original mangrove area from 1800 to 2012 [3]. Considering the importance of the role of mangroves to protect and conserve the ecosystem components of coastal and marine areas, the sustainability management of mangrove ecosystem is absolutely necessary [8].

Indramayu Regency is one of the regencies in West Java Province that has the considerable potential of marine and fishery resources. From a geographical point of view, Indramayu Regency is very strategic for marine trade area because it is crossed by The Pantura (North Coast Line), the main and densest ocean route in Java Island. Coastal ecosystems in the Indramayu Regency roughly cover 38 villages in 11 sub-districts with sea depths of 4 miles along 147 kilometers. Almost all of the 315 urban villages and villages in Indramayu District have a focus on fisheries, seafood processing, aquaculture and oil and gas mining. One of the villages in Indramayu Regency that has great potential for mangrove development is Karangsong Village. In addition to having a well-known fishing port
with a large fleet of vessels with the reach of fishing operations to the area of Borneo and full of potential for the development of coastal cultivation (milkfish and shrimp), Karangsong Village is a coastal area which had managed to maintain its mangrove rehabilitation area by restoring and reforesting its coast area. Karangsong Village is a village located in Indramayu District, Indramayu Regency, West Java. Until 2016, mangrove rehabilitation on the north coast of Indramayu have reached 103.19 hectares covering Balongan, Indramayu, Cantigi and Pasekan sub-districts.

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Figure 1. Karangsong Village Area, West Java

The limited information about the potential and condition of the mangrove ecosystem in Karangsong Village creates a room for improvement to determine the best management practice of mangrove ecosystems in this region. This research aims to analyze the diversity of mangrove species in Karangsong Village as the basic approach to preserve the mangrove ecosystem by the implementation of zoning forest conservation policies, especially in its rehabilitation practices.

2. Materials and Method

The study was conducted in November 2017 at Karangsong Village Mangrove Ecotourism area, West Java. The materials used in this research are GPS (Global Positioning System), scissors, roll-meter, camera, rope, compass, observation sheet notes, notebook, and pencil. The other materials used include water and alcohol 70% (to cleanse mangrove specimen from mud and dirt) and a mangrove species identification database.

The exploratory survey technique and transect vegetation analysis are the methods used within this study. The observation to the vegetation diversity is collected by tracking the path along the Mangrove Ecotourism Area of Karangsong Village. The data of plant species was collected by drawing a 20 meters line on the track and counting each type on the left and right, for each 1 meter respectively divided from the baseline (10 plots). Sampling plots 1 to 8 are located in the mangrove tracks, while plots 9 and 10 are located on the coast. Data collection on stem diameters and tree heights were carried out by measuring using a roll-meter (for reachable plants) and tree height prediction (for unreachable plants). The unidentified plant species names are determined using mangrove species database.

The mangrove sampling was carried out for three different growth phases of the plants: seedling, sapling, and mature stage. The path that had been made was marked for making square plots with areas of 2 × 2 m (for seedling phase), 5 × 5 m (for sapling phase), and 10 × 10 m (for mature phase), alternating in directions (left and right) with a distance of 10 m. Seedling phase are all mangrove species observed in 2x2 sample plots with a stem diameter of less than 1.5 cm, sapling phase are all mangrove species observed in 5x5 sample plots with a stem diameter of 1.5 - 10 cm, and mature trees are all mangrove species observed in 10x10 sample plots with a stem diameter of 10 - 20 cm. Placement of sampling plots for mangrove species can be seen in Figure 2.
Figure 2. Sampling Placement of Sampling Plots for Mangrove Species. A) Seedling Observation Plot (2 x 2 m); B) Sapling Observation plot (5 x 5 m); C) Mature Plant Observation Plot (10 x 10 m).

Data collected in the field will be processed to obtain the Importance Value Index (IVI). IVI is obtained from the sum of the Relative Density (RDi), Relative Frequency (RFi), and relative dominancy (RCi) using the calculation formula for vegetation analysis obtained from similar researches [9][10]. For the seedling and sapling phase, RCi was not included to the calculation. Following is calculation formula:

$$IVI = RDi + RFi + RCi$$  \( (1) \)

where:
- IVI = Importance Value Index (sapling and mature stage)
- RDi = Relative Density
- RFi = Relative Frequency
- RCi = Relative Dominancy

where:

$$RDi = \frac{\sum \text{Density of Plant Species } i}{\sum \text{Total Plant Density}} \times 100\%$$  \( (2) \)

$$RFi = \frac{\sum \text{Frequency of Plant Species } i}{\sum \text{Total Plant Frequency}} \times 100\%$$  \( (3) \)

$$RCi = \frac{\sum (\pi \cdot \text{Tree Diameter Species } i^2 / 4)}{\sum (\pi \cdot \text{Tree Diameter All Species } i^2 / 4)} \times 100\%$$  \( (4) \)

Species diversity, determined with Diversity Index, is used to analyze the community structure and community stabilization, which can be determined as the ability of a community to keep itself in a stable condition despite the disruption to its components. High species diversity shows that a community has a high complexity due to the high interaction of species that occur in the community, on the contrary, the low species diversity of species indicate that community is composed by few species, thus, higher Dominancy Index [9]–[11]. Diversity Index is calculated by the formula:

$$H' = - \sum \left( \frac{n_i}{N} \right) \ln \left( \frac{n_i}{N} \right)$$  \( (5) \)

where:
- $H'$ = Shannon-Wiener Diversity Index [11]
- $n_i$ = Total of individual from species $i$
- $N$ = Total of individual from all species

Dominancy Index is calculated by the formula:

$$C = \sum \left( \frac{n_i}{N} \right)^2$$  \( (6) \)
where: $C$ = Simpson Dominancy Index [11]  
$n_i$ = Total of individual from species $i$  
$N$ = Total of individual from all species

3. Results and Discussion

3.1. Observed Plant Species

Overall the biodiversity of mangroves ecosystem can be broadly categorized into two groups i.e.: exclusive/major mangrove species (also called strict/obligate/true mangrove) and non-exclusive/minor/associates mangrove species [12][13]. Based from the track observation from 10 plots, there are 9 species of plants: *Avicennia marina*, *Avicennia alba*, *Rhizophora mucronata*, *Rhizophora stylosa*, *Rhizophora apiculata*, *Terminalia catappa*, *Casuarina equisetifolia*, *Ziziphus mauritiana*, and *Thespesia populnea*. These species are found in various growth phase: conception (seed), birth (sprout), infancy (seedling), juvenile (sapling), and adult (mature). The data collected for the vegetation analysis are from three phase: seedling, sapling, and mature plant.

3.2. Importance Value Index (by Growth Phase)

From the count of plant individuals, it is determined that *Avicennia mariana* and *Rhizopora mucronata* are the dominant species in the Karangsong Village Mangrove Ecotourism area. This is evident from their presence frequency, which was found in 7 (seven) sample plots.

| No. | Species                  | Species Density (Individual/ha) | Relative Density (%) |
|-----|--------------------------|---------------------------------|----------------------|
|     |                          | Seedling | Sapling | Mature | Seedling | Sapling | Mature |
| 1.  | *Rhizopora mucronata*   | 5500     | 3400    | 540    | 45.83    | 25.15   | 61.36  |
| 2.  | *Rhizopora apiculata*   | 1250     | 1160    | -      | 10.42    | 8.58    | -      |
| 3.  | *Rhizophora stylosa*    | 4000     | 1480    | -      | 33.33    | 10.95   | -      |
| 4.  | *Ziziphus mauritiana*   | 1250     | -       | -      | 10.42    | -       | -      |
| 5.  | *Avicennia marina*      | -        | 3040    | 190    | -        | 22.49   | 21.59  |
| 6.  | *Avicennia alba*        | -        | 3280    | 20     | -        | 24.26   | 2.27   |
| 7.  | *Terminalia catappa*    | -        | 1120    | 40     | -        | 8.28    | 4.55   |
| 8.  | *Casuarina equisetifolia* | -       | -       | 90     | -        | -       | 10.23  |
| 9.  | *Thespesia populnea*    | -        | 40      | -      | -        | 0.3     | -      |
|     | **Total**               | 12000    | 13520   | 880    | 100      | 100     | 100    |

| No. | Species                  | Species Frequency (Plots of observed/total plot) | Relative Frequency (%) |
|-----|--------------------------|-----------------------------------------------|------------------------|
|     |                          | Seedling | Sapling | Mature | Seedling | Sapling | Mature |
| 1.  | *Rhizopora mucronata*   | 0.2      | 0.6     | 0.4    | 33.33    | 24      | 33.33  |
| 2.  | *Rhizopora apiculata*   | 0.1      | 0.2     | -      | 16.67    | 8       | -      |
| 3.  | *Rhizophora stylosa*    | 0.1      | 0.3     | -      | 16.67    | 12      | -      |
| 4.  | *Ziziphus mauritiana*   | 0.2      | -       | -      | 33.33    | -       | -      |
| 5.  | *Avicennia marina*      | -        | 0.5     | 0.4    | -        | 20      | 33.33  |
| 6.  | *Avicennia alba*        | -        | 0.5     | 0.1    | -        | 20      | 8.33   |
| 7.  | *Terminalia catappa*    | -        | 0.2     | 0.1    | -        | 8       | 8.33   |
| 8.  | *Casuarina equisetifolia* | -     | -        | 0.2    | -        | -       | 16.67  |
| 9.  | *Thespesia populnea*    | -        | 0.2     | -      | -        | 8       | -      |
|     | **Total**               | 0.6      | 2.5     | 1.2    | 100      | 100     | 100    |
Table 3. Mangrove Importance Value Index, Diversity Index, and Dominancy Index (by Species)

| No. | Species                  | Importance Value Index (%) | Relative Dominancy, Mature (%) | Diversity Index (H’) | Dominancy Index (C) |
|-----|--------------------------|----------------------------|--------------------------------|----------------------|---------------------|
|     |                          | Seedling | Sapling | Mature | 51.93 | 19.93 | 1.47 | 0.05 | 0.05 | 0.12 | 0.02 | 0.01 |
| 1.  | Rhizophora mucronata     | 79.17    | 45.19   | 146.63 | 1.75  | 0.37  | 0.19 | 0.05 | 0.05 | 0.12 | 0.02 | 0.01 |
| 2.  | Rhizophora apiculata     | 27.08    | 16.58   | -      | -     | -     | -    | -    | -    | -    | -    | -    |
| 3.  | Rhizophora stylosa       | 50.00    | 22.95   | -      | -     | -     | -    | -    | -    | -    | -    | -    |
| 4.  | Ziziphus mauritiana      | 43.75    | -       | -      | -     | -     | -    | -    | -    | -    | -    | -    |
| 5.  | Avicennia marina         | 42.49    | 74.85   | -      | -     | -     | -    | -    | -    | -    | -    | -    |
| 6.  | Avicennia alba           | 44.26    | 12.08   | -      | -     | -     | -    | -    | -    | -    | -    | -    |
| 7.  | Terminalia catappa       | 16.28    | 19.35   | -      | -     | -     | -    | -    | -    | -    | -    | -    |
| 8.  | Casuarina equisetifolia  | -        | 47.10   | -      | -     | -     | -    | -    | -    | -    | -    | -    |
| 9.  | Thespesia populnea       | -        | 8.30    | -      | -     | -     | -    | -    | -    | -    | -    | -    |
| Total|                          | 200      | 200     | 300    | 100   | 1.75  | 0.209704 |

Table 1 shows the calculation of mangrove density of each species within their growth phase respectively, based on the estimated count of plant individual per hectare. Table 2 shows each species’ observed frequency per total plots within their respective growth phase. The study finds the 4 species of plants were included in the seedling phase criteria; from which 3 out of 4 species was found growing in mangrove ecosystem plots, namely: Rhizophora apiculata, Rhizophora mucronata, and Rhizophora stylosa, and other species was found in the coastal plots, Ziziphus mauritiana. From Table 3, it can be concluded that for seedling phase, Rhizophora mucronata has highest IVI: 79.17%, which indicates that this species has high dominance within the seedling phase. The dominance of this species is due to its ability to grow in various substrate conditions, which indicates that it is suitable for the rehabilitation of mangrove areas. In the sapling phase, 7 species of plants were observed within this study area. 5 of them were found growing in mangrove ecosystem plots, namely: Avicennia alba, Avicennia mariana, Rhizophora apiculata, Rhizophora mucronata, and Rhizophora stylosa, while the other 2: Terminalia catappa and Thespesia populnea were found growing in coastal plots. From Table 3, it can be concluded that Rhizophora mucronata also has highest IVI for sapling phase: 49.15%, but the dominance is not as significant due to Avicennia alba’s IVI: 44.26% and Avicennia mariana’s IVI: 42.49% within the same growth phase. It can be approximated that three of them have similar dominancy within the growth phase. Next, for the mature phase, 5 species of plants were observed. 3 of them were found growing in mangrove ecosystem plots, namely: Avicennia alba, Avicennia mariana, and Rhizophora mucronata, while the other 2: Terminalia catappa and Casuarina equisetifolia were found growing in coastal plots. It can also be concluded from Table 3 that Rhizophora mucronata also has high dominancy within the mature phase.

The criteria described for the Shanon-Wiener Diversity Index (H’) value are: H’<1 categorized as low in diversity, H’ = 1-3 categorized as medium in diversity, and H’>3 is high in diversity [11]. The Diversity Index (H’) calculated for Karansong Village Mangrove Ecotourism area is 1.75, so it can be concluded that this area has medium vegetation diversity. Simpson Dominancy Index (C) ranged from 0-1, where higher value describes the pattern of growth domination is focused on certain species, whereas the lower value indicates that the species within the community are growing in a scattered pattern, thus higher in diversity. The calculated Dominancy Index for Karansong Village Mangrove Ecotourism area is 0.210, which indicates that the study area has low species dominancy, as all species has scattered growth pattern, thus means moderately high in diversity.

4. Conclusions
There are 9 species of plants were observed growing in diverse pattern in Karansong Village Mangrove Ecotourism area, namely: Rhizophora mucronata (moderately dominant species in area within seedling, sapling, and mature phases), Rhizophora stylosa, Rhizophora apiculata, Avicennia marina, Avicennia alba, Terminalia catappa, Casuarina equisetifolia, Ziziphus mauritiana, and Thespesia populnea. Rhizophora mucronata are the. The index of diversity (H’) of vegetation in...
mangroves and coastal of study area is 1.75, which indicates medium vegetation diversity, while the Dominancy Index is 0.210, which indicates that mangrove species has moderately diverse growth pattern.

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