Study of development of mangrove forest potential for ecotourism in Kunkun Village, Mandailing Natal Regency, Indonesia

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Abstract. The mangrove ecosystem in Kunkun Village has been used as a tourist destination to be closer to nature. In addition, at this location there is also a river that is used as fishing tourism, as well as a mangrove forest that still has various fauna as one of the areas developed to be a mangrove ecotourism area. The aim of this study were to identify the suitability index of mangrove ecotourism and to determine the carrying capacity of the tourist area. This research was conducted using survey method with a sampling technique and determination of suitability based on weighting and scoring. The suitability index for mangrove tourism is included in the conditionally appropriate category with a percentage value of 55% to 75% which means that further management is needed so that the potential that exists in the mangrove ecosystem in this area can continue to be developed into an environmentally-based tourism area. While the carrying capacity of the area is 235 people/day which is divided into two groups of land and water tourism. However, the management of the ecotourism area is still lacking in terms of promotion of existing tourist spots, infrastructure in the ecotourism area is still less supportive and other facilities are not yet available.

1. Introduction
The existence of mangrove forests in the ecosystem is very important because they have ecological and economic potential. Mangrove forests have an important role as nursery areas and habitats for various kinds of fish, shrimp, shellfish and others. In this forest there are also many important nutrient sources as a food source for many species, especially migratory species such as shorebirds. Mangrove forests also act as a green belt that protects the coast from erosion due to ocean waves or tsunami storms and traps sediment as accretionary activity. Furthermore, mangroves make a significant contribution to estuarine and coastal productivity through the flow of energy from the litter decomposition process. Food chains that depend on microbes and the results of plant decomposition are very supportive of various types of animals that live in them. And the surrounding habitat [1,2].

Kunkun Village is an expansion village of Sundutan Tigo Village in Natal District. Kunkun Village which has a natural-based mangrove forest area. This is what underlies the need for a study on the potential of mangrove forests based on a community approach in the village. Through this approach, the study can be used as a reference for determining appropriate and sustainable management of mangrove forests in Kunkun Village, Natal sub district, Mandailing Natal District. In addition, to avoid damage caused by visitors and maintain the sustainability of mangrove ecotourism, it is necessary to carry out carrying capacity analysis.
Ecotourism is not just a tourism business that aims to maximize profits. It is more about the impact of tourism on communities and environmental resources, and emerges from community development strategies, as a tool to strengthen the capacity of rural community organizations to manage tourism resources with the participation of local communities [3]. Tourist visits to tourist sites provide benefits for the surrounding community in particular, by providing various food sales and souvenirs. Ecotourism is now an important economic activity that provides opportunities for tourists to gain experiences about nature and culture to learn and understand how important the conservation of biodiversity and local culture is. This study aims to determine the tourism suitability index so that the area can be managed into a tourist area that focuses on environmental conservation, and also to determine the carrying capacity or the limit of allowed visitors so that tourist sites are protected from damage.

2. Materials and Methods

2.1. Research site
The research was conducted in December 2020 in the village of Kunkun, Natal District. Based on the survey results, the determination of the station was determined based on the density of mangroves in the research location. Identification of mangrove species as well as density measurement and distribution of mangrove ecotourism questionnaires were carried out directly in the field.

![Figure 1. Research location (Kunkun village, Mandailing Natal District)](image)

2.2. Method of collecting data
In this study, data collection was carried out in several stages: literature study on the potential of natural and human resources, conducting field surveys, interviews with the community through the provision of questionnaires to the community and tourist visitors.

The types of data collected in this study were grouped into several groups with the aspects studied including: biological data (diversity of birds, fish, crustaceans, and mangrove plants around the study site), physical and chemical data of mangrove area waters (including temperature, turbidity, discharge, pH, and BOD), field physical data covering the general condition of the area, attractions, and
accessibility, and population social data regarding population characteristics related to identity, perception, participation, and expectations.

2.3. Mangrove sampling
Sampling of vegetation at each station is carried out with modified sampling plot method [4]. At each observation location, place a quadrant plot with a size of 10 x 10 m for tree level (stem diameter > 4 cm), 5 x 5 m for sapling (stem diameter < 4 cm and height > 1 m), 1 x 1 m for seedlings and undergrowth (height < 1 m). The data taken in the observation of the mangrove ecosystem is the type of mangrove that is in the observation station, then the diameter of each tree at chest height (1.3 meters) is measured in the station and visual observations of the biota in the station [5].

2.4. Mangrove density analysis
The data that has been obtained from the measurement activities in the field are then calculated the density of each species [6]. Calculation using the following formula:

a. Species density
Mangrove species density was determined using the following equation:

\[ D_i = \frac{n_i}{A} \]

b. Total density
\[ D_t = \frac{\sum n}{A} \]

Where: \( D_i \) = the density of mangrove species i (ind/ha); \( n_i \) = total number of stands of mangrove species I; A = total sampling area (number of transects x area of plot per hectare unit) [6].

2.5. Analysis of mangrove ecotourism suitability
Tourism feasibility analysis was conducted to determine the suitability of the area for tourism development. This is based on the territorial ability to support activities that can be done in the area. The formula used for the suitability of marine ecotourism is as follows [7]:

\[ ESI = \sum \frac{N_i}{N_{max}} \times 100\% \]
Table 1. The suitability matrix of mangrove ecotourism

| No | Parameter                          | Weight | Category | Score | Category | Score | Category | Score | Category | Score | Category | Score |
|----|------------------------------------|--------|----------|-------|----------|-------|----------|-------|----------|-------|----------|-------|
| 1  | Mangrove width (m)                 | 5      | >500     | 3     | >200-500 | 2     | 50-200   | 1     | >50      | 0     |
| 2  | Mangrove density (Ind/Ha)          | 3      | >15-25   | 3     | >10-15   | 2     | 5-10     | 1     | <5       | 0     |
| 3  | Mangrove species                   | 3      | >5       | 3     | 3-5      | 2     | 1-2      | 1     | 0        | 0     |
| 4  | Tidal range (m)                    | 1      | 0-1      | 3     | >1-2     | 2     | >2-5     | 1     | >5       | 0     |
| 5  | Fauna species                      | 1      | fish, shrimps, crabs, mollusks, reptils, birds | 3 | fish, shrimps, crabs, mollusks, | 2     | fish, mollusks | 1     | one of the species | 0     |

Note: Very suitable (S1): 75-100%; suitable (S2): 50-75%; not suitable (N): <50%. Source: [7]

2.6. Analysis of carrying capacity of mangrove ecotourism
Tourism feasibility analysis was conducted to determine the suitability of the area for tourism development. This is based on the territorial ability to support activities that can be done in the area. The formula used for the suitability of marine ecotourism is as follows [7]:

\[
CC = Kx \frac{Lp}{L_t} x \frac{W_t}{W_p}
\]

Where: \(CC\) = carrying capacity of the area (person); \(K\) = maximum visitors per unit of area (person); \(L_p\) = area or length of area that can be utilized (m\(^2\) or m); \(L_t\) = unit area for a particular category (m and m\(^2\)); \(W_t\) = Time allocated for tourism activities in one day (hours); \(W_p\) = time spent by visitors for certain activities (hours).

Table 2. The ecological potential of visitors (K) and unit area (Lt)

| Type of activity        | Visitor (person) | Unit area (Lt) | Information                              |
|-------------------------|------------------|----------------|------------------------------------------|
| mangrove tourism        | 1                | 50 m           | Calculated the length of the track, each person is 50 m |

Table 3. Prediction time for each tourism activity

| No | Type of activity | Time required (Wp) (hours) | Total time per day (Wt) (hours) |
|----|------------------|-----------------------------|---------------------------------|
| 1  | mangrove tourism | 2                           | 8                               |
3. Results and discussion

3.1. Ecosystem Mangrove

The results of observations of mangroves at three stations located in Kunkun Village, Natal District, obtained the types of mangroves listed in Table 4.

| No. | Name of species          | Station |
|-----|--------------------------|---------|
| 1.  | Acrostichum aureum       | √       |
| 2.  | Avicennia officinalis     | √       |
| 3.  | Bruguiera gymnorrhiza     | √       |
| 4.  | Bruguiera parviflora     | √       |
| 5.  | Gymnanthera paludosa     | √       |
| 6.  | Nypa fruticans           | √       |
| 7.  | Pandanus odoratissima    | √       |
| 8.  | Rhizophora mucronata     | √       |
| 9.  | Scaevola taccada         | √       |

Regarding to observation result of mangroves, there are nine species of mangroves, which seven of them are true mangroves, namely: Acrostichum aureum, Avicennia officinalis, Bruguiera gymnorrhiza, Bruguiera parviflora, Gymnanthera paludosa, Nypa fruticans, Rhizophora mucronata. Meanwhile, Pandanus odoratissima and Scaevola taccada are associated mangroves.

According Noor et al [8] stated that Indonesia has the largest mangrove area in the world (3.5 million hectares). Indonesia has recorded at least 202 species of mangroves. A total 202 species, 43 species (including 33 species of trees and several species of shrubs) were found as true mangroves, while other species were found around mangroves and are known as associated mangrove species.

| Station | Species                | Number of trees (Ni) | Area (m²) | Density (ind/ha) |
|---------|------------------------|----------------------|-----------|-----------------|
| I       | Acrostichum aureum     | 4                    | 50        | 80              |
|         | Bruguiera gymnorrhiza  | 15                   | 50        | 300             |
|         | Bruguiera parviflora   | 5                    | 50        | 100             |
|         | Nypa fruticans         | 10                   | 50        | 200             |
|         | Total                  | 34                   | 680       |                 |
| II      | Acrostichum aureum     | 4                    | 50        | 80              |
|         | Rhizophora mucronata   | 20                   | 50        | 400             |
|         | Bruguiera gymnorrhiza  | 10                   | 50        | 200             |
|         | Gymnanthera paludosa   | 5                    | 50        | 100             |
|         | Total                  | 37                   | 780       |                 |
Table 6. Fauna found in the mangrove area in Kunkun Village, Natal District

| No | Class            | Species                                      |
|----|------------------|----------------------------------------------|
| 1. | Birds            | Stork (ciciiiidae sp)                        |
| 2. | Reptil           | Lizard (varanus salvator)                    |
|    | Primate          | Crocodile (Crocodylus pororus)               |
|    |                  | Monkey (Hominoidea sp)                      |
| 3. | Mollusks         | Telecopium, Sphaerassiminea miniata, Paguroidae, Polymesoda bengalensi |
| 4. | Fish             | Red snapper (Lutjanus campechanus)           |
| 5. | Crustaceans      | Shrimp (Panaeus monodon), Scylla serrata, Metopograpsus Latifrons |

Measurement of the density value of mangrove species based on tree category in each plot at each station showed that the Rhizophora mucronata species had the highest density value of 400 ind/ha (station 2) compared to other species. While at station 1 the highest density is Bruguiera gymnorrhiza at 300 ind/ha, and station 3 has the highest density value at 160 ind/ha (Pandanus odoratissima).

R. mucronata is a type of mangrove that has a habitat near or located on tidal river embankments and in river mouths. This species is included in the core mangrove flora which has a major role in mangrove formation [9].

3.2. Feasibility analysis and carrying capacity of mangrove ecotourism

The value of tourism suitability is calculated based on the actual physical condition of the location. The results of the tourism suitability analysis are presented in Table 7.
Table 7. Tourism suitability index for mangrove category

| Location | Suitability index (%) | Category           |
|----------|-----------------------|--------------------|
| Station 1| 75                    | Conditional suitable|
| Station 2| 65                    | Conditional suitable|
| Station 3| 55                    | Conditional suitable|

The conditionally suitable category indicates that to make this location as a tourist destination, it needs to be managed first before being used as a tourist spot. Therefore, there is a need for further management so that the potential that exists in the mangrove ecosystem in this area can continue to be developed into an environmentally-based tourism area.

Carrying capacity is the ability of a location to accommodate a number of visitors at the same time. So that tourist sites are protected from damage and provide sustainable benefits. Based on the analysis results, the total carrying capacity of mangroves in Kunkun village is 235 people/day. The activities visitors can do are fishing, photography, and boating. While the main activity is tracking on the track board that has been provided.

Sukuryadi et al [11] found a different carrying capacity value at the location of Lembar village, West Lombok Regency, which was 2337 people/day. Differences in research result may occur because the mangroves in Lembar Village are wider than the Kunkun Village, Mandailing Natal District.

4. Conclusion

There are some potential tourism activities that can be developed at mangrove area in Kunkun Village such as tracking, fishing, bird watching and photography. Based on the results of the spatial analysis of the suitability of mangrove ecotourism land, it is known that the mangrove area in Kunkun Village has the potential to be developed with a tourism suitability index value ranging 55-75%. Several things that support the attractiveness of ecotourism are the condition of the extensive and dense mangrove ecosystem supported by rivers, the diversity of animals/biota and the beautiful landscape. The total carrying capacity of mangrove ecotourism is 235 people per day.

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