Rehabilitation strategy for mangrove ecotourism development in Tanjung Burung, Tangerang

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Abstract. Mangrove ecotourism is a tourism concept that pays attention to the sustainability of natural resources and the environment as the main tourist object. This study aims to design a mangrove rehabilitation strategy based on a potential analysis of the mangrove ecosystem's suitability and carrying capacity for ecotourism development. The study was conducted from February to March 2020 in Tanjung Burung Village, Teluk Naga District, Tangerang Regency. The data analysis uses tourism suitability index (TSI) processed by spatial analysis tool and area carrying capacity (RCC). Tanjung Burung mangrove ecotourism has an ecotourism potential of 28 ha, with tracking of 2859 m, this can happen if the entire area is planted with mangroves and can grow well. The potential of mangrove ecotourism based on its carrying capacity is 229 people/day considering the length of the trip for each visitor is 4 hours for 8 operational hours per day. The strategy for the rehabilitation of mangrove ecosystems is to analyze the characteristics of damage and mangrove habitats, repair seawater irrigation systems, and plant mangrove vegetation

Keywords: carrying capacity; ecotourism; mangrove; rehabilitation; suitability

1. Introduction
Tanjung Burung is a village located in Teluk Naga District, Tangerang Regency. This village is categorized as a potential area developed for mangroves. Nevertheless, environmental damage increased, such as converting mangrove areas into aquaculture, settlements and coastal abrasion. The mangrove ecosystem in Teluk Naga District has 1,192 ha, but conversion from 1997 to 2006 reached 85.91% [3]. Land conversion damages the environment and threatens the sustainability of the mangrove ecosystem, especially in Tanjung Burung Village. Thus, a solution to preserve the mangrove ecosystem is needed. Mangrove ecotourism can be the right solution to preserve the mangrove ecosystem because ecotourism is a form of tourism based on coastal and marine resources by including interpretations of the natural environment, education and sustainable community culture [23].

Mangrove ecosystem is a coastal natural resource with complex physical functions, apparently, ecology, economic, and social. Mangrove ecosystem can help as disaster mitigation, coastal stabilizer, coastal erosion control, maintaining sediment stability, increasing land expansion (land building), and protecting coastlines (protected agent). It has also ecologically function to provide growth dynamics for coastal areas as spawning grounds, nursery grounds and feeding grounds for particular marine biota. In terms of economy, it functions as a livelihood for coastal communities, especially those who work as
fishermen and socio-culturally function such as the development of cultural values, tourism, conservation, rehabilitation, and education [8, 15]. The application of the concept of education is one of the attractions in the development of mangrove ecotourism as an aspect of learning, mental cultivation in preserving the environment.

Mangrove rehabilitation is one of the efforts to preserve the mangrove ecosystem, and it can be carried out to restore ecosystem functions sustainably. Mangrove rehabilitation in Tanjung Burung Village has been carried out by local people who care about the environment from 2007 until now. They got a positive impact from ecotourism activities in their area. The utilization of mangrove ecosystems for ecotourism is in line with the shift in tourist interest from old tourism to new tourism. Initially, they only came to do tours without any elements of education and conservation, but now they come to do tourism with elements of education and conservation [2]. Ecotourism is a new sustainable tourism to support environmental sustainability and control the impact of tourists on the environment. [11] Ecotourism is a form of sustainable tourism in natural areas with the aim of educating visitors to protect the environment will contribute to economic development and improve the quality of life of local residents. Ecotourism can be defined into five concepts, namely: 1) nature conservation, sustainability, minimal damage, environmental education and community involvement [7]. Ecotourism is often considered a potential strategy in supporting ecosystem conservation while promoting sustainable tourism [18]. Ecotourism is a trip to natural areas to preserve the environment, enjoy nature, preserve life and the welfare of the population [27]. Thus, this study analyses' the potency of mangrove ecosystems that can be developed for ecotourism and optimizes the existing potential by recommending mangrove rehabilitation strategies.

2. Material and methods
2.1. Time and research area
This research was conducted from February to March 2020 in Tanjung Burung Village, Teluk Naga District, Tangerang Regency (figure 1).
2.2. Data collection and data analysis

Mangrove ecotourism research data in Tanjung Burung comes from primary data (ecological, social and economic) as well as secondary data. Primary data is obtained from direct measurements (mangrove sampling and interviews), while secondary data is obtained from references. The primary data collected is measuring mangrove thickness (m), density (ind/m) using raffia rope, and roll meter using the quadratic transect method. The collection of biotas is found at the study site along with side measurements of mangroves. The secondary data is tidal (m) obtained from tides.big.go.id.

Spatial analysis tools, proven to be important and sustainable tool for monitoring and mapping mangrove ecosystems [24]. These one of image processing is used as an effective tool in controlling land use management, identifying areas including land cover status [9, 12, 17]. GIS technology also has high efficiency in detecting land use changes and processing detailed information [6, 16]. The technology presents data and maps, and it can be applied to support decision systems for both conservation and other fields. The tools equipped with spatial overlay modelling techniques by using weighting on several influential factors and the suitability score for each predetermined criterion. The analyzes used are as follows:

| Parameter                  | Weight | Category             | Score |
|----------------------------|--------|----------------------|-------|
| Mangrove thickness (m)     | 0.380  | >500                 | 3     |
|                            |        | >200-500             | 2     |
|                            |        | 50-200               | 1     |
|                            |        | <50                  | 0     |
| Mangrove density (ind/100 m²) | 0.250  | >15-20               | 3     |
|                            |        | >10-15;>20           | 2     |
|                            |        | 5-10                 | 1     |
|                            |        | <5                   | 0     |
| Mangrove species           | 0.150  | >5                   | 3     |
|                            |        | 3-5                  | 2     |
|                            |        | 1-2                  | 1     |
|                            |        | 0                    | 0     |
| Tidal (m)                  | 0.120  | 0-1                  | 3     |
|                            |        | 3-4                  | 2     |
|                            |        | >2-5                 | 1     |
|                            |        | >5                   | 0     |
| Biota Object               | 0.100  | Fish. Shrimp. Crab. Mollusk. Reptile. Bird. | 3 |
|                            |        | Fish. Shrimp. Crab. Mollusk | 2 |
|                            |        | Fish. Mollusk        | 1     |
|                            |        | One of aquatic biota | 0     |

Source: [28]
where:
TSI 2.5 = Very suitable
2.0 TSI < 2.5 = Appropriate
1 TSI < 2.0 = Not suitable
TSI < 1 = Very inappropriate
2.2.1. Tourism suitability index (TSI). To calculate the suitability analysis for mangrove tourism using the formula [28]:

\[ TSI = \sum_{i=1}^{n} (Bi x Si) \]  

(1)

where:
- \( n \) = Number of suitability parameters;
- \( Si \) = Score of parameters \( i \);
- \( Bi \) = Weight of parameter \( i \);

Parameters being measured in tourism suitability are mangrove thickness (m), mangrove density (ind/100 m\(^2\)), mangrove species, tides (m), biota objects determined using a suitability matrix and classified into three suitability classes, namely very suitable (S1), suitable (S2), not suitable (S3) based on [28] are presented in (Table 1).

2.2.2. Regional carrying capacity (RCC). Analysis of the area's carrying capacity is the ability of the area to accommodate the maximum number of visitors at a certain time without harming nature and humans. RCC analysis using the formula [27] as follows:

\[ RCC = K \times \left( \frac{Lp}{Lt} \right) \times \left( \frac{Wt}{Wp} \right) \]  

(2)

where:
- \( RCC \) = Regional carrying capacity (person/day)
- \( K \) = Ecological potential of visitors per unit area (person)
- \( Lp \) = Area (m\(^2\)) or length of area (m) that can be utilized
- \( Lt \) = Unit area for a particular category (m\(^2\) or m)
- \( Wt \) = Duration of visit Time allocated for tourism activities in 1 day (hours)
- \( Wp \) = Time spent by visitors for each particular activity (hours)

Visitor time is calculated to minimize disruption to natural resources with the time provided by the area (Wt), the duration the area is opened in one day for tourism activities. Visitor activity time (Wp) is calculated based on the length of time spent by visitors to enjoy the beauty offered by nature (Table 2).

| Activity               | K (\( \sum \) visitor) | Lt (area) | Wp (hour) | Wt (hour) |
|------------------------|-------------------------|-----------|-----------|-----------|
| Mangrove Ecotourism    | 1                       | 25 m (calculated length of the path, every 1 person along the 25 m) | 2         | 8         |

Source: modification [28]

3. Result and Discussion

3.1. Rehabilitation strategy

Mangrove rehabilitation is an effort to restore damaged mangrove ecosystems. Mangrove rehabilitation is a global problem, positive reasons for rehabilitation are the benefits of nutrient cycling, plant and animal habitat, carbon storage and human well-being [10]. The Mangrove Ecosystem in Tanjung Burung is the result of mangrove rehabilitation being done by a community group who cares about the environment. They have realized the importance of the benefits of the mangrove ecosystem, this activity has been going on for ten years. Various types of mangroves that have been successfully planted include Rhizophora mucronata, Rhizophora apiculata, Sonneratia caseolaris, Sonneratia mucronata, Avicennia alba, Avicennia lanata, Avicennia marina, Bruguiera gymnorrhiza, Nypa fruticans, Carbera manghas, and Terminalia catappa. One of the benefits of mangrove rehabilitation felt for educational-based ecotourism activities is mangrove tourism activities by planting mangroves on vacant land as a form of education and concern for the environment. Mangrove rehabilitation activities are carried out by seeding in containers, preparing planting areas, planting and monitoring. Mangrove rehabilitation that has been
carried out so far has not given maximum results, so a sustainable rehabilitation strategy is needed. Several rehabilitation strategies that need to be carried out are socialization and training to increase human resources, support from local governments, analysis of the potential and carrying capacity of mangrove ecosystems in ecotourism activities. Mangroves play a key role in ecosystem services so that a sustainable strategy or policy is needed, if this is ignored, some of the mangrove ecosystem will be lost [3] and the number of mangroves can determine the carbon stock stored [25].

3.2. Mangrove ecosystem condition
Sonneratia caseolaris and Sonneratia mucronata with a combination of mangrove species associated with Terminalia catappa, Nypa fruticans, Carbera manghas are the dominant species in Tanjung Burung Village mangrove ecosystem. The mangrove ecosystem is formed by rehabilitation efforts taken by local communities who care about the environment to restrain abrasion of coastal areas. Rehabilitation is an effort to restore and create new ecosystems by changing the damaged system into a more stable one and returning to its natural function. Mangrove forest conservation is a complex subject because it needs the full participation of all parties around the area [14]. The development and management of mangrove ecotourism require government attention in the development of facilities and infrastructure [20]. It also needs community involvement in its management to maintain the mangrove ecosystem and sustain and support the local economy. The framework for the management and conservation of mangroves consists of three concepts: the protection of the mangrove ecosystem, the utilization of the mangrove ecosystem, and the rehabilitation of the mangrove ecosystem. These three concepts provide legitimacy and understanding that mangroves need management and protection to remain sustainable and utilized sustainably [13].

The mangrove thickness in Tanjung Burung Village ranges from 130 - 232 m with an average of 196 m, calculated using Google Earth satellite imagery. Mangrove thickness is one of the essential parameters in developing mangrove ecotourism; mangrove thickness from four stations got different results, where only three stations are included in the appropriate category (S2) for tourism, based on the criteria of [28] (table 3).

This research found that there are seven families of mangroves in the research area, namely Rhizophoraceae, Sonneratiaceae, Avicenniaceae, Combretaceae, Arecaceae, Apocynaceae and eleven species of mangrove, namely Rhizophora mucronata, Rhizophora apiculata, Sonneratia caseolaris, Sonneratia mucronata, Avicennia alba, Avicennia lanata, Avicennia marina, Bruguiera gymnorrhiza, Nypa fruticans, Carbera manghas and Terminalia catappa (figure 2).

Table 3. Mangrove thickness of each research station.

| Stations | Coordinate          | Mangrove thickness (m) | Criteria |
|----------|---------------------|------------------------|----------|
| 1        | S: -6.006624  
           E: 106.643962 | 143                    | S3       |
| 2        | S: -6.006121  
           E: 106.644603 | 183                    | S3       |
| 3        | S: -6.005611  
           E: 106.645138 | 230                    | S2       |
| 4        | S: -6.004838  
           E: 106.645941 | 323                    | S2       |
| 5        | S: -6.004211  
           E: 106.648301 | 130                    | S3       |
| 6        | S: -6.004894  
           E: 106.647820 | 164                    | S3       |
| 7        | S: -6.005492  
           E: 106.647100 | 202                    | S2       |

Source: [28]
Mangrove density at each station has different values, caused by many factors, including mangrove adaptation patterns, substrate conditions, and habitat (Figure 3). The suitability matrix describes mangrove density values: <5 Ind/100 m² (score 0), 5-10 Ind/100 m² (score 2), >10-15 Ind/100 m² (score 2), >15-20 Ind/100 m² (score 3) [28]. Mangrove conditions based on density parameters in all stations fall into the very appropriate category (score 3).
The level of mangrove survival also influences mangrove density; each type has different survival abilities [5]. The difference in mangrove density is influenced by adaptation patterns and human involvement in the mangrove ecosystem [21].

3.3. Tidal (m)

The calculation of tidal observations obtained in the Tanjung Burung area is included in the single daily tidal type. This type can be generated from the analysis of monthly tidal calculations (figure 4).

The tidal conditions in the period January - December 2019 averaged around 0.78 m, this is in the category very well mangrove ecotourism suitability index [28], the tidal value in Tanjung Burung is in the very appropriate category (score 1) with tidal value 0 - 1 for mangrove ecotourism activities. Tides are one of the indicators in determining the suitability of ecotourism. If the water is too high, it affects the life of mangrove seedlings and causes death in the long term. Meanwhile, the tides can also affect the ease of tracking areas, which impacts the accessibility of tourist visits. Tides significantly affect the mangrove ecosystem, which is the central pillar of natural resistance in coastal areas from the threat of waves and erosion [22]. There are three basic types of tides based on their period and regularity, namely (1) a single daily type of tide (diurnal type) if within 24 hours there is one high tide and one low tide, (2) the tides of the mid-daily/double type (semi-diurnal type) if within 24 hours there are two high tides and two low tides, (3) the mixed tides (mixed tides) if within 24 hours there are mixed forms which gravitate to the single diary-type or the multiple diary type [26].

3.4. Biota potency

The attractiveness of mangrove ecotourism can be seen in terms of biodiversity. Biodiversity in Tanjung Burung mangrove ecotourism consists of crabs, birds, mudskipper fish, shrimp, gastropods, and monitor lizards (figure 5). Biota potential indicates that biodiversity is still maintained and becomes its habitat. Mangrove ecosystem is a habitat for birds, fish, crabs, and molluscs [18], this is appropriate by the condition of mangrove ecotourism in Tanjung Burung, which still has biodiversity.

3.5. Mangrove ecosystem suitability for ecotourism development

Mangrove conditions based on the five parameters of the suitability of mangrove ecotourism in Tanjung Burung for all stations are included in the unsuitable category (Figure 6) based on the suitability matrix criteria [28]. Mangrove ecotourism is not suitable because not all mangrove ecosystems thrive, this can

![Figure 4. Tides on the Tanjung Burung period Januari-December 2019.](image-url)
be caused by different mangrove adaptation patterns, basic substrate conditions, total nutrient content, salinity turbidity, and pH. Water quality or turbidity and pH affect the growth of plant height, number of leaves, and stem diameter of mangrove seedlings [1].

The condition of the mangrove ecosystem that has been planted is still in the sapling and seedling category, so it will take about 4-7 years to reach the tree category. Suitable results for ecotourism development. Another factor that causes the value of the suitability of mangrove ecotourism is not suitable because not all areas can be overgrown with mangroves properly at the current conditions because the topography and depth of the waters are not supportive. This requires gradual rehabilitation so that the substrate can form to form conditions that can be planted with mangroves.
3.6. Regional carrying capacity (RCC)

The length of the coastline of the Tanjung Burung area can be developed for mangrove ecotourism through a predetermined route of about 2859 m, so that the carrying capacity of ecotourism in the mangrove ecosystem area is 229 people/day. The current condition and status of the suitability of mangrove ecotourism is still not optimal so that the fulfillment of carrying capacity cannot be carried out normally because the condition of the mangrove ecosystem is still being carried out by rehabilitating mangrove planting. However, the development of ecotourism can still be carried out through a mangrove rehabilitation approach which has educational substance so that it can be called an edutourism activity. The average number of tourist visits is around 20-100 people/month (results of community interviews). The potential to bring in visitors to offer edutourism aspects as well as invite mangrove planting is quite large. Therefore, an education-based mangrove ecotourism management strategy is needed.

4. Conclusions

The condition of the mangrove ecosystem in Tanjung Burung is generally at the age of seedlings and saplings with a density that still needs to be increased for ecotourism development. The development of ecotourism is directed at education-based mangrove rehabilitation efforts so that the ecotourism currently being developed is edutourism with a carrying capacity of 229 people/day considering that the travel time for each visitor is 4 hours for eight operational hours per day. The strategy for the rehabilitation of mangrove ecosystems aims to analyze the characteristics of mangrove damage and habitat, repair seawater irrigation systems, and plant mangrove vegetation.

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