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# Analysis of Tourism Suitability and Carrying Capacity of Mangrove Areas in Sumberkima Village, Buleleng Regency, Bali

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**Abstract**. The mangrove forests in Sumberkima Village, Buleleng Regency, Bali, hold significant potential for development as eco-friendly tourism destinations. This study aims to analyze the mangrove health index and the suitability of the mangrove area as an ecotourism destination, and to determine the area's carrying capacity for tourism activities. The methodology involves analyzing ecotourism parameters, including mangrove thickness and density, mangrove species, tidal patterns, and the presence of biotic objects. Primary data were collected through field observations, while secondary data were obtained from official sources. The study results indicate that the mangrove area in Sumberkima Village has a mangrove health index ranging from 34.89% to 51.18%, categorized as moderate. The mangrove tourism suitability index reveals that one observation station falls into the "suitable" category, with an index of 2.12, while the other two stations are classified as "not suitable." The carrying capacity for mangrove trekking activities is estimated at 223 visitors per day. This study concludes that the mangrove area in Sumberkima Village has potential for development as an ecotourism area. However, efforts to improve the quality of the mangrove ecosystem and tourism infrastructure are necessary to optimize the area's potential in a sustainable manner.

***Keywords***: mangrove health; tourism suitability; mangrove tourism; carrying capacity; Sumberkima village

## I. INTRODUCTION

Mangrove forests play a crucial role in coastal ecosystems, providing ecological, economic, and social benefits. They support local economies through forestry, fisheries, industry, and tourism [40]. Ecotourism, which promotes environmental conservation while generating economic opportunities, is one aspect of mangrove forests that remains underutilized [12].

Beyond their economic contributions, mangroves serve as carbon sinks, prevent erosion, filter pollutants, and provide shelter for diverse marine species [2]. Additionally, they support local communities by providing resources for fisheries and alternative livelihoods [31]. Sumberkima Village in Buleleng, Bali, boasts a rich mangrove ecosystem, making it a prime candidate for ecotourism development.

The Buleleng Regency Government has identified several key coastal attractions in Sumberkima, including Gili Putih, mangrove forests, and diving sites. This region boasts a dynamic marine ecosystem, characterized by coral reefs, seagrasses, and mangrove habitats [32]. Assessing the health of the mangroves is essential to maintaining their ecological function and ensuring they remain viable for tourism. The biodiversity of mangrove species and their associated fauna serves as a key indicator of the ecosystem's overall health.

Previous research by Pradisty et al. [32] focused on characterizing Sumberkima's mangrove ecosystem but lacked a comprehensive health assessment. This study fills that gap by evaluating the suitability of the area for ecotourism, using a tourism suitability index and estimating the maximum visitor capacity to prevent environmental degradation.

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## II. METHODS

The research was conducted in September 2024 in the mangrove area of Sumberkima Village, Buleleng, Bali.

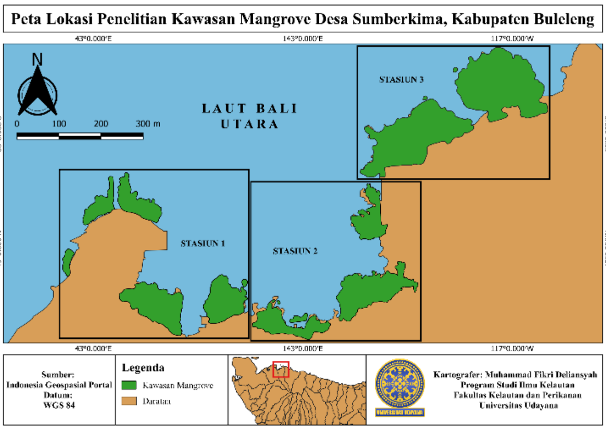


Figure 1. Research Site

TABLE 1
RESEARCH STATION COORDINATE

| STATION | Research Coordinate | |
|---|---|---|
| | Latitude | Longitude |
| 1 | -8.1352746 | 114.5990562 |
| 2 | -8.1359862 | 114.6046382 |
| 3 | -8.1339068 | 114.6055016 |

### Research Implementation

The selection of sampling locations used a purposive sampling method, where observation stations were determined based on specific research objectives. Sampling stations were selected to represent the various mangrove zones in the study area. The parameters measured to assess mangrove suitability and health included mangrove thickness, density, species composition, trunk circumference, and canopy cover. Additionally, tidal fluctuations and biotic components associated with the mangrove ecosystem were observed [52].

*Mangrove Data Collection*

Mangrove thickness was measured using satellite imagery and GPS tools, with three points per station measured from the outermost seaward line, perpendicular to the landward edge of the mangrove vegetation, and averaged per station in meters. Mangrove density and species data were collected using the 10 × 10 m² quadrant transect method with nine plots per station. In each plot, data on tree circumference and diameter were recorded. Canopy cover data were collected using hemispherical photography in 10 m × 10 m plots.

*Tidal and Biota Data Collection*

Tidal data were obtained from secondary sources on the website pasanglaut.com. The real tidal range was calculated by subtracting the lowest tide value from the highest tide value over one month. Biota data were collected through direct observation and documentation using cameras. Identified biota were classified to the genus level using the Field Identification Guide to the Living Marine Resources of Kenya.

*Carrying Capacity Data Collection*

The parameter measured for analyzing the carrying capacity of mangrove ecotourism was the utilizable mangrove area length (Lp) for ecotourism activities. Here, Lp was calculated based on the total mangrove thickness at each observation station, measured during the suitability data collection phase, in meters.

### Data Analysis

*Mangrove Density*

Species density refers to the number of stands of species i per unit area. Density was calculated using the formula:

$$Xi = Ni/A$$

Where $X_i$ = density of species i (ind/m²), $N_i$ = number of individuals of species i, and A = sampling area.

*Mangrove Canopy Cover Percentage*

According to Dharmawan and Pramudji (2014), the percentage of mangrove canopy cover is calculated using the following formula:

$$\%\ Canopy\ Cover = \frac{P_{255}}{\sum P}$$

Where $P_{255}$ = number of pixels with a value of 255 (representing mangrove canopy), and $\sum P$ = total number of pixels.

If the percentage of sky cover is found to be greater than the percentage of mangrove canopy cover, an additional step is required before calculating the canopy cover percentage. This involves adjusting the canopy pixel count ($P_{255}$) by subtracting the number of sky pixels from the total number of pixels.

$$P_{255} = P_{tot} - P_0$$

$$C = \frac{P_{255}}{P_{tot}} x100\%$$

$$C = \frac{(P_{tot} - P_0)}{P_{tot}} x100\%$$

Where C = canopy cover percentage (%), $P_{255}$ = number of pixels representing canopy, $P_{tot}$ = total number of photo pixels, $P_0$ = number of pixels representing sky.

Before applying the above formula, the first step involves converting the image's RGB color combination to grayscale by reducing the image resolution from 64-bit to 8-bit. Subsequently, the pixel values for the sky and mangrove are separated, resulting in two distinct values: 0 (minimum) for the sky and 255 (maximum) for the mangrove canopy. This pixel value conversion is performed using the ImageJ software.

*Mangrove Health Index (MHI) Analysis*

The Mangrove Health Index (MHI) was calculated for each plot using three components: canopy cover, sapling density, and tree diameter. The methodology followed by Dharmawan et al. (2020):
Canopy Cover Score ($S_c$):

$$S_c = 0,25\ x\ C = 13,06$$

This is only valid if Sc < 10; if $S_c$ >10, set $S_c$ = 10.

Sapling density score ($S_{nsp}$):

$$S_{nsp} = 0,13\ x\ N_{sp} + 4,1$$

Where only valid if $S_{nsp}$ < 10, if $S_{nsp}$ > 10, set $S_{nsp}$ = 10.

Tree diameter score ($S_{dbh}$):

$$S_{dbh} = 0,45\ x\ DBH\ x\ 4,1$$

This is only valid if Sdbh < 10; if $S_{dbh}$ > 10, set $S_{dbh}$ = 10.

Final MHI calculation:

$$MHI\ (\%) = \frac{S_c + S_{nsp} + S_{dbh}}{3} x10$$

Where:
MHI: Mangrove Health Index
DBH: Tree Diameter
C: Canopy cover Percentage
NSP: Sapling Density

The calculated MHI can be interpreted using the criteria outlined by Dharmawan (2021):
Poor Condition: 0.00% - 33.32%
Moderate Condition: 33.33% - 66.66%
Excellent Condition: 66.67% - 100%

*Mangrove Tourism Suitability Parameters*

Mangrove tourism suitability is assessed based on five parameters, each with four classification criteria. The parameters for mangrove suitability include mangrove thickness, density, species diversity, tidal patterns, and biota objects [52].

TABLE 2
MANGROVE TOURISM SUITABILITY PARAMETERS

| Parameter | Weight | Category | Score |
|---|---|---|---|
| Thickness (m) | 0.380 | >500 | 3 |
| | | >200-500 | 2 |
| | | 50>200 | 1 |
| | | <50 | 0 |
| Density (ind/100m$^2$) | 0.250 | >15-20 | 3 |
| | | >10-15;>20 | 2 |
| | | 5-10 | 1 |
| | | <5 | 0 |
| Mangrove type | 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 | 0.10 | I K M R B | 3 |
| | | I K M B | 2 |
| | | I M | 1 |
| | | One of the Biota | 0 |

Where: I= Fish; K = Crustacean; M = Mollusca; R = Reptile; B = Bird.

The suitability index (IKW) was calculated as:

$$IKW = \sum_{i=1}^{n} (Bi\ x\ Si)$$

Where $B_i$ = Parameter Weight and $S_i$ = Parameter Score.

*Carrying Capacity Analysis*

Carrying capacity (DDK) for mangrove trekking was calculated using:

$$DDK = K\ x \frac{L_p}{L_t}\ x \frac{W_t}{W_p}$$

Ecological potential of visitors per unit area (person) (K), Utilizable area (m²) or length of area (m) (Lp), Unit area for a specific category (m² or m) (Lt), Time allocated by the region for nature-based tourism activities in one day (Wp), and Time spent by visitors per activity (hours) (Wt).

## III. RESULTS AND DISCUSSION

### Mangrove Health Index

*Mangrove Individual Density*

The measured mangrove density ranged from 1,600 to 6,200 individuals per hectare (ind/ha). The average density across all stations was 3,370 individuals per hectare, indicating moderate to good growth conditions.

TABLE 3
INDIVIDUAL MANGROVE DENSITY IN SUMBERKIMA VILLAGE

| Plot | Density (ind/ha) | | |
|---|---|---|---|
| | Station 1 | Station 2 | Station 3 |
| 1 | 6.200 | 3.100 | 3.700 |
| 2 | 5.200 | 1.600 | 4.700 |
| 3 | 1.900 | 2.000 | 4.300 |
| 4 | 2.400 | 2.000 | 2.600 |
| 5 | 2.500 | 3.300 | 4.200 |
| 6 | 4.400 | 3.200 | 4.300 |
| 7 | 3.600 | 3.200 | 3.300 |
| 8 | 3.500 | 2.000 | 2.700 |
| 9 | 4.600 | 2.900 | 3.600 |
| Average per station | 3.811 | 2.589 | 3.711 |
| Overall average | | 3.370 | |

The mangrove density in Sumberkima Village ranges from 2,589 to 3,811 ind/ha, with no significant differences between stations. This uniformity is attributed to the muddy substrate, which supports the growth of mangroves.

*Mangrove Canopy Cover*

The canopy cover percentage ranged from 17.00% to 87.38%, with an overall average of 59.65%. The interpretation of the overall canopy coverage result is shown in Table 4.

TABLE 4
MANGROVE CANOPY COVER IN SUMBERKIMA VILLAGE

| Plot | Canopy coverage (%) | | |
|---|---|---|---|
| | Station 1 | Station 2 | Station 3 |
| 1 | 60,59 | 78,80 | 41,55 |
| 2 | 49,85 | 71,95 | 83,35 |
| 3 | 28,85 | 81,68 | 34,13 |
| 4 | 17,00 | 87,38 | 46,49 |
| 5 | 33,39 | 77,63 | 85,20 |
| 6 | 78,09 | 65,86 | 80,05 |
| 7 | 75,92 | 84,72 | 74,00 |
| 8 | 27,64 | 38,17 | 51,95 |
| 9 | 33,93 | 36,26 | 86,15 |
| Average per station | 45,03 | 69,16 | 64,76 |
| Overall average | | 59,65 | |

The average canopy cover percentage was 59.65%, with Station I having the lowest rate (45.03%) and Station II having the highest (69.16%), which was slightly higher than Station III (64.76%). The overall average canopy cover of 59.65% across the study area falls under the moderate category. This mangrove canopy cover percentage is lower compared to the study conducted in Kwanyar District by Yusuf and Muhsoni (2020), which reported a range of 67.37% to 77.29%. According to Nurdiansah and Dharmawan (2018) and Tinambunan et al. (2021), mangrove canopy cover is influenced by tree density categories and environmental suitability. Additionally, Wasil and Muhsoni (2023) state that canopy cover is affected by anthropogenic activities and irregular canopy patterns.

*Mangrove Individual Density*

The Mangrove Health Index (MHI) values ranged from 34.89% to 51.18%, categorizing all stations as moderate health. Station 2 had the highest MHI (51.18%), followed by Station 3 (45.56%) and Station 1 (34.89%). These results reflect the combined effects of moderate canopy cover, sapling density, and tree diameter.

TABLE 5.
MANGROVE HEALTH INDEX (MHI) RESULTS

| Station | Density (ind/ha) | Canopy coverage (%) | MHI (%) | Interp. |
|---|---|---|---|---|
| 1 | 3.811 | 45,03 | 34,89 | Moderate |
| 2 | 2.589 | 69,16 | 51,18 | |
| 3 | 3.711 | 64,76 | 45,56 | |
| Average | 3.370 | 59,65 | 43,87 | |

This is supported by the relatively uniform height of mangrove trees and a canopy cover that falls into the moderate category. Tree density and canopy cover percentage, when combined with tree diameter, can determine the health condition of mangroves [22]. The MHI value obtained in this study is lower compared to the research by Wasil and Muhsoni (2023), which recorded MHI values ranging from 51.33% to 73.18% in the excellent category, supported by a very dense canopy cover.

**Mangrove Tourism Suitability Index**

*Mangrove Thickness*

The measurement of mangrove thickness in the mangrove ecosystem area of Sumberkima Village resulted in values ranging from 88.42 meters to 184.77 meters, with an average thickness of 123.2 meters. The mangrove thickness at each station is still categorized as not suitable for designation as an ecotourism area. The thickness value for each station is listed in Table 6.

TABLE 6
MANGROVE THICKNESS MEASUREMENTS

| Station | Thickness Mangrove | |
|---|---|---|
| | Line | Panjang (m) |
| 1 | 1 | 88,4 |
| | 2 | 103,67 |
| | 3 | 117,27 |
| | Average | 103,1 |
| 2 | 1 | 96,64 |
| | 2 | 114,66 |
| | 3 | 111,68 |
| | Average | 107,66 |
| 3 | 1 | 184,77 |
| | 2 | 111,89 |
| | 3 | 179,83 |
| | Average | 158,83 |
| Average total | | 123,2 |

The mangrove thickness condition in Sumberkima Village, based on the observation results, falls into the "not suitable" category (<200 m) according to Yulianda (2020). This is because the measured mangrove thickness, from the outermost vegetation facing the sea to the last mangrove vegetation perpendicular to the land, does not exceed 200 meters. Mangrove thickness data serves as a crucial parameter in determining the suitability of an area for mangrove ecotourism, carrying a weight of 0.38 out of 1.00, which significantly influences whether a mangrove area is considered suitable for ecotourism.

A higher mangrove thickness positively affects the abundance of organic matter and the availability of macrobenthos [39]. According to Sadik et al. (2017), mangrove thickness can be an indicator of an area's conservation status and its level of exposure to human activities. This also influences the biodiversity within the region. The thicker the mangrove ecosystem, the more diverse the associated biota, allowing visitors to observe various species that interact with the mangrove forest [53].

*Mangrove Tree Density*

The tree density values in the mangrove area of Sumberkima Village range from 9 individuals/100m² to 42 individuals/100m², with an overall average of 23 individuals/100m². The mangrove density falls into the "Suitable" category.

Based on the obtained results, the calculated mangrove density at the three stations is classified as high. Station 1 has a density value of 24 individuals/100 m², which falls into the "Suitable" category, as a suitable mangrove density ranges between 10–15 and 20 individuals/100 m² [52]. Meanwhile, at Station 2, the recorded mangrove density is 18 individuals/100m², placing it in the "Highly Suitable" category, as the most ideal density falls between >15–20 individuals/100m². Lastly, Station 3 is categorized as "Suitable" with a mangrove density of 27 individuals/100m².

TABLE 7
MANGROVE TREE DENSITY PER STATION

| Plot | Tree Density (Ind/100 m2) | | |
|---|---|---|---|
| | Station 1 | Station 2 | Station 3 |
| 1 | 32 | 31 | 26 |
| 2 | 34 | 16 | 36 |
| 3 | 12 | 14 | 27 |
| 4 | 11 | 20 | 10 |
| 5 | 18 | 22 | 42 |
| 6 | 39 | 16 | 39 |
| 7 | 26 | 19 | 26 |
| 8 | 9 | 11 | 17 |
| 9 | 35 | 17 | 22 |
| Average | 24 | 18 | 27 |

The ideal mangrove density is in the range of 15–20 individuals/100 m². If the number of individuals in a 100m² area is less than 15, it indicates that the mangrove vegetation is too sparse. Conversely, if there are more than 20 individuals per 100m², it suggests that the mangrove vegetation is too dense [29]. These findings indicate that the mangrove ecosystem in Sumberkima Village is classified as "Highly Suitable" at Station 2 and "Suitable" at Stations 1 and 3, making it highly potential for ecotourism development.

According to Susi et al. (2018), the level of human involvement and adaptation patterns in the mangrove ecosystem contribute to differences in mangrove density. Variations in density can impact the survival rate of mangroves, as different species exhibit varying levels of resilience [5]. Additionally, natural support is essential in creating an attractive nature tourism experience, including a well-preserved environment, diverse and non-harmful biota for visitors, and a variety of mangrove species that can also serve as an educational tourism attraction [30].

*Mangrove Species Diversity*

The results indicate that 10 species of mangroves are distributed across all observation stations. Station 1 has 8 different mangrove species, while Stations 2 and 3 each have 7 different species. This indicates that the mangrove species in the area fall into the "Highly Suitable" category, as more than five species are present. The overall distribution of mangrove species is presented in Table 8.

TABLE 8.
MANGROVE SPECIES DISTRIBUTION

| No | Species Name | Station | | |
|---|---|---|---|---|
| | | 1 | 2 | 3 |
| 1 | *Avicennia marina* | + | + | + |
| 2 | *Bruguiera gymnorrhiza* | - | - | + |
| 3 | *Ceriops decandra* | + | - | - |
| 4 | *Ceriops tagal* | + | + | + |
| 5 | *Excoecaria agallocha* | - | + | - |
| 6 | *Lumnitzera racemosa* | + | - | - |
| 7 | *Rhizopora apiculata* | + | + | + |
| 8 | *Rhizopora mucronata* | + | + | + |
| 9 | *Rhizopora stylosa* | + | + | + |
| 10 | *Sonneratia alba* | + | + | + |
| | Total Species | 8 | 7 | 7 |

According to Pradisty et al. (2021), the mangrove area in Sumberkima Village covers approximately 9.59 hectares and hosts a diverse range of associated mangrove species. Based on field observations, 10 different mangrove species were identified in the mangrove area of Sumberkima Village. The majority of the mangrove population is dominated by *Rhizophora mucronata*, which accounts for 42%, and *Sonneratia alba*, which makes up 17%. These two species were present at every observation station. This finding is consistent with the statement by Pradisty et al. (2021), who noted that *Rhizophora spp*. and *Sonneratia spp*. are the most dominant mangrove species in the Sumberkima mangrove area.

Clustered distribution patterns are generally influenced by similar environmental factors and the tendency of species to select favorable habitats. In contrast, random distribution patterns indicate that a mangrove species exhibits uniformity and is not selective in choosing its habitat. The high dominance of *Rhizophora mucronata* is likely due to its ability to grow in various mangrove zones, including marine, terrestrial, and tidal zones. This adaptability allows *Rhizophora mucronata* to thrive more dominantly, comprising nearly half of the total mangrove species found in the Sumberkima Village area.

Additionally, Sonneratia alba also grows naturally and is dominant throughout the entire mangrove area. This aligns with the findings of Pradisty et al. (2021), who stated that Sonneratia alba is estimated to grow and spread naturally in Sumberkima Village.

*Tidal Range*

The tidal data used in this observation was obtained from secondary data provided by the Geospatial Information Agency's website, covering a full year in 2024. The average tidal range for a one-month period was recorded at 1.3 meters, which falls into the "Suitable" category (>1–2 meters).

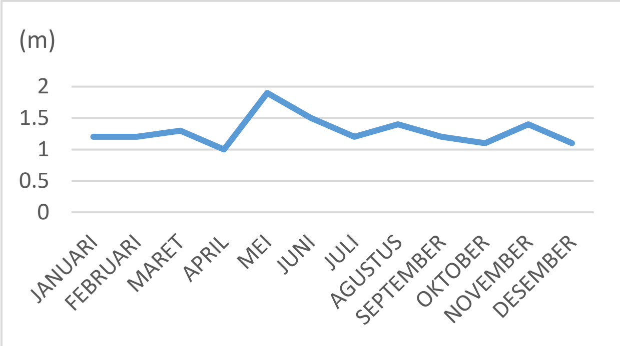


Figure 2. Tidal average of Sumberkima Village on 2024

Based on the secondary data from the Geospatial Information Agency's website, the tidal type in the mangrove area of Sumberkima Village is classified as a semidiurnal tide, meaning there are two high tides and two low tides of equal height within a single day [47]. The average tidal range in September was recorded at 1.3 meters, categorizing it as "Suitable" (>1–2 m).

This condition aligns with the findings of Maulida et al. (2014), which state that mangrove ecosystems are influenced by tidal fluctuations, thereby earning the name "tidal forests." Tides significantly impact sediment characteristics, as they play a dominant role in sediment transport between land and sea [7].

*Biota Objects*

The mangrove ecosystem in Sumberkima Village has a high biodiversity potential, as shown in the table. The diversity of biota found in the Sumberkima mangrove area was observed directly through visual field observations.

A high level of biotic potential plays a crucial role in the biodiversity of an ecosystem, indicating that the Sumberkima mangrove ecosystem has a high level of biodiversity [13]. The highest diversity was found in mollusks, particularly in the Gastropod and Bivalvia classes. Mollusks play an essential role in the ecosystem as decomposers and primary consumers. They are typically found within the substrate or attached to mangrove trees. This finding is consistent with the study by Ginantra et al. (2020) in Pejarakan Village, which has a coastline adjacent to Sumberkima Village, where mollusks were identified as the group with the highest biodiversity.

Other biota found in the area include fish and echinoderms. The diversity of fish species associated with the mangrove ecosystem is also significant in supporting the development of ecotourism. Four fish species were recorded in the area: mudskipper, tembakul, halfbeak, and mullet.

Additionally, the presence of hazardous biota is a crucial indicator in determining ecotourism suitability. The absence of hazardous biota in the Sumberkima mangrove area suggests that it is a safe and suitable location for ecotourism development.

TABLE 9.
BIOTA ASSOCIATED WITH MANGROVES

| No. | *Genus* Biota | Local Name | Station 1 | Station 2 | Station 3 |
|---|---|---|---|---|---|
| 1. | Fish | | | | |
| a. | *Periopthalmus* | *Ikan Glodok* | + | + | + |
| b. | *Boleophthalmus* | *Tembakul* | + | + | + |
| d. | *Parastromateus* | *Ikan Bawal* | - | + | - |
| e. | *Dermogenys* | *Julung-Julung* | + | + | + |
| 2. | Crustacea | | | | |
| a. | *Uca* | *Kepiting Uca* | - | + | + |
| b. | *Macrobrachium* | *Udang Bakau* | - | + | - |
| c. | *Scylla* | *Kepiting Bakau* | + | + | + |
| 3. | Mollusca | | | | |
| a. | *Ostrea* | *Tiram* | + | - | - |
| b. | *Terebralia* | *Siput cincinut* | + | + | + |
| c. | *Telescopium* | *Siput Rodong* | + | + | - |
| d. | *Cassidula* | *Keong Bakau* | + | - | + |
| e. | *Nerita* | *Kubat* | - | + | + |
| 4. | Bird | | | | |
| a. | *Halcyon* | *Raja Udang* | + | + | - |
| b. | *Aerodramus* | *Wallet* | + | + | + |
| c. | *Geopelia* | *Perkutut* | - | + | - |
| d. | *Aegithina* | *Sirtu / Cipoh kacat* | - | + | + |
| e. | *Ardeola* | *Blekok* | - | - | + |
| 5. | Reptill | | | | |
| a. | *Emoia* | *Kadal Bakau* | - | + | + |

*Tourism Suitability Index (IKW)*

The mangrove area in Sumberkima Village has great potential for ecotourism, with a relatively high suitability index. However, among the three data collection stations, only Station 2 falls into the "Suitable" category with an index value of 2.12. Meanwhile, Stations 1 and 3 are still classified as "Not Suitable", with an index value of 1.77.

The suitability map of the area is shown in the following Figure 3.

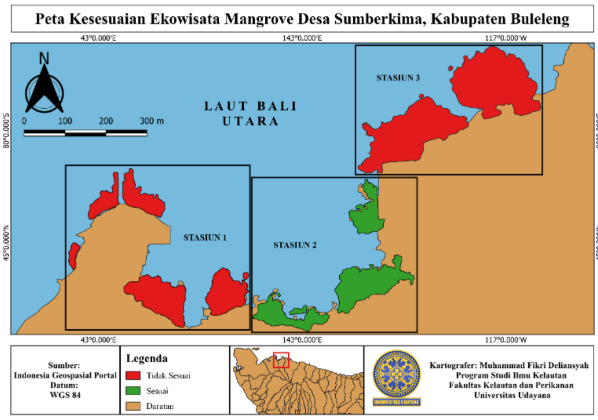


Figure 3. Suitability Map of Sumberkima Village Mangrove Tourism

From all the stations in Sumberkima Village, only one station (Station 2) is categorized as Suitable (2.0 ≤ IKW < 2.5), with an index value of 2.12. Meanwhile, Stations 1 and 3 are categorized as Not Suitable (1 ≤ IKW < 2.0), with an index value of 1.77.

TABLE 10.
TOURISM SUITABILITY INDEX

| Station 1 | | | | |
|---|---|---|---|---|
| Parameter | Weight | Hasil | Score | Ni |
| Thickness | 0,38 | 103,1 | 1 | 0,38 |
| Density | 0,25 | 24 | 2 | 0,5 |
| Type | 0,15 | 8 Type | 3 | 0,45 |
| Tide (m) | 0,12 | 1,3 | 2 | 0,24 |
| Biota object | 0,1 | I, U, K, B | 2 | 0,2 |
| IKW | | Not Suitable | | 1,77 |

| Station 2 | | | | |
|---|---|---|---|---|
| Parameter | Weight | Hasil | Score | Ni |
| Thickness | 0,38 | 107,6 | 1 | 0,38 |
| Density | 0,25 | 18 | 3 | 0,75 |
| Type | 0,15 | 7 Type | 3 | 0,45 |
| Tide (m) | 0,12 | 1,3 | 2 | 0,24 |
| Biota object | 0,1 | I, U, K, R, B | 3 | 0,3 |
| IKW | | Suitable | | 2,12 |

| Station 3 | | | | |
|---|---|---|---|---|
| Parameter | Weight | Hasil | Score | Ni |
| Thickness | 0,38 | 158,3 | 1 | 0,38 |
| Density | 0,25 | 27 | 2 | 0,5 |
| Type | 0,15 | 7 Type | 3 | 0,45 |
| Tide (m) | 0,12 | 1,3 | 2 | 0,24 |
| Biota object | 0,1 | I, K, R, B | 2 | 0,2 |
| IKW | | Not Suitable | | 1,77 |

The tourism suitability index obtained for the mangrove area in Sumberkima Village shows that, in terms of mangrove species and density, the area has high species diversity and density across all stations. A higher number of mangrove species supports the diversity of associated biota and serves as a primary habitat for other organisms [33]. In addition, the tidal parameter recorded in the Sumberkima Village waters is classified as ideal and falls within the Suitable category for ecotourism, ensuring comfort and safety for visitors engaging in ecotourism activities. This is further supported by the rich biodiversity of organisms associated with the mangrove area, including fish, mollusks, crustaceans, and birds found in the region.

Based on the land suitability parameter for thickness, the mangrove area has a low thickness value. This is likely due to its proximity to residential areas and the high level of fishing activities in the area. The greater the mangrove ecosystem thickness, the higher the diversity of associated biota, allowing visitors to observe various species living in the mangrove forest [35].

Additionally, the relationship between mangrove tourism suitability and the mangrove health index in this study shows a direct correlation. This is influenced by overlapping parameters between mangrove health assessment and tourism suitability evaluation, particularly mangrove density. A healthy mangrove ecosystem is an attractive feature for visitors, making ecotourism activities more enjoyable. Therefore, the better the health condition of a mangrove ecosystem, the more suitable it is for ecotourism development [33].

Based on the calculated tourism suitability index for the Sumberkima Village mangrove area, reforestation efforts in the mangrove ecosystem are necessary as an alternative strategy to enhance the potential of mangrove resources. Mangrove rehabilitation and replanting are crucial solutions to increase mangrove thickness, which has a significant impact on mangrove litter production —a key component of the mangrove food chain. This, in turn, enhances the associations between mangrove ecosystems (Rodiana, 2019).

**Carrying Capacity**

Based on the obtained results, the calculation of the area's carrying capacity was conducted to determine the maximum number of tourists that can be physically accommodated within a certain period without causing disturbances to nature and human activities. In mangrove tourism, one of the activities with high development potential is mangrove trekking. Therefore, a mangrove trekking design plan was created to measure the area that can be utilized for tourism activities.

The calculation performed after obtaining the usable area length (Lp) for ecotourism activities was followed by a design plan for the mangrove trekking route. Strategic design, commonly known as a site plan, is an effort to develop tourism by adapting the route length to the conditions, potential, and characteristics of the existing mangrove ecosystem [43].

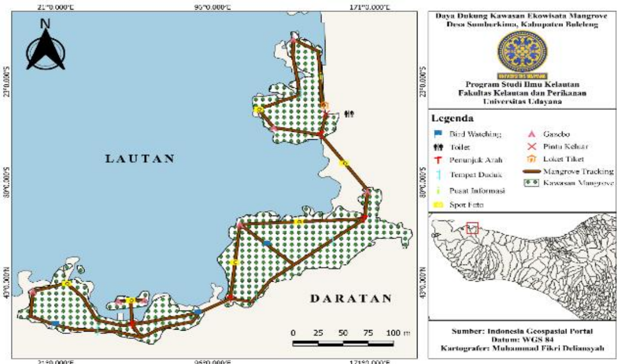


Figure 4. Carrying Capacity Map of Sumberkima Village Mangrove Tourism

One of the most promising ecotourism activities is mangrove trekking. According to the trekking design plan developed for the Sumberkima Village mangrove area, the site features 12 tracks with a total length of 1,393 meters. Based on the calculated carrying capacity, the estimated maximum number of visitors per day is 223 people. This finding aligns with Yulianda (2020) in Ekowisata Perairan, which states that the suitable length for a mangrove trekking route is 25 meters per visitor per day.

The mangrove trekking route serves as a supporting facility for educational tourism, allowing visitors to explore and learn about various mangrove species and associated fauna through a wooden bridge pathway [46]. The mangrove trekking route design can be enhanced with additional facilities to support other ecotourism activities, such as ticket booths, photo spots, information centers placed at several locations along the route to provide details about mangrove species and associated fauna, gazebos for visitors to rest or seek shelter during rain, and toilets for visitor convenience.

Furthermore, given the rich bird diversity in the mangrove ecosystem, it is recommended to install bird-watching facilities at several points along the route, allowing visitors to observe birds using telescopes [33].

## IV. CONCLUSION

This research addresses the critical gap in empirical assessments of mangrove ecosystems' potential for sustainable ecotourism by analyzing the health, suitability, and carrying capacity of Sumberkima Village's mangrove area. Through a multidisciplinary approach integrating ecological parameters (thickness, density, species diversity, canopy cover) and socio-environmental factors (tidal patterns, biota presence), the research reveals that while the mangrove health index (34.89–51.18%) reflects moderate conditions, only one of three stations meets ecotourism suitability criteria due to suboptimal mangrove thickness and uneven density. The calculated carrying capacity of 223 visitors/day underscores the need for balanced infrastructure development to prevent ecological degradation. Contributing to coastal ecosystem management, this research presents a replicable framework for assessing mangrove ecotourism potential, highlighting the interplay between ecological resilience and human activities. It advances scientific understanding by linking quantitative health metrics to tourism suitability, providing policymakers and conservationists with actionable insights to optimize mangrove-based tourism while safeguarding biodiversity—a model applicable to similar coastal regions worldwide.

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