Carrying capacity of mangrove tourism in the district of Cilamaya Wetan, Karawang regency, West Java province

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Abstract. The study was conducted in the District of Cilamaya Wetan, Karawang Regency, West Java Province from November to December 2019. The purpose of this study was to analyze the carrying capacity of tourism in mangrove tourism areas. Based on the results in the field, the carrying capacity of tourism is only found in Sukakerta Village with the wide area that can be used as tourism and there is a visit by tourists, precisely in the Tangkolak Maritime Center which is able to accommodate as many as 1,345 persons with the time provided in the development of the area by tour manager, that is for 24 hours/day. Tourist activities based on interviews include sitting relaxed, taking photos, walking down the road, enjoying the scenery, and planting mangrove seedlings scattered in Sukakerta Village.

1. Introduction
The coastal ecosystem is a community unit of plants, animals and other organisms that interact between individuals and their environment. This coastal ecosystem has potential natural resources and environmental services, for example, mangrove forests. Mangrove is a type of woody tree that grows in coastal areas between land and sea which only exists in tropical and partly subtropical areas [1]. As a typical ecosystem in coastal areas, the mangrove forest ecosystem has many functions and benefits in supporting the sustainability of other ecosystems involved in it. Mangrove forest ecosystems can function physically, ecologically (biophysically) and economically. One of the economic functions of mangroves is as a potential area for recreation (tourism), aquaculture land and conservation areas [7]. The richness and versatility of the mangrove ecosystem attract people to use it, both from the agencies in regulating its use and also from the community as the driving agent.

One of the mangrove forest ecosystems which is used as a recreation area (tourism) is in the Cilamaya Wetan District, Karawang Regency, West Java, Indonesia. Since the inauguration of the Tangkolak Maritime Center (TMC) in Sukakerta Village on 26 December 2018, there have been activities of tourist visits that have increased by ± 100%. Based on this, it is necessary to study the carrying capacity of tourism. [2] states that carrying capacity is intended to determine ecological disturbances from the use of an area. According to Hammit & Cole (1987) in [3], the ecological disturbance in question is an undesirable condition in the scope of outdoor recreation. In the context of tourism, [8] explains that carrying capacity is the ability of an area to receive tourists as expressed in the number of tourists per unit area per unit time. [5] more specifically define the carrying capacity in the context of tourism as the maximum amount of tourists in the use of a location without any changes to the physical environment and the quality of visiting activities that tourists get. The carrying capacity of tourism according to the concept developed by [10], namely AAC (Area Supporting Capacity), which considers the area or length...
of an area and the length of time to use the area of an ecosystem. The carrying capacity of this tourism is intended from the concern that human activities could disrupt the mangrove ecosystem in terms of quality and resources. The mangrove ecosystem in Cilamaya Wetan District is spread over 4 villages, namely Sukakerta Village, Rawagempol Kulon Village, Muara Baru Village, and Muara Village.

2. Methods

2.1 Study area
The research area includes coastal villages that have mangrove areas in the Cilamaya Wetan District, namely Sukakerta Village, Rawagempol Kulon Village, Muara Baru Village, and Muara Village. This district is bordered by Subang Regency in the east. While in the north it is bordered by the Java Sea. To the west and south, it is bordered by Cilamaya Kulon and Banyusari Districts. The area of Cilamaya Wetan District has a total area of 69.66 km\(^2\) (3.96% of the total area of Karawang Regency), with the largest area being Muara Village (15.69 km\(^2\)) and the smallest is Tegalsari Village (2.1 km\(^2\)). The tides in Karawang waters are included in the semi-diurnal type, which is two times the tide and the low tide overnight \[9\].

The selection of the research area was based on the physical existence of mangroves that could potentially be developed for tourism with an area of 150 hectares, 110 hectares, 227 hectares, and 305 hectares, respectively. The sea currents in Karawang Regency are influenced by winds, especially the east monsoon and the west monsoon wind. From December to February, the wind blows from the southeast, for March to May, the wind blows from the northeast. Both conditions are caused by the east monsoon wind, while the west monsoon wind affects from June to August, where the wind blows from the west and from September to November, where the wind blows from the south.

2.2 Data collecting
The research was conducted from November to December 2019. Administrative data were collected from Basic Geospatial Information (BGI). The BIG data used comes from GIA (Geospatial Information Agency). The administrative data in question is Karawang Regency in 2013. Administrative data is selected on the ArcGIS tool to obtain administrative boundaries of Karawang Regency. Collecting data for the carrying capacity of mangrove tourism includes observation and direct interviews with tourists at each observation station using a research questionnaire. In addition, direct interviews were conducted with mangrove ecosystem managers.

Observations were made to see tourist visits at the Tangkolak Maritime Center location. Sampling for tourists based on non-probability sampling with the type of convenience sampling. Interviews were conducted based on the operational hours of the tourist area with attention to the tourist population based on [4] with a number of \(\geq 30\) person and supported by [6] with a number of \(\geq 30\) person. The tools and materials in this research used include stationery (research questionnaires, books, pencil/pen), smartphone camera, meter gauge, raffia rope, ArcGIS 10.3, Avenza Maps, and ENVI 5.1 software.

2.3 Data processing
Mangrove tourism carrying capacity data processing is based on [10] by taking into account the visits from tourists. Interviews were conducted with visiting tourists. The calculation of the carrying capacity of mangrove tourism is as follows:

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ACC = K \times \frac{Lp}{Lt} \times \frac{Wt}{Wp}
\]

Information:

- \(ACC\): Carrying capacity of tourism area (person/day)
- \(K\): Ecological potential of tourists per unit area (number of person)
- \(Lp\): Area or length of usable area (m/m\(^2\))
- \(Lt\): Unit area for a certain category (m/m\(^2\))
Wt: Time provided by the mangrove ecosystem for tourism activities in a day (hours)
Wp: Time spent by tourists on tours of each particular activity (hours)

The constant "K" is obtained based on the number of tourists who become the overall sample of each activity. The constant "Lp" is obtained based on directions from the manager and the local government regarding the extent and length of the Tangkolak Maritime Center location for tourism. The constant "Lt" is obtained based on [11], in which there is a measure for each activity. For example, it takes 10 meter²/person to sit back and relax. In addition, it is also obtained based on calculations in the field, for example, the activities of the photographs are assumed by the researcher as 10 meter x10 meter/person. The constant "Wt" is obtained based on the provisions of the manager and local government in serving tourist activities. And for the constant "Wp" is obtained from the amount of time spent by tourists per activity.

2.4. Data analysis
The analysis carried out in this research is in the form of spatial, quantitative, and descriptive. Spatial analysis can explain which locations have the carrying capacity of high, medium, and low tourism categories, as well as regional characteristics of the three categories. Meanwhile, quantitative analysis to determine the carrying capacity of mangrove tourism from [10]. And descriptive analysis are used to explain the overall tourism carrying capacity of mangroves

3. Result
The carrying capacity of mangrove tourism which has value is in the mangrove area in Sukakerta Village because there are visits by tourists. The carrying capacity of mangrove tourism is carried out based on [10] formula using a research questionnaire for tourists. Mangrove tourism carrying capacity data obtained is presented in Table 1.

| Activities                  | K   | Lt   | Lp   | Wt   | Wp   | ACC   |
|-----------------------------|-----|------|------|------|------|-------|
| Sitting relaxed             | 132 | 1320 m² | 6.003 m² | 24 hour | 37 hour | 389   |
| Taking photo                | 48  | 4800 m² | 833 m² | 7 hour | 29    |       |
| Walking down the road       | 49  | 1225 m | 1.410 m | 11.75 hour | 115    |       |
| Enjoying the scenery        | 83  | 2075 m² | 510 m² | 24.5 hour | 20     |       |
| Planting mangrove seedlings| 55  | 5500 m² | 16.500 m² | 5 hour  | 792    |       |

After the data is integrated into the formula [10], the total value for the carrying capacity of mangrove tourism at the Tangkolak Maritime Center is obtained, which is 1.345 person/day (total of ACC). This value indicates that the maximum number of visitors allowed to tour the Tangkolak Maritime Center mangrove area is 1.345 person in one day based on 24 hour operational time. This value means that there is a limit to the number of visitors aimed at reducing the negative impact and it is feared that it will cause harm to the mangrove tourism area. The value of the carrying capacity of mangrove tourism for sitting relaxed activities is 389 person/day with a usable area of 6.003 meter².
Figure 1. Map of sitting relaxed, taking photo, and enjoying the scenery activity

This activity is usually carried out by tourists around the *saung* (gazebo) attraction in the western and eastern parts of the Tangkolak Maritime Center. The carrying capacity value for photo activities is 29 person/day with a usable area of 833 m$^2$ (210 m$^2$ comes from the east and west bridges with a width of 0.5 meter, 660 m$^2$ comes from the east side of the Tangkolak Maritime Center road with a width of 1 meter, and 3 m$^2$ comes from the gazebo at the east end of Tangkolak Maritime Center with a width of 3 meter). This activity is carried out by tourists in places that have aesthetic value, such as in the midst of a dense mangrove ecosystem, *saung* attractions, and bridge attractions. Especially for bridge attractions, tourists usually do this activity at sunrise and sunset. For activities along the road, the value of mangrove tourism carrying capacity obtained is 115 person/day with an area that can be utilized along 1.410 m (990 meter from the trail, 200 meter from the rail on the west bridge of Tangkolak Maritime Center, and 220 meter from the rail on the eastern bridge of Tangkolak Maritime Center).

Figure 2. Map of walking on the road and planting mangrove seedling activity

This activity is carried out by tourists based on the boundaries of tourism at the 330 meter (track length) west Tangkolak Maritime Center and 660 meter (track length) east Tangkolak Maritime Center.
In addition, along the road activities are also carried out at the bridge attraction, which is in the west part of the Tangkolak Maritime Center is 200 meter (track length for tracking) long and the eastern part is 220 meter (track length for tracking) of Tangkolak Maritime Center. Then for the activity of enjoying the view, the value of mangrove tourism carrying capacity is obtained by 20 person/day with an area of 510 meter$^2$ (210 meter$^2$ comes from the west and east side of the bridge attraction of Tangkolak Maritime Center, and 300 meter$^2$ comes from the east lane of Tangkolak Maritime Center with a width of 1 meter and a length of 300 meter) that can be utilized. This activity is carried out by tourists at the bridge attraction and while walking along the road which is served by dense mangrove trees.

Meanwhile, for the planting of mangrove seedlings, the tourism carrying capacity value was 792 person/day with a usable area of 16,500 meter$^2$ (6,000 meter$^2$ comes from the mangrove nursery near the west side of the Tangkolak Maritime Center bridge with a length of 200 meter and a width of 30 meter. And 10,500 meter$^2$ comes from a mangrove nursery near the eastern bridge of Tangkolak Maritime Center with a length of 350 meter and a width of 30 meter). The area that can be used for this activity is carried out on the shoreline to the open sea with details of 200 meter x 30 meter on the west side of the Tangkolak Maritime Center and 350 meter x 30 meter in the eastern part of the Tangkolak Maritime Center. This activity is usually carried out by tourists who come from the type of group, namely both provinces, districts/cities, and universities. For more details regarding the visualization of tourist activities, it can be seen in figure 2.

![Map of the tourism support capacity of sukakerta village](image)

**Figure 3.** Map of the tourism support capacity of sukakerta village

Based on the map in figure 3, the high tourism carrying capacity was located in the area where mangrove seedlings were planted, along the road on the west side of the Tangkolak Maritime Center, and along the west side of the road in the east of the Tangkolak Maritime Center area. Meanwhile, the medium tourism carrying capacity is located in the gazebo attraction area in the eastern part of Tangkolak Maritime Center. And for the low category tourism carrying capacity lies in the attractions of bridges and road tracks in the eastern part of the Tangkolak Maritime Center. The level of tourism carrying capacity is obtained based on the number of tourists that can be accommodated by an area in activities. The more tourists that can be accommodated in an area, the higher the tourism carrying capacity of the region. High tourism carrying capacity can facilitate tourist activities to plant mangrove seeds and walk along the road. Medium category can facilitate tourist activities to plant mangrove trees, and the low category can facilitate tourist activity down the road, taking photos, and enjoying the scenery.
Figure 4. Map of tourism support capacity based on the number of tourists in Sukakerta village

The carrying capacity of the high category in total can accommodate as many as 907 person/day in 4 different locations. Based on field findings and visualization of figure 4, the first location is on the west coast of the Tangkolak Maritime Center area which can accommodate 15 person for planting mangrove seedlings. The second location is also on the shoreline but in the eastern part of the Tangkolak Maritime Center area which can accommodate 40 person for planting mangrove seedlings. The third location is on the west side of the Tangkolak Maritime Center area which can accommodate 17 person for activities along the road. The fourth location is on the west line along the eastern part of the Tangkolak Maritime Center area which can accommodate 27 person for activities along the road. In the activity of planting mangrove seedlings, the second location (the eastern shoreline of the Tangkolak Maritime Center area) is more preferred by tourists for activities compared to the first location. This is because there are differences in the area for planting mangrove seedlings themselves. For the western part it is only 200 meter x 30 meter, while the eastern part is 350 meter x 30 meter.

There are many programs from the government, both from regencies/cities or provinces, as well as universities which are also the reason for this second location more tourists than the first location. Another reason is that this second location is close to the road leading to the Tangkolak Maritime Center entrance and is easily accessible by two-wheeled or four-wheeled vehicles. Meanwhile, the first location is far from the road to the entrance to the Tangkolak Maritime Center area and is difficult to access using two wheeled and four-wheeled vehicles, but requires walking. Because to reach this first location, we must pass through the narrow alleys of the local residents’ houses. In activities along the road, the second location is also chosen by more tourists than the first location. Apart from the reasons for easy access and the existence of many programs from the government and universities, there are also other reasons, namely that the railing in the fourth location has been cast, which makes it easier to mobilize tourists in their activities.

The carrying capacity of the medium category can accommodate 418 person/day in 2 different location. Based on field findings and visualization of figure 4, the first location is in the hut in the western part of the east of the Tangkolak Maritime Center area which can accommodate 114 person in total, with details of 97 person for sitting and relaxing activities and 17 person for taking photos. The second location is in the huts in the eastern part of the east of the Tangkolak Maritime Center area which can accommodate 43 person in total, with details of 35 person for sitting and relaxing activities and 8 person for taking photos. The first location has more tourist activity because this location is the closest
to the road to the Tangkolak Maritime Center entrance. Then this location has a relatively large number of attractions for the shelters compared to the second location. In addition, the presence of booths for food or drink sellers and souvenirs is also the reason this location is more supportive of sitting and taking photos.

The carrying capacity of the low category in total can accommodate as many as 164 person/day in 3 different location. Based on field findings and visualization of figure 4, the first location is on the bridge in the western part of the Tangkolak Maritime Center area which can accommodate 45 person in total, with details of 8 person for taking photo activities, 3 for walking along the road, and 34 for enjoying the scenery. The second location is on the bridge as well, but in the eastern part of the Tangkolak Maritime Center area which can accommodate 55 person in total, with details of 8 person for photo activities, 4 person for walking along the road, and 43 person for enjoying the scenery. The third location is on the eastern side of the road in the east of the Tangkolak Maritime Center area which can accommodate 18 person in total, with 7 person for photo-taking activities, 5 person for walking along the road, and 6 person for enjoying the scenery.

It can be interpreted that most activities were in the second location, namely the bridge in the eastern part of the Tangkolak Maritime Center area. This is because the location of the bridge in the eastern part of the Tangkolak Maritime Center area is close to the location of planting mangrove seedlings on the eastern shoreline of Tangkolak Maritime Center, where the pathways have been cast and are more accessible than the first and third locations. In addition, the attraction of the bridge is bigger and longer than the bridge in the western part of the Tangkolak Maritime Center area. And in terms of enjoying the view, especially at sunset, tourists are more satisfied seeing it from this location.

4. Conclusion

The value of the carrying capacity of tourism in the mangrove area in Sukakerta Village, namely 1.345 person/day in total and for each activities. High tourism carrying capacity has a characteristic area of 16.500 meter$^2$ and 1.410 meter with details that can facilitate planting mangrove seedling and walking down the road as many 907 person/day. Medium carrying capacity has a characteristic area of 6.836 meter$^2$ with details that can facilitate sitting relaxed and take photo as many 418 person/day. And low carrying capacity has a characteristic area of 1.343 meter$^2$ and 1.410 meter with details of being able to facilitate take photo, walking down the road, and enjoying the scenery as many 164 person/day. It can be seen that the closer to accessibility and the easier the accessibility is to pass, the higher the value of the tourism carrying capacity of a location. The results of this tourism carrying capacity value can be used as a policy for local managers and governments in tourism development to improve the local economy by prioritizing the environmental sustainability of the existing mangrove ecosystem.

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