Potential of mangrove ecosystem as coastal tourism based on biophysical conditions and water quality in Cilamaya Wetan, Karawang Regency

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Abstract. Mangrove ecosystem is the ecosystems that has an important role not only for the life of flora and fauna, but also for the society around the ecosystem. This ecosystem needs to be considered for its sustainability as an effort to utilize the ecosystem. Cilamaya Wetan Sub-district is one of the sub-districts in Karawang Regency which has a very wide mangrove forest that reaches 1,019 ha. Biophysical condition and water quality, and also location factors for accessibility and its distance from the settlement need to consider, in which to develop mangrove ecosystem into tourism. Biophysical variables were analyzed using the suitability of mangroves for tourism, then water quality variables were analyzed using Pollution Index (PI), and location aspects were analyzed spatially using buffer method. The results of the potential of mangrove ecosystems for coastal tourism based on biophysical conditions and water quality obtained three zones that suitable to develop into tourism. Those zones are Maryamah-Tunut zone, Tarsip-Ci lamaya zone, and Cilamaya zone. Then based on spatial analysis using locational factors based on accessibility and distance from settlements, Tarsip-Ci lamaya zone and Ci Lamaya zone have the potential to be used as mangrove marine tourism. Besides those 2 zones area are suitable based on the biophysical conditions and water quality, the accessibility is quite good due to the main road is provided towards the ecosystem and also the distance from the settlement is in ideal distance, so that the ecosystem can be kept in good condition. Good accessibility and suitability mangrove ecosystem can increase the potential of the ecosystem to be used as coastal tourism.

Keywords: Mangrove, suitability, biophysical conditions, water quality, potential

1. Introduction

Coastal Tourism becomes one of the most potential tourism that can be developed in Indonesia, considering enormous coastal object that lives on Indonesian coast. Mangrove ecosystem is a part of coastal ecosystem which can be developed into coastal tourism [1]. Beside become an attraction for tourism, mangrove has very important role in maintaining ecosystems and nutrient cycles in coastal areas as controlling erosion of the coast, catching sediment, and controlling waves to protect the coast from flood [2]. Karawang Regency is one of the regencies in West Java that has the most extensive mangrove forest, with 10,005.46 ha mangrove forest which covers approximately 28.76 % of the total area of mangrove forest in West Java [3].

Therefore, in order to increase tourist attractiveness and maintain existing ecosystem, developing ecosystem mangrove into coastal tourism becomes the right way to do [4]. It is also intended as a form
of strategy to create and preserve tourism area that are suitable for the development of mangrove ecotourism areas [4]. According on 2005–2025 Local Long-Term Development Plan (RPJPD) Karawang Regency, Cilamaya Wetan coast becomes a priority to do a development in mangrove forest. The aims of this study are to analyze the suitability of coastal tourism based on biophysical conditions and water quality, and to analyze the potential mangrove ecosystem for coastal tourism in Cilamaya Wetan.

2. Materials and method

2.1. Study area
Cilamaya Wetan Subdistrict is located on the east coast of Karawang Regency between 6°12'50"S–6°17'20" S and 107°33'19" E–107°37'10" E as shown in figure 1. This subdistrict has 12.48 km length of the coastline which stretches from Sukakerta Village to Muara Village [5]. There are 4 villages located on the coast of Cilmaya Wetan subdistrict, which are Sukakerta, Rawagempol Kulon, Muara Baru, and Muara. Based on Regional Environment Status Book of Karawang Regency (SLHD), in 2013, total area of mangrove forest in Cilmaya Wetan reached 1,019 ha with the average trees density was 50–150 trees/100m² [6].

2.2. Method
Biophysical conditions such as the condition of mangrove forest and coastal environment, and water quality are the primary factors in terms of tourist attraction and sustainable mangrove ecosystem. Hence, biophysical conditions and water quality are used to analyze suitability mangrove ecosystem for tourism. Field survey was conducted on September to October, 2019 by dividing study area became 10 observation zone. Each zone is bonded by the rivers and the zone is named by each side rivers. This research methods consisted of observation and water quality assessment in field study area. The observation was conducted to observe the condition of mangrove ecosystem such as mangrove density, the thickness of mangrove forest, diversity of mangrove species, organism or fauna that associated in mangrove ecosystem, and tidal condition in each observation zone with transect method. Water quality samples was conducted in-site to assessing temperature and dissolve oxygen of water, while ex-site to assessing salinity, total suspended solid, and pH in Karawang Fisheries Business Service Laboratory (BLUPPB Karawang). Biophysical conditions were analyzed by adopting the method of Yulianda et al. [2] and for water quality were analyzed using Pollution Index by comparing between sampling water and quality standards in accordance with Minister of the Environment Decree Number 51 in 2004.

Furthermore, to see the potential of natural tourism it is necessary to consider locational factors that need to be considered to ease the development [7]. The potential of mangrove ecosystem for coastal tourism were analyzed spatially by using locational factors, such as accessibility toward mangrove ecosystem and the distance from settlements. Accessibility need to be considered for assessing the ease to reach the ecosystem mangrove [8]. In addition, the distance from settlement is analyzed by the concept of ecovillage. According on ecovillage concept, the settlement areas must be within 1.5 km from nautical attractions or 30 minutes if passed on foot, so that people still reach the tourist sites of the surrounding settlements [9, 10].

3. Results and discussion

3.1. Mangrove tourism suitability based on biophysical conditions
The results of the suitability based on Biophysical Conditions are given in table 1, which based on the data that has been obtained, there are 4 observation zones that suitable to be developed for mangrove tourism based on biophysical conditions in Cilamaya Wetan coast. The suitable zone is located in
Maryamah–Tunut zone, Apurtunggal–Ci Herang zone, Tarsip–Ci Lamaya zone, dan Ci Lamaya zone. In all of those zones, the mangrove is in good condition with high mangrove density and the thickness of mangrove forest reaches more than 200 m. With a thickness that reaches more than 200 m from the coastline, causing the formation of mangrove species that are quite variative, which can be found more than 5 different species of mangrove species in those four zones, as well as varied fauna that can be found in the mangrove ecosystem. Besides those zones are suitable to be developed as tourism, the originality and the beauty of the mangrove scenery on those zones can also enhance tourist attraction values [11].

3.2. Mangrove tourism suitability based on water quality
By using the Pollution Index method in each zone, the water quality conditions in the Cilamaya Wetan Subdistrict are various from good condition to moderate polluted (table 2). There were 5 observation zones with water quality conditions were suitable to be developed as mangrove tourism. Those zones were Langen – Cermin zone, Cermin zone, Cermin – Gebong zone, Tarsip – Ci Lamaya zone, and Ci Lamaya Zone, which were located on the western side and eastern side of Cilamaya Wetan subdistrict.

On the western part of Cilamaya Wetan (Langen – Cermin zone and Cermin zone), those 2 zones have water quality in good condition because the ecosystem has been sufficiently maintained due to the establishment of the Tangkolak Mangrove Ecotourism area in Sukakerta Village. Then, on the eastern part of Cilamaya Wetan (Tarsip – Ci Lamaya Zone and Ci Lamaya Zone) also have suitable water quality because these zone is still far from human activities, so that those areas can minimize water pollution caused by household waste which can directly reduce water quality [12]. However, in the middle of Cilamaya Wetan District, water quality falls into the category of “moderate polluted” because in those zones, many mangrove ecosystems have been converted into fish pond and salt ponds, causing high levels of waste because exposed by high human activity [13].
3.3. The potential of mangrove tourism

Based on the results given in table 3, there were 3 observation zones that were considered suitable to be developed into mangrove tourism. Those zones were Maryamah – Tunut zone, Tarsip – Ci Lamaya zone, and Ci Lamaya zone (figure 2). Thereafter, those 3 zones were analysed spatially by considering accessibility and the distance from settlement to obtain the potential of those zone to be developed as mangrove tourism.

3.3.1. Maryamah–Tunut zone. Maryamah–Tunut zone is located on coastal area that has sufficient access (figure 3a). Accessibility is considered sufficient, because the road that can be passed is not only 2-wheeled vehicles but also 4-wheeled vehicles and the distance between mangrove ecosystem and the main road is only 200 meters away. So that, the people are not too difficult to reach this zone. However, this zone is located around the settlement not too far from mangrove ecosystem, so there was some massive human activity that potentially will harm the ecosystem. Some activities such as dispose household waste and park the boat on mangrove ecosystem captured during observation.

3.3.2. Tarsip–Ci Lamaya Zone and Ci Lamaya Zone. Tarsip–Ci Lamaya zone (figure 3b) and Ci Lamaya zone (figure 3c) are located on easternmost of Cilamaya Wetan subdistrict. The accessibility of this zone is quite good, which the main road is not provided directly to mangrove ecosystem and need to walk on foot to reach mangrove because the main road is only provided until 500 meters from the ecosystem. With the condition that main road does not directly reach mangrove ecosystem, causing these zones still have mangrove in a good condition and far from human intervention that can damage the ecosystem.

Table 1. Suitability score based on biophysical conditions.

| Observation zone       | Mangrove thickness | Mangrove density | Mangrove species | Biota association | Tidal condition | Score  | Suitability  |
|------------------------|--------------------|------------------|------------------|------------------|----------------|--------|-------------|
| Langen – Cermin      | S3                 | S1               | S2               | S1               | S1             | 66.67  | Conditionally Suited |
| Cermin                | S3                 | S1               | S1               | S2               | S1             | 71.79  | Conditionally Suited |
| Cermin – Gebong      | S3                 | S1               | S2               | S2               | S1             | 64.1   | Conditionally Suited |
| Gebong – Maryamah    | S3                 | S3               | S3               | S2               | S1             | 41.03  | Not Suitable    |
| Maryamah – Tunut     | S2                 | S1               | S1               | S1               | S1             | 87.18  | Suitable       |
| Tunut – Kecipruk     | S3                 | S2               | S3               | S2               | S1             | 48.72  | Not Suitable    |
| Kecipruk – Nawijar   | S1                 | S3               | S2               | S3               | S1             | 71.79  | Conditionally Suited |
| Apurtunggal – Ci Herang | S1           | S1               | S2               | S2               | S1             | 89.74  | Suitable       |
| Tarsip – Ci Lamaya   | S1                 | S1               | S1               | S1               | S1             | 92.31  | Suitable       |
| Ci Lamaya            | S2                 | S1               | S2               | S1               | S1             | 79.49  | Suitable       |
Both of these zones are still within a radius that is in accordance with the concept of ecovillage. So that, at this distance, can balance the conditions of the mangrove ecosystem and the society. In addition, with the distance between the mangrove ecosystem and the location of the settlement as previously stated, this situation is located at a distance of more than 300 m from the settlement to keep mangrove ecosystem in good condition.

Furthermore, the presence of bird *Egretta garzetta* on these zones will gain tourist attraction. Tourist can see flocks of this birds that perch on mangrove trees and fly in groups. In addition, due to the lack of human activity in this zone, mangrove forests are seen not only on along coastline, but also along the rivers around the observation zone so that they can increase value for mangrove tourism because tourists can enjoy the scenery of mangrove during the way to the coast. The scenery around the mangrove ecosystem can also be used as an added value to attract visitors if this area will be used as a tourist attraction [9]. Because before reaching mangrove ecosystem, tourist's trips will be entertained by a vast expanse of rice fields, so that tourists who visit will not only be able to enjoy the beauty of the mangrove ecosystem and associated biota objects in it, but also the beautiful views of rice fields.

### Table 2. Water quality score

| Observation zone | PI score | Water quality conditions |
|------------------|----------|--------------------------|
| Langen – Cermin  | 0.932    | Good (Suitable)          |
| Cermin           | 0.852    | Good (Suitable)          |
| Cermin – Gebong  | 2.469    | Low Polluted             |
| Gebong – Maryamah| 1.575    | Low Polluted             |
| Maryamah – Tunut | 0.963    | Good (Suitable)          |
| Tunut – Kecipruk | 5.939    | Moderate Polluted        |
| Kecipruk – Nawijar| 7.537   | Moderate Polluted        |
| Apurtunggal – Ci Herang | 5.646 | Moderate Polluted |
| Tarsip – Ci Lamaya| 0.869 | Good (Suitable)          |
| Ci Lamaya        | 0.5      | Good (Suitable)          |

### Table 3. Biophysical and water quality suitability

| Observation zone | Biophysical suitability | Water quality suitability |
|------------------|-------------------------|----------------------------|
| Langen - Cermin  | Conditionally Suited    | Suitable                   |
| Cermin           | Conditionally Suited    | Not Suitable               |
| Cermin – Gebong  | Conditionally Suited    | Not Suitable               |
| Gebong – Maryamah| Not Suitable            | Not Suitable               |
| Maryamah – Tunut | Suitable                | Suitable                   |
| Tunut – Kecipruk | Not Suitable            | Not Suitable               |
| Kecipruk – Nawijar| Conditionally Suited   | Not Suitable               |
| Apurtunggal – Ci Herang | Suitable | Not Suitable               |
| Tarsip – Ci Lamaya| Suitable               | Suitable                   |
| Ci Lamaya        | Suitable                | Suitable                   |
Figure 2. Mangrove tourism suitability based on biophysical conditions and water quality

(a)

Figure 3. Potential zone for mangrove tourism
4. Conclusion
There are 3 zones that are suitable for mangrove tourism based on biophysics and water quality. Those zones are Maryamah - Tunut Zone which is in the central part of Cilamaya Wetan Subdistrict, Tarsip-Ci Lamaya Zone and the Ci Lamaya Zone which is on the easternmost of the Cilamaya Wetan District. While from the third zone, only two zones that potential to be developed into mangrove tourism, those zones are Tarsip - Ci Lamaya Zone and the Ci Lamaya Zone. Both zones are intended to be mangrove tourism because both zones are suitable based on physical and environmental. Those two zones also have an ease accessibility and also the distance between mangrove ecosystem and settlements are not too close, so that the mangroves are still in good condition. In addition, the attractive landscape

**Figure 3 (continued).** Potential zone for mangrove tourism
of rice fields around the mangrove ecosystem on these zones, and the presence of several endemic fauna in mangrove forest around the zone are also gaining attractions for tourists who will visit.

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