Coastal management strategy for small island: ecotourism potency development in Karimata Island, West Kalimantan

A W Rudiastuti¹, Munawaroh¹, I E Setyawan¹ and G H Pramono¹

¹Badan Informasi Geospasial
Jalan Raya Jakarta-Bogor Km 48, Cibinong, Kab. Bogor, Indonesia 16911
aninda.wisaksanti@big.go.id; anindarudiastuti@gmail.com

Abstract. Sustainable coastal management is playing an important role in coastal resources conservation, particularly on small islands. Karimata archipelago has unique characteristics and great potential to be developed as a tourism object, one of which is Karimata Island as the largest island and also reserve area. The concept of ecotourism focuses on the ecology conservation, economic benefits, and social life. Ecotourism aims to build sustainable tourism that provides economically viable and social benefits to the community. This study aims to develop coastal management strategy based on ecotourism at Karimata Island. Spatial approaching through coastal type was done. Qualitative descriptive analysis and SWOT are used to develop sustainable management strategies for the coast of Karimata Island, where the opportunities and challenges to the development of coastal ecotourism Karimata Island also included. If this potential is optimally utilized, it can be relied as an economic opportunity for local communities. Structurally shaped coast, marine depositional coast and coast build by organism are several of coastal types found at Karimata Island. Coastal ecosystems inhabited Karimata Island are mangroves, coral reefs, and macro-algae. Karimata Island have not been optimally utilized for tourist destinations. The biggest obstacle encountered is the accessibility from Kalimantan or other island at Karimata islands. Several problems related to the utilization of coastal resources were found such as mangrove and coral reef damage, also regulation that less supportive. The results of this study are expected to provide an overview of solutions for the development of coastal tourism potentials in Karimata Island.

1. Introduction
As a country with a vast coastal area, Indonesia obliged to oversee its coastal areas, especially the small islands. The coastal region has a strategic value that plays an important role in improving the national economy and people's welfare. However, coastal areas are highly vulnerable to threats of damage [1]. Smart management which involves proportion of coastal environmental protection interests and proportional economic interests is indispensable. Coastal area management strategies and policies focus on such issues as physical characteristics, resources, and resource utilization needs for the community. In the process of managing coastal areas, policy-making is directed at preservation. Goodwin (1997) in [2] suggests efforts to ensure local community participation and steps in eco-tourism activities. The need for interaction between the three parties involved, namely the government sector, private and local communities. Sustainable coastal management in the area of regional economic development and conservation of coastal natural resources, especially on small islands, is a long-term responsibility between government and society [3], [4]. Involvement and understanding of local community to the economic, social and environmental issues become the basis of shaping related policies [5].

For decades, marine tourism has grown throughout the world, especially in those who are in the tropical area with coastal assets; Reefs, Mangroves, and beaches. That coastal asset which has natural beauty represents an important touristic attraction for water sports (surfing and scuba diving), and natural tourism [6]. A row of contributions that put up by Mangrove ecosystem to protect the environment as well as local economic value. As the coastal protection from disasters [7], a place to
spawn, to nurse, and to be living habitat [8], [9], as nutrient sources for organisms, as a source of seafood provision and timber [10], also for tourism. Mangrove-based tourism has been encouraged in Surabaya [11], Jakarta [12] and Bali [13]. The sustainable management approach relies on the availability of coastal habitat resources, together with conservation efforts, cultural education, and economic empowerment of local communities. Those lead to a concept of sustainable tourism of eco-tourism [14]. Eco-tourism becomes one of the alternative development that can help overcome the problems in the utilization pattern that is destructive to the sustainability of coastal resources [15]. Therefore, to be able to optimize the potential of ecotourism in Karimata Island, it is necessary to do an assessment to know the potential and existing problems.

Utilization of remote sensing imagery to provide potential data and information on coastal resources are common nowadays. Thus, it is advantageous to sense the coastal condition for sustainable development and management. Remote sensing data as one of the best source to acquire condition of mangrove areas and benthic habitat, in the manner of advantages such as synoptic coverage, capable of inaccessible area, historical and near real-time data [16]–[22].

This research intends to develop coastal management strategy of Karimata island based on coastal characteristics and resources. Both of spatial and qualitative analysis (SWOT) was carried out to get an overview of tourism management strategy in Karimata Island. Karimata Island is chosen because it is a small island that has a wealth of good quality of coastal ecosystem and have not been empowered. Development of sustainable tourism concept is needed, it is in line with the status of Karimata Island as a marine reserve area. The concept of ecotourism focuses on ecology, economic benefits, and the local community. In addition, this research is addressed to support promotion of Karimata Island to be one of Indonesia's eco-tourism destinations in accordance with sustainable development.

2. Methodology
This study focused on two processes. First, coastal habitat mapping using remote sensing technology assisted with ground-truthing results that have been carried out in 2016 by PPIT-BIG team. Second, forming the sustainable management strategies for eco-tourism in Karimata Island using SWOT analysis. Both of spatial and non-spatial data were used to deliver the strategy of coastal management in Karimata Island (table 1). Brief and clear work flow of this study were depicted in figure 1.

| Types       | Data                                | Source                                                   | Year  |
|-------------|-------------------------------------|----------------------------------------------------------|-------|
| Spatial     | World-View2                         | LAPAN                                                    | 2015  |
|             | Free Hi-res Imagery                 | ESRI                                                     | 2016  |
|             | RBI 1:50,000                        | BIG                                                      | 2016  |
| Secondary   | Statistic Data of Karimata          | BPS; Marine and Fisheries Agency of Kayong Utara         | 2015  |
|             | Marine Reserve Boundary Map         | BKSDA – Kalimantan Barat                                | 2016  |
|             | Zonation Planning Document          | Marine and Fisheries Agency of Kayong Utara             | 2016  |
|             | Spatial Planning Document           | Public Works Agency of Kayong Utara                     | 2016  |

2.1. Study area
Karimata archipelago stands for a group of 83 small islands, which every island has its name registered in United Nation. Only 14 islands are inhabited. Since 1981, Karimata Islands have becoming Nature Reserve prior to Decree of the Director General of Forestry No. 2240/ DJ / I / 1981 dated June 15, 1981. The nature reserve status is continued and strengthened by Decree of the Minister of Forestry No. 381 / Kpts - II / 1985 where Karimata appointed as Marine Reserve, with extent shown in Figure 2. As it states, it is demanding people having the permit to enter the Marine Reserve area. In figure 2, Karimata
Marine Reserve area covered all the coastal and small islands in the eastern part of Karimata Island. Thus, the western part of Karimata Island can be accessed without a permit.

2.2. Methods

2.2.1 Image interpretation. For spatial data as listed in table 1, the preparatory steps which applied include geometric correction and radiometric correction. For radiometric correction, different treatments applied to the image depending on the needs related to the mapping method used. For mangrove classification and interpretation, as well as coastal typology, correction process used to attain the reflectance value, whereas the images prepared for shallow water habitat mapping further corrected by sun glint and water column correction. Digital transformation, multispectral classification, and visual interpretation are used because of their effectiveness to obtain optimal results.

![Figure 1. Flowchart of data processing and analysis.](image-url)
Figure 2. (a) Karimata Island and Marine Reserve Boundary (b) Survey plots in Karimata Islands.

Combination of digital classification and visual interpretation were applied. Green - Red - NIR bands combination used for on-screen digitation of mangrove areas. Canopy density classification using NDVI transformation were also implemented [23] besides the visual interpretation. Besides, delineation of mangrove extension and canopy density classes takes the advantages of hi-res imagery such as World-View2. Canopy density classes can be easily differentiated using enhanced true and false color composite. Benthic habitat interpretation of satellite imagery using several approaches such as composite band and image reinforcement with Depth Invariant Index Algorithm. This algorithm applies the correction method of the water column known as the Lyzenga Algorithm [24]. This method is effective for improving the quality of the identification and classification of shallow basin habitats thematically. In line with this, the distinction of coastal type is done by visual interpretation and then combined with field survey results. Classification of canopy density referred to the national standard for Mangrove Surveying and Mapping (SNI 7717: 2011) scale of 1: 25.000. Meanwhile, the classification for benthic habitat referred to Draft of Technical Guidelines for Collection and Processing of Geospatial Data of Shallow Benthic Habitat (scale of 1: 10.000). For mangrove, the canopy density classes are very high, high, moderate, rare, and very rare. For benthic habitat there are eight classes, and only five classes will be used according to the purpose. However, drawbacks found in some data, so that another type image is used to cover up the shortcomings from another imagery. The temporary map resulted from image interpretation becomes the primary information to conduct ground truth.

2.2.2 Field survey. Determination of sample points using stratified proportional random sampling method in each class of image data processing results. The sample size is determined proportionally to the class extent of each map as well as considering the ease of accessibility in sampling.

The land survey initiated to do the measurement of geomorphological parameters (slope, lithology, and geological structure); In situ soil parameters (pH, soil lime, organic matter, and soil drainage); and also the measurement of hydrology (measurement of groundwater level). For mangroves, the method for canopy density validation used is canopy photos using the fisheye camera. For benthic habitat, field data collection is done by two methods namely "Stop and Go" to obtain many ground truth points; and the 'transect quadrant' method to get a percent closure of the habitat class (figure 2b).
2.2.3 SWOT Analysis. In this study, the SWOT (Strength, Weakness, Opportunities, and Threats) analysis had been used to reach qualitative results. SWOT analysis is a strategic planning method used to evaluate the strength factor, weakness, opportunities (opportunities), and threats in a region [25]. These factors are based on the considerations that occur in the research location as follows:

- **Strength factor**, which is the internal strength owned by Karimata Island. By knowing the strength, then this region can be directed to be more resilient.
- **Weakness Factor**: all internal factors that are not profitable or harmful to Karimata Island
- **Opportunity Factors**: external factors that potentially improve the welfare of Karimata Island community
- **Factor Challenges (Threats)**: external factors that can bring harm to Karimata Island

Qualitatively, the determination of a SWOT analysis carried out after descriptively determine and analyze the strengths, weaknesses, opportunities, and threats [25]. This qualitative model produces the SWOT matrix as shown in the following table 2.

| Internal Strength (S) | External Opportunity (O) |
|-----------------------|---------------------------|
|                       | S-O Strategies            |
|                       | S-T Strategies            |

3. Result And Discussions

3.1. Coastal ecosystems of Karimata Island

Karimata archipelago is a group of islands in West Kalimantan province which connected to the Karimata Strait and the South China Sea. Karimata Island is the largest and populated island besides Penebang Island, Serutu Island, Pelapisgenting Island, and Pelapistiang Island. [26] Informed that people in Karimata Island inhabit coastal areas tend to have maritime culture rather than agrarian. About 80% of land cover in Karimata Island is the forest where it indicates the high level of human activity that influences the pattern of land use change. Human activities in Karimata Island are still limited based on land cover variations such settlements, roads, coconut plantations, clove plantations and mixed plantations.

The existence of coastal ecosystem in Karimata Island can be found either at east or west side (figure 2a). The establishment of Marine Reserve Area on the northeast to the southern coast of Karimata Island covering an area of 77,000 ha to the southeast. This study is focused on the Non-Marine Reserve area which spread along the southwest to the northwest coast of Karimata Island. Worldview-2 imagery acquired in 2015 showed that on the west side of Karimata Island is dominated by mangroves and coral. While much of the terrestrial environment is forests and plantations, the coastal environment consists of a diverse array of habitats, including mangroves, sand, and corals. A large mangrove area is located in western Karimata (Sei Ulu Betok - Dusun Kelumpang), spanning around 12 km of the coastline (figure 2a). All at Karimata Island, it is predicted to be around 1,122.24 ha and more than 85% located outside of the Karimata nature reserve area (table 3). In the Karimata Marine Reserves, mangrove existed on the south and east coast, especially at Tanjung Ujung Pandang and Tanjung Gemuk (figure 3). Mangrove canopy density class categorized into five classes. The 'very high' canopy density has the most substantial extent (727.22 ha). Several mangrove genera were found such *Sonneratia*, *Bruguiera*, *Lumnitzera*, and *Rhizophora* sp. is dominantly appeared in this region (figure 4). The mangrove condition in Karimata is becoming a concern to develop a sustainable management strategy for mangrove ecosystems in Karimata island, which is socially beneficial to the surrounding communities [11] [27] [28].
Table 3. Mangrove and Benthic Habitat in Karimata.

| Mangrove Density | Area (Ha) | Non Marine Reserve | Benthic Habitat | Total | Non Marine Reserve |
|------------------|----------|---------------------|-----------------|-------|---------------------|
|                  |          |                     |                 |       |                     |
| Very high        | 770.4890 | 727.2179            | Coral           | 1106.71 | 162.9769           |
| High             | 174.8999 | 132.7026            | Dead Coral      | 1385.56 | 328.6137           |
| Moderate         | 30.0461  | 11.0469             | Macro Algae     | 488.04  | 127.5050           |
| Rare             | 17.0395  | 8.0261              | Sand            | 1625.76 | 288.5112           |
| Very rare        | 41.6724  | 41.2027             | Rubble          | 26.16   | 6.1129              |
| Total            | 1034.1469| 920.1962            | Total           | 4632.23 | 920.7197           |

Figure 3. Mangrove and benthic habitat at non-marine reserve area.

Figure 4. Mangroves at non-marine reserve area in Karimata Island.

Shallow water habitats which owned natural beauty such coral and seagrass are great attractions that suitable for water sports such as snorkeling and scuba. Coral reefs in good condition are spread evenly in the southeast, north and south sides, which belong to the Karimata Nature Reserve. In the north coastal,
coral reefs are found in small island clusters in front of Penghujan Bay and Teluk Alam (figure 3). Among the benthic habitat, coral reefs area extent to ± 1.106 Ha (21%) on a scale of 1: 10,000 (table 2). In line with the previous research results [29], Karimata Island is dominated by non-Acropora with a massive and branched life form, built between 3 - 15 m depth. Seagrass is hardly found on the coast of Karimata Island, its existence only in a small extent.

Based on the results of image interpretation, several coral spots located outside the Marine Reserve region spread on the southwestern side, northwest (Tokong Kepayang Islands - Kera Island) and north of Karimata Island (Teluk Liseng and Teluk Alam). In the southwestern part of the island (Tanjung Kalung Bay and Tanjung Kalung), living corals form separate colonies with Acropora tabulate (ACT), coral sub-massive (CS), and coral massive (CM) (figure 5). The coral health condition is poor, and visibility was limited due to wave condition [26].

On the western side of Karimata, on the Kelumpang Bay area bordering on mangroves, benthic habitat dominates by algae, ruins, mud sludge substrate and dead corals (Figure 6). Several small places of coral reefs found in the view of Dusun Kelumpang, in the southern part of Teluk Kelumpang. Based on survey results (2016), benthic habitat habitats encountered are corals with a cover range of 5 - 10% comprising Acropora Digitite (ACD), CM, Branching, encrusting, and foliose. Seagrass existence is very rare, only Cymodoceea sp and Syringodium sp. found in a tiny patch (< 10% cover). Similarly, Domination of algae is coming from the Sargassum and Padina genera (figure 7). From table 2 it can be known the extent of habitat benthic residing in Non-Marine Reserve area at Karimata Island. However, dead corals and sand substrate dominated by benthic habitat. Various conditions above might show that Teluk Kelumpang can be directed to be mangrove tourism.

Figure 5. Coral at Teluk Tanjung Kalung dan Tanjung Kalung.

Figure 6. Benthic habitat condition at Teluk Kelumpang, in front of Mangroves area.
3.2. Coastal Type

3.2.1 Sub aerial deposition coast. Coastal typology of the sub aerial deposition coast is found in the western part of Karimata Island, at the mouth of the Sei Ulu Betok, the Sei Are and the Sei Gelombang (figure 8; yellow box). The coastal area had sediment material from the erosion material that carried by the river and deposited at the mouth of the river. The material carried down to the downstream is a fine-sized material and becomes the substrate. The results of the image interpretation showed the existence of clay substrate connected with the existence of mangrove ecosystems along the Gulf Kelumpang that can be used as a mangrove tourism (figure 2).

3.2.2 Marine deposition coast. Marin deposition coast found in several areas such as Dusun Kelumpang, Teluk Alam, Teluk Penggaram, and Teluk Lisin (figure 8; red box). Those coasts are consist of two forms; tidal flat and pocket beach. This typology formed by the tidal process of seawater that carried marine sediments. The extent of these two can vary depending on the tidal activity, and can only be distinguished by identifying the base material. The pocket beach has a bright white quartz sand material, while the tidal flat has a finer clay-sand material. Sandbanks also sometimes formed in the tidal plains. This marine sediment beach typology has the potential to be developed into tourism.

3.2.3 Coast built by organism. Coastal built by organisms can be found almost around Karimata Island forming a fringing reef, especially on Tokong Kepayang Island, Kepayang Island and Teluk Begunyai (figure 8, blue box). These coastal typologies include reef flat, reef patches such as in northern of Teluk Liseng and Teluk Alam, and reef crests. Those coastal has potential for snorkeling or diving sites, due to the coral and seagrass. Another coastal type found in Karimata Island is erosional coast (figure 8, green box) which also has potency for sunbathing locations and panoramas seeker [30].
3.3. Strength, Weakness, Opportunities, and Threats (SWOT) Analysis

Sustainable tourism can be developed and also aware of its impact by incorporating environmental resource management and monitoring in an integrated plan [2]. Cultural and physical aspect are an integrated unity that supports each other as a coastal and marine tourism area. All characteristics and conditions of Karimata Island translated as strengths, weaknesses, threats, and opportunities. Those are needed to deliver an excellent strategy for sustainable management of Karimata island's natural resources (table 3).
| Internal Strength (s) | External Weakness (W) |
|-----------------------|------------------------|
| 1. Karimata has mangrove forest area outside the marine reserve with good condition | 1. Residents are still dependent on marine resources |
| 2. Marine depositional coastal typology as a tourist attraction | 2. Inadequate public transport facilities and infrastructure |
| 3. Having historical value as an ancient shipping lane becomes a region's marketing potential | 3. Inadequate electricity and communications infrastructure |
| 4. Abundant fishery potential (seasonal) | 4. Not complete benthic habitat, Sea-grass ecosystems are found very rarely |
| 5. Local people are maritime community | 5. Conditions of coral reefs mostly are damaged |
|                      | 6. Unavailability of facilities and infrastructure of marine product management |
|                      | 7. The fulfillment of logistics needs still depends on the supply of the mainland |

| Opportunity (O) | S-O Strategies | W-O Strategies |
|----------------|----------------|----------------|
| 1. The location is strategic because it is the archipelagic sea lanes of Indonesia (ALKI 1) and international shipping lanes | 1. Ecotourism development in mangrove forest area and Optimizing the potency of marine tourism sector in coastal areas | 1. Enhancing the quality of human resources (entrepreneur training) |
| 2. Good hydrological condition to sustain the water needs | 2. Development of marine tourism based on local wisdom and cultural heritage | 2. Optimization of cooperation between regions to develop facilities and infrastructure of marine product management |
| 3. Natural condition that support the development of ecotourism and marine tourism | 3. Development of facilities and infrastructure to support the independency of energy, food and tourism development | 3. Development of facilities and infrastructure to support energy independence and tourism |
| 4. Potential development of micro hydro power plant for energy independence Karimata Island | 4. Development of fishery-based aquaculture sector as an alternative to regional development | 4. Coastal Ecosystem rehabilitation by involving the community |
| 5. Inter-regional | 5. Regulation framing for eco-tourism management at Karimata Island | |
cooperation to develop fisheries and tourism potential

6. The status of Karimata Island Region as Marine Reserve based on the Decree of the Minister of Forestry no. 381 / Kpts - II / 1985 control the utilization of natural resources

| Threats (T)                                                                 | S-T Strategies                                                                 | W-T Strategies                                                                 |
|----------------------------------------------------------------------------|--------------------------------------------------------------------------------|--------------------------------------------------------------------------------|
| 1. Natural and man-made hazard (Sea level rise, oil spills, coastal erosion) | 1. Development of tourism areas based on local wisdom                           | 1. Increasing the capacity and quality of facilities and infrastructure of transportation, infrastructure and energy |
| 2. Natural resource management has not been implemented optimally and sustainably | 2. Community empowerment to participate in the natural resources management of Karimata region. | 2. Regulation enforcement of Marine Reserve Area (CAL) |
| 3. Unavailability of environmental sanitation                               | 3. Development of environmental sanitation facilities                          | 3. Government support for investment and integration of development programs in tourism and fisheries sectors |
| 4. IUU Fishing                                                              | 4. Regulation framing to keep down the impact of man-made hazard (oil-loaded ship lanes). | 4. Development of engineering techniques to reduce the potential for coastal disaster risk in Karimata Island |

4. Conclusion
The existence of Karimata Island as a small island in Indonesia has its attractiveness. However, the development of sustainable tourism utilizing coastal ecosystem resources has not been initiated by the local government. Most of the eastern coastal area of Karimata Island belong to the Karimata Marine Reserve area. Thus the western part of the island can be utilized for tourism activities. Based on the mapping results, Karimata Island has the coastal ecosystem resources like mangroves and coral reefs that scattered almost throughout the island. More than 80% of the mangroves area is concentrated on the western side of the island, ie, in Kelumpang Bay. The condition becomes a significant base in the development of mangrove ecotourism. The study result of coastal types, Karimata Island, has several coastal types that support marine tourism activities.

In the preparation of sustainable management strategies, it is important to assess the characteristics of the strengths, weaknesses, and opportunities and threats. The development of tourism considerations for the region of the economy is also an important step.
Karimata Island has an eco-tourism and marine tourism attraction. The availability of qualified human resources for tourism management is essential. Thus, local society resources enhancement is important. The adequacy of training in the aspect of entrepreneurial for the development of eco-tourism strongly required. Accordingly, the local government should follow an aggressive growth strategy. While all the tourists are the target, the facilities and infrastructure to support the tourism development must be implemented. Also, there is the high need for regulation, promotion, and public relations.

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