

Coastal Typology of Landform in Pelabuhan Ratu Bay, Sukabumi Regency, Jawa Barat Province

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Abstract. Sukabumi Regency has potential tourism sector which encourage the use of beach attractions in Pelabuhan Ratu Bay. The main tourist attraction is the hilly and plain panorama beach. This study is aimed to analyze landform and coastal typology to support coastal tourism development. This research provides overlay method of height and slope map, field observation, and verification. Identification of coastal typology was based on coastal materials (rock types and structures), relief (slopes and altitudes), and genesis. Comparative and descriptive spatial analysis were used as method of analysis. The result showed that the coastal typology of landform of Pelabuhan Ratu Bay consisted of volcanic, marine deposition, and organic coast. The beaches such as Cibareno, Cibangban, Karang Naya, Kadaka, and Loji have volcanic coast landform with flat, wavy, sandy, rocky beach typologies. The beaches in Pelabuhan Ratu sub-district, such as Citepus, Gado Bangkong, and Karang Pamulang, have landform of marine deposition with flat and sandy beach typology. Karang Haji and Karang Hawu beaches are coral reef organic beaches. Meanwhile, estuaries were found in Cikakak estuary and Cimaja beaches. The existence of beach tourism in Pelabuhan Ratu Bay is dominated by rocky sandy beaches and flat reliefs strongly support the development of coastal ecotourism.

Keywords: Coastal Ecotourism; Coast Typology; Landform; Pelabuhan Ratu Bay

1 Introduction

Indonesia, as the world's largest archipelago has 81.000 km² of coastline and 3,1 million km² of sea area, has the opportunity to develop the costal tourism sector due to the availability of the coastal area and biodiversity [1]. Sukabumi sub-district is located in the south coast of Java has 128,45 km of coastline [2]. The coastal area, that is directly facing the Indian Ocean, is part of the series of mountains in West Java with its characteristic of hilly and steep beach [3].

In the southern part of Sukabumi sub-district there is a bay called Pelabuhan Ratu Bay. Not to mention, its existence helps to reduce the speed of the coming wave, thus the maximum speed only reaches 0,43 m/s or the average is 0,07 m/s [4]. The height of the wave that reaches the southern coast could be >3 meter.

Pelabuhan Ratu Bay consists of various types of beaches, such as coral beaches, rocky, and sandy, with hilly and plain morphology. Therefore, it creates a potential in the field of tourism as the hilly and plain panorama beach be the main attraction point [5]. As a result, the beaches around Pelabuhan Ratu Bay attract tourists from both domestic and international.

Due to the potential that Pelabuhan Ratu Bay owns, the development concept for the ecotourism has arisen to utilize and sustain its environment, with the support of the Reginal Regulation of Spatial Planning (Perda

RTRW) of Sukabumi sub-district in 2012 [6]. It is expected that ecotourism development in Sukabumi Regency can be realized. The purpose of this research is to analyze the landforms and coastal typology in order to support the development of coastal tourism and developing low carbon society.

2 Methodology

Pelabuhan Ratu Bay is the largest bay in the Indian Ocean coast, located in the south of West Java. Geographically, Pelabuhan Ratu Bay is located at 6°57' to 7° 07' south latitude and 106° 22' to 106° 33' east longitude, with a 105 kilometers long coastline. The ecotourism of Pelabuhan Ratu Bay consists of four districts, which are Cisolok, Cikakak, Pelabuhan Ratu, and Simpenan,

2.1 Materials

This study consists of three variables including which are, coastal materials, coastal reliefs, and genesis. Classification of coastal materials in the preparation of coastal typology, is coastal areas with sand, stone, mud, and organism (coral reefs) materials. Classification of the coastal area's materials such as sand, stone, mud and organism (coral reefs) was used in the preparation of the

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coastal typology. By utilizing the DEM data obtained from SRTM (Shuttle Radar Topographic Mition) then created a map of altitude areas [10]. Moreover, by utilizing the DEM data from the SRTM (Shuttle Radar Topographic Mition), the map of altitude areas was created.

The field study was conducted for observation, verification, and documentation in order to obtain the coastal typology data which are coastal materials and reliefs, and genesis. Coastal materials were obtained from the Google Earth map digitization. Coastal relief was obtained by processing the data of DEM SRTM, and digitized from Geological Map System, Java. JAMPANG Sheet (9/XIV-A) -BALEKAMBANG (8/XIV-C) Scale 1:100.000.

2.2 Methods

The processing data of coastal area relief was done through the overlay map of altitude and slope area by using Van Zuidam classification (1985) [7]. (The processing data of coastal area relief was done by using the Van Zuidam classification through the overlay map of altitude and slope area) The classification of reliefs that was used in the preparation process of coastal typology is as follows [8].

- Flat Relief, with the height difference of the beach of 0 - 25 meters;
- Wavy reliefs, with the height difference of the beach 25 - 75 meters;
- Relief of hills, with a height of the difference of the beach of 75 - 300 meters;
- Relief mountains, with the height difference of the beach of more than 300 meters.

The identification of coastal typology was based on the Shepard classification (1958) in Rahardjo (2003) [8]. The classification of coast or coastal materials that was based on coastal sediments, terrain forms, river deposition, and ocean waves can be seen in Table 1 [8].

Table 1. Beach Classification [8]

Beach	Sediment	Terrain Form	River Sedimentation	Ocean Wave
Sandy beach	Sand or mix	Slope slightly	There is deposition	Faced with big waves enough
Rocky beach	Gravel or mix	Slope slightly to Steep	There is no or little deposition	Faced with big waves directly
Muddy beach	Silt, clay or mix	Flat	A Lot of deposition	Protected from waves

The genesis classification that was used in coastal typology is as follows [8]:

- Erosion beach, is a beach that is formed due to the destruction and transport of coastal materials, whether caused by land activities (land erosion), like rivers or by marine activity (sea erosion) due to the wave activity and ocean currents.

- Deposition beach is a beach that is formed due to the process of deposition of coastal materials as the result of the land activities (fluvial or river) or the sea activity (waves and ocean currents).
- Aeolian beach is a beach that is formed due to the wind processes, beach sand dunes.
- Volcanic beach is a beach that is formed due to the volcanic activity.
- Structural beach is a beach that is formed due to the tectonic processes, creases and fractures.
- Solutional beach is a beach that is formed due to the dissolution process, karst beaches.

In this research, the comparative analysis and descriptive spatial analysis were used to compare and explain the coastal typology at the ecotourism area of Pelabuhan Ratu Bay.

3 Result and Discussion

3.1 Ecotourism Area of Pelabuhan Ratu Bay

The four districts in the ecotourism area of Pelabuhan Ratu Bay has a total area of 546,67 km². Cisolok sub-district has an area of 173,56 km², Cikakak District with 113,23 km², Pelabuhan Ratu District with 91,86 km², and Simpenan District with 168,02 km². There are 11 objects in Pelabuhan Ratu Bay Ecotourism Area: Cibareno Beach, Cibangban Beach, Karanghawu Beach, Cimaja Beach and Karang Naya Beach at Cisolok District; Muara Cikakak Beach and Kadaka Beach at Cikakak District; Citepus Beach, Gado Bangkong Beach and Karang Pamulang Beach at Pelabuhan Ratu District; Loji Beach at Simpenan District. **Fig. 2** show the Map and object of Pelabuhan Ratu Bay Ecotourism Area.

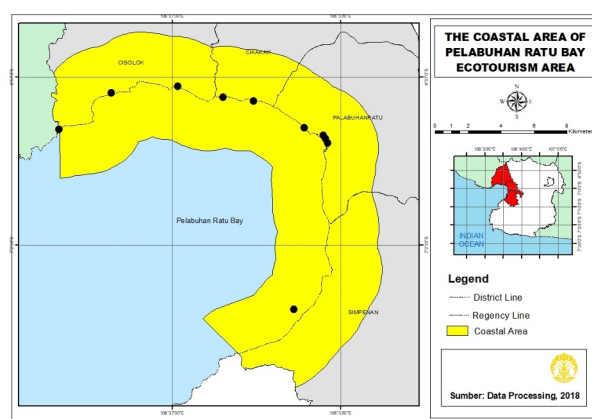


Fig. 2. The Coastal Area of Pelabuhan Ratu Bay Ecotourism Area

3.2 Coastal Landforms of Pelabuhan Ratu Bay

The study area had a height of -1 to 1.742 meters above the sea level (mdpl). The ecotourism area of Pelabuhan Ratu Bay which consisted of four sub-districts. Cisolok, Cikakak, Pelabuhan Ratu, and Simpenan, had variant height; however, it was dominated by the moderate height. The area with a range height of 0 – 7 meters

above the sea level was considered as the smallest altitude with the total area of 2,71 km² or about 2,4% of the total studied area, precisely located on the north, northeast, and east coast of Kawasan Ecotisata Pelabuhan Ratu Bay. Area with the height between 76 - 200 meters above the sea level was the most dominant, with an area of 42,75 km² or 38,17% of the total area of research. This area was located in the northwest to southeast Pelabuhan Ratu Bay ecotourism area. **Fig. 3** shows a spatial picture of the elevation of Pelabuhan Ratu Bay Ecotourism Area.

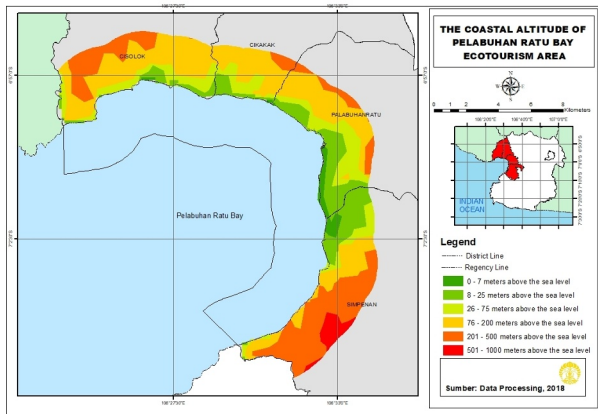


Fig. 3. The Coastal Altitude Area of Pelabuhan Ratu Bay Ecotourism Area

The slope in the sub-districts, Cisolok, Cikakak, Pelabuhan Ratu, and Simpunan, of ecotourism area of Pelabuhan Ratu was diverse. Slope area between 56 - 100 % was considered the smallest because it only has 0,024 km² or about 0,02% of the total of the research area and was located in the middle of Pelabuhan Ratu District. Slope area between 21 - 55% was the dominant slope area in the research area, with an area of 225,99 km² or 40,9% of the studied area, moreover it spreaded from north to south Pelabuhan Ratu Bay Ecotourism Area. In detail of the six slope classes based on the Van Zuidam class, can be seen in **Fig. 4**.

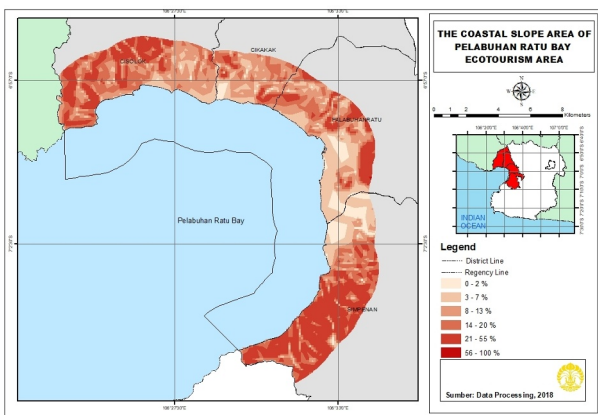


Fig. 4. The Coastal Slope Area of Pelabuhan Ratu Bay Ecotourism Area

In the research area there was six classes of reliefs or terrain forms. The area with flat terrain form - almost flat

in Pelabuhan Ratu Bay Ecotourism Area only had an area of 0,96 km² or 0,17% of the total research area and was located on the coast of Pelabuhan Ratu and Simpunan Subdistricts. The form of hilly terrain - the mountains was a type of forms that dominated the research area. It had an area of 283 km² or about 51,6% of the total area of research, moreover, it spreaded from north to south Pelabuhan Ratu Bay Ecotourism Area (**Fig 5**).

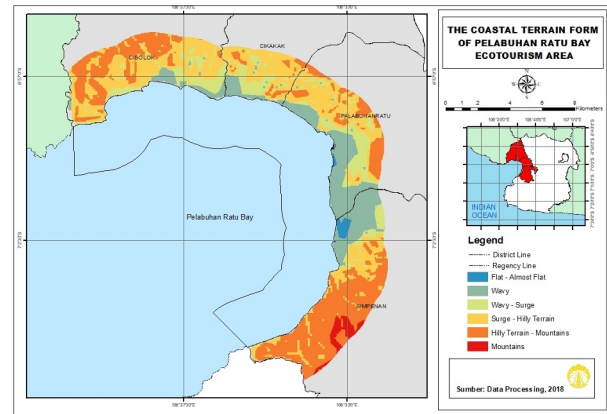


Fig. 5. The Coastal Terrain Form of Pelabuhan Ratu Bay Ecotourism Area

There were three main types of rocks in the research area, which were igneous rocks, sedimentary rocks and surface sediment (**Fig. 6**). Area with frozen parent rocks had an area of 162,44 km² or 43% of the total area of research located on the north to east coast Pelabuhan Ratu Bay Ecotourism Area. Area with sedimentary rock types was dominated the research area with the total of 196,43 km² or about 52% of the total of the research area from District Cisolok to District Simpunan. Area with surface sedimentary rock types were 18,06 km² or 4,9% of the total area of research, and was scattered in the area northwest to east Pelabuhan Ratu Bay Ecotourism Area.

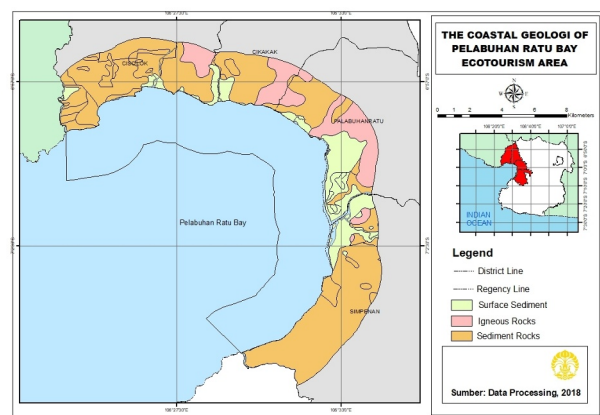


Fig. 6. The Coastal Geology of Pelabuhan Ratu Bay Ecotourism Area

There are four types of coastal landform in the study area, which were, marine deposition landform, tectonic or structural landform, fluvial landform, and volcanic landform. The landform of the research area is

dominated by volcanic landform with the help of wavy territory, sandy and rocky beach materials. Coastal tourism objects in the Pelabuhan Ratu Bay Ecotourism Area only have 2 kinds of landform, that is volcanic landform and marine landform. The landforms of Pelabuhan Ratu Bay Ecotourism Area can be seen in Fig. 7.

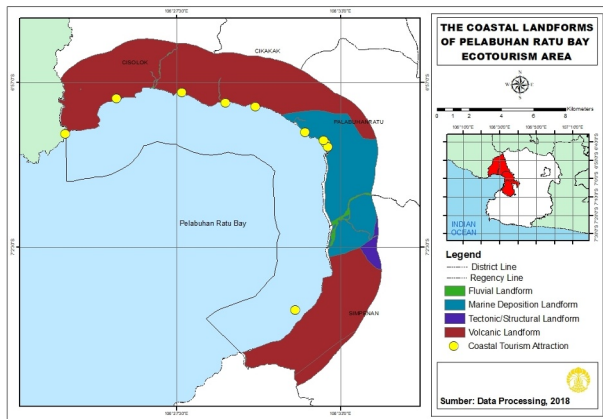


Fig. 7. The Coastal Landforms of Pelabuhan Ratu Bay Ecotourism Area

3.3 Beach Typologies of Pelabuhan Ratu Bay

The beaches with the volcanic landform is Legonwaru Beach, Cikembang Beach, Karang Haji Beach, Cibangban Beach, Cimaja Beach, Karang Naya Beach, Karang Hawu Beach, Muara Cikakak Beach Kadaka Beach, and Loji Beach. The sand and rocks in the type of volcanic coast were due to the eruption then filled the coast of Pelabuhan Ratu Bay since there was a series of mountains in the south of West Java.

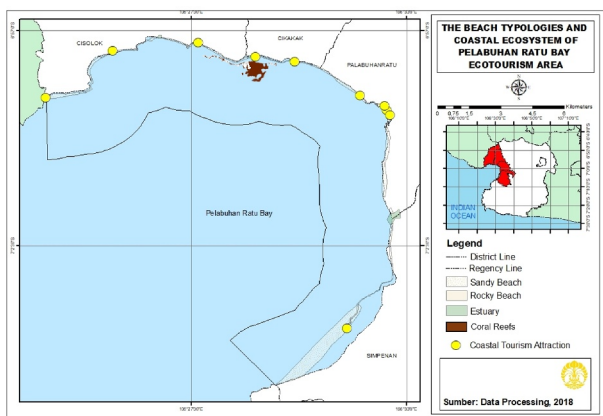


Fig. 8. The Beach Typologies and Coastal Ecosystem of Pelabuhan Ratu Bay Ecotourism Area

On the other hand, Pelabuhan Ratu Beach, Citepus Beach, Parang Karang Beach, and Gado Bangkong Beach had marine deposition coast of land. Beach deposition of the sea occurred due to the direct accumulation of marine sedimentary materials towards the land. There is a fairly wide marine sand. Margin sand was precipitated by the presence of ocean waves carrying sediment particles that were in the sea and had a

reaction with sea water, then later to be deposited along the coast.

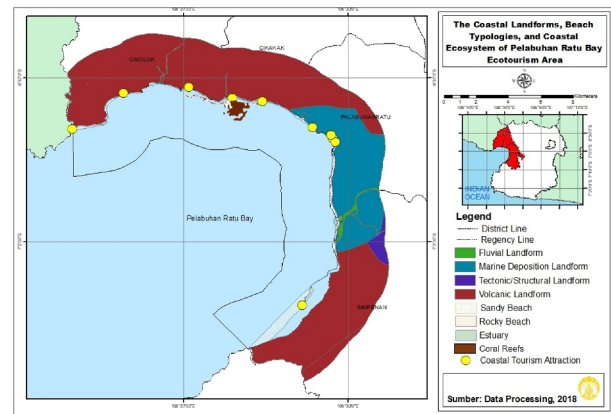


Fig. 9. The Coastal Landforms, Beach Typologies, and Coastal Ecosystem of Pelabuhan Ratu Bay Ecotourism Area

Table 2. Beach Typologies of Pelabuhan Ratu Bay Ecotourism Area

No.	Beach	Beach Material	Relief Area	Coastal Typology
1.	Cibangban	Sandy & Rocky	Flat	Volcano Beach
2.	Karang Hawu	Organism	Wavy	Organic
3.	Karang Haji	Organism	Flat	Organic
4.	Cimaja	Rocky	Flat	Volcano Beach
5.	Karang Naya	Sandy	Flat	Volcano Beach
6.	Muara Cikakak	Sandy	Flat	Volcano Beach
7.	Kadaka	Sandy	Flat	Volcano Beach
8.	Citepus	Sandy	Flat	Marine Deposition Beach
9.	Gado Bangkong	Sandy	Flat	Marine Deposition Beach
10.	Karang Pamulang	Sandy	Flat	Marine Deposition Beach
11.	Loji	Sandy & Rocky	Wavy	Volcano Beach

Beach typology in the Pelabuhan Ratu Bay Ecotourism Area was dominated by the sandy beach typology, which was geologically composed by alluvium, with the size of homogeneous sand as a result from weathering and transport of the Cimandiri River that was affected by the marine process. On the other hand, rocky beach typology was only found in Cibangban Beach, Karang Hawu Beach, Karang Haji Beach, Cimaja Beach, and Loji Beach. The rocks that were found on those beaches were varies; a unit of

Formasi Jampang and there was an outcrop of rocks in the form of sandstone, breccias, and coral reefs. The Beach Typologies and Coastal Ecosystem of Pelabuhan Ratu Bay Ecotourism Area can be seen in **Fig. 8**.

Cibangban and Loji beaches were classified as volcanic beaches which is part of the volcanic genesis due to the sandy and rocky materials on the beach, also flat and wavy reliefs. Cimaja beach had a characteristic of rocky and flat relief, thus it was classified as volcanic genesis, and was part of volcanic beach. Karang Naya, Muara Cikakak, and Kadaka beaches were classified as volcanic genesis and was part of the volcanic beach because of its sandy material and the flat relief. Citepus, Gado Bangkong, and Karang Pamulang beaches had sandy material and flat reliefs and for those reasons they were classified as marine deposition beach, and were ocean-deposition shore. Karang Hawu and Karang Haji beaches had coastal organism ; coral reefs, flat and wavy reliefs. Thus, they were classified as organism genesis, and were organic beaches (**Fig. 9** and Table 2).

4 Conclusion

There were four types of coastal landforms in Pelabuhan Ratu Bay, which were earth moving coast, volcanic coast, fluvial, and marine deposition coast. Cibangban, Karang Naya, Kadaka, and Loji beaches had the volcanic coastal landform with flat, wavy, sandy, and rocky typologies. While, the beaches; Citepus, Gado Bangkong, and Karang Pamulang, in the sub-district of Pelabuhan Ratu Bay area had the marine deposition coast type of landform due to the flat and sandy typologies. Karang Haji and Karang Hawu beaches were the type of coral reef organic beaches. On the other hand, the estuary ecosystem was found on Muara Cikakak and Cimaja beaches. The coastal landform that dominated the beaches was the volcanic coast as a result of erupted volcanoes. The beach typology in that coastal landform was sandy and rocky with the flat relief in order to support the development of ecotourism. The coastal ecotourism attractions were developing especially on the beaches in the Pelabuhan Ratu sub-district. Thus, those attractions contributed to the low carbon development.

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