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A Geomorphological Evaluation of Sea Turtles Nesting in the Southern Sea of West Java

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Abstract. Sea turtles are reptile that classified to the 'red list' at IUCN and Appendix I CITES. It means that their existence in nature has been threatened by a human, predator, and climate changes, so it should be conserved. Among various species of sea turtles, most of them laid their eggs in the coastal area of Indonesia, likely in Java Island. Under these conditions, this research is going to evaluate the condition of coastal areas where turtles laid their eggs in some part of the southern sea of Java Island based on geomorphological approach. Batu Hiu and Pangumbahan coastal area, West Java took for sampling area. The characteristics of geomorphology that affect turtle nesting habitats including its morphology, sand material, and coastal processes. Those aspects divide into the beach slope, beach wide, beach length, grain-size, wind parameters, waves parameters, and vegetation as an additional aspect. Based on those measurements, the coastal geomorphology characteristic on two sampling sites used as a standard evaluation for sea turtles nesting. Identification on beaches along the southern sea of west Java found that there are nine potential locations with the same characteristic with Batu Hiu and Pangumbahan coastal area as turtle nesting habitats.

1. Introduction

Sea turtle is a reptile that lived in the ocean and able to migrates over long distances along The Indian Ocean, Pacific Ocean, and South East Asian Sea. Sea turtles can migrate annually over long distances from its food source location to its nesting area. Generally, sea turtles are looking for their food at the places overgrown with marine plants and sea algae. Sea turtle migrates to the nesting area when breeding season is coming [1]. Their existence has been threatened by human activities and natural conditions. Turtles are classified in "The Red List" based on international agreements of IUCN and Appendix I CITES [2]. However, turtles in Indonesia also protected by Government Law's Indonesia No. 7 1999, about Preservation of Protected Plants and Animals. It means that their existence is endangered, so they have to get a serious attention. Java is one of the islands that turtle's spawned down, especially the south coast of Java [3]. Its mean that all of the coastal areas of south Java need to be observed of the sea turtles existence for their preservation. Some coastal areas that have already been sea turtles preservation are Batu Hiu and Pangumbahan coastal area (Fig. 1). Those locations are very well established, so the geomorphological evaluation can be done on that location. Result from



geomorphological evaluation on that location can be used for searching the potential location of sea turtles spawned area over the southern part of West Java coastal area.

Study of the coastal region is very close to the geomorphological study. Coastal geomorphology discusses landform in coastal areas. This is different from coastal geology that discusses the structure and rock formations in coastal areas. These are what distinguishes the subject between these two. In certain conditions, coastal regions are structured by various forms and materials. The morphology of coastal area can be affected by the tidal wave of sea water. The changes of the landform will certainly affect the morphology of the coastal region [4], also affect to the condition of the coastal ecosystem as already investigated that tides can affect sea turtle habitats [5].

Sea turtle makes the nest as an incubator on a beach that has sandy materials. Sea turtle's embryo requires good environmental conditions for its grown. The characteristic of coastal for nesting sea turtle habitats that suits must be 1) beach that could be reached by marine processes, 2) loose and intermediate sandy materials, and 3) high beach position to afford submerged eggs when the tide occurs [6]. Sea turtles in choosing habitats to lay their eggs have unique characteristics. The light condition affects migration of turtles to the beach because sea turtles are using visual guide to find their nesting habitat [7]. The light pollution also increases the vulnerability of hatchability, predator, and the dynamic population of turtle, reproduction, navigation, and migration behavior of sea turtles. That light pollution causes a decrease in the population by more than 7% compared to the population of migrated turtles [8]. Beach slope configuration greatly influences the sea turtle nesting activities. The range of beach slope that suitable for sea turtles nesting is between $0,06^{\circ}$ - $22,34^{\circ}$ [9]. In general, beach areas that suitable for sea turtle nesting have special vegetation characteristics. There are some types of vegetation that usually grow on the beach for turtle nesting [3]. The aim of this research is to evaluate the condition of the coastal region where turtles lay their eggs based on geomorphological approach. The evaluation results can be used as a baseline for assessing a coastal suitability for turtle habitats across the southern coast of Java Island.

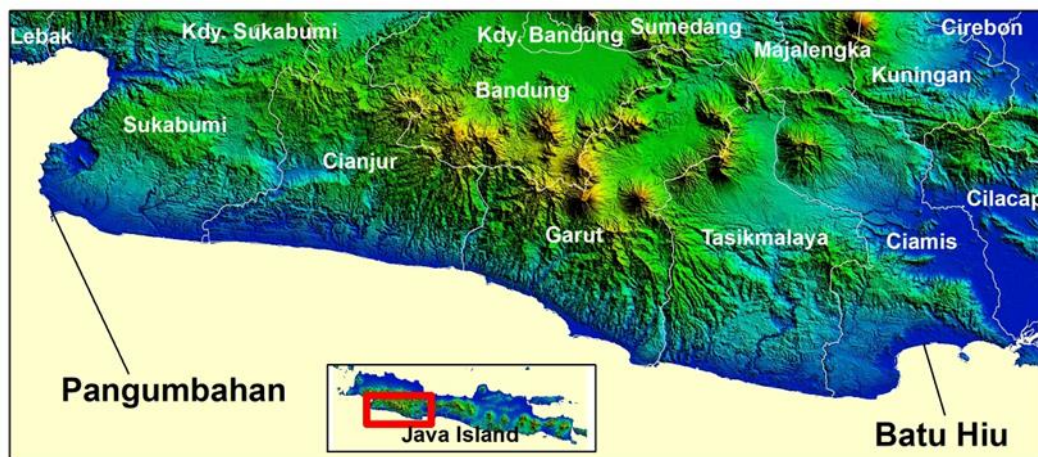


Fig. 1. The location of Batu Hiu and Pangumbahan coastal area

2. Method

Based on the recent studies, coastal geomorphology parameters that able to affect the sea turtle habitat consist of coastal morphology, the material characteristics (granulometry), coastal processes such as wind and waves, and land cover such as vegetation as an additional aspect. Analysis of morphological is conducted through the classification of beach slope based on the relief classification [10]. Measurement of granulometry/grain size was done by taking samples from sea turtle spawning grounds. Then, the samples were sieving in the laboratory and the result processed statistically using Gradistat [11]. The measurement of coastal processes divided two main parameters, they are wave parameter and wind parameter. These measurements used a laser rangefinder, stopwatch, and automatic anemometer as field tools. Those parameters observed in the field were utilized as the

parameters to conduct on the waves type by Galvin classes [12]. The parameters were such as the wind velocity in 2 m, wind velocity in 10 m, wave-length, wave height, the coefficient of the type of wave breakers. The formulas used are below, and the classification of the type of wave breaker by Galvin classes are shown in Table 1.

Wind velocity in 10 m above

$$U_{10} = U_2 \times (10/2)^{1/7} \quad (1)$$

U_{10} = Wind velocity in 10 m above (m/dt)

U_2 = Wind velocity in 2 m above (m/dt)

Wave Length

$$L = \frac{(g \times T^2)}{2\pi} \quad (2)$$

L = Wave length (m)

g = acceleration of gravity (m/dt²)

T = wave period (dt)

Wave Height

$$H = 0,031 \times U_{10} \quad (3)$$

H = Wave height (m)

The Coefficient of The type of wave breakers

$$B_b = \frac{H_b}{g \times s \times T^2} \quad (4)$$

B_b = The coefficient of the type of wave breakers

s = slope (%)

H_b = The height of the type of wave breakers, with the formula:

$$H_b = 0,38 \times g^{1/5} \times (T \times H^2)^{2/5} \quad (5)$$

Table 1. The Classification of The type of wave breakers by Galvin

Bb Value	The type of wave breaker
<0,003	Surging
0,003-0,068	Plunging
>0,068	Spilling
-not classified-	Collapsing

Coastal vegetation was also included as important variables in turtle breeding locations because many published said that turtles prefer to stay in open coastal areas with moderate vegetation cover. Therefore, the existence of vegetation along the coastal line need to be observed in the field. Aside from terrestrial observations, an aerial observation also needs to be done using a UAV/drone. UAV produced detail aerial image that could enrich our analysis regarding vegetation analysis, actual land cover information, highest wave distant, and display the nest spot in the holistic point of view. A potential map was also conducted by interpretation of the geomorphic characteristic on the registered beach on Wes java. The data for assembling the map itself was considered on the geomorphic characteristic that has been explained above. First, we arranged a hypothesis which place was supposedly suitable for the sea turtle spawn and which not. After that, we verified the hypothesis on the field check activity. The sample itself was chosen based on the most accessible spots since some of the spots were hard to reach.

3. Result and Discussion

Batu Hiu and Pangumbahan coastal area are famous for turtle nesting conservation area in West Java region. In the last previous decades, Teluk Penyus in Cilacap coastal area was also the spot where

plenty of sea turtles lay their eggs. However, based on the field observation and depth interview with the local stakeholders, turtles have been disappeared since several development and constructions established in the Teluk Penyu coastal area in the last decades. The name of "Teluk Penyu" strongly represents the condition of the coast for turtle habitats, therefore "Teluk Penyu" means "Turtle's Bay". The dynamic change of geomorphology at the coastal area like in Teluk Penyu is widely influenced to the migration and turtles for laying their eggs, and those have a positive correlation to the turtle nest [13].

Geomorphological analysis for sea turtle nesting samples was conducted in Batu Hiu beach, Pangandaran and Pangumbahan beach, Sukabumi. The result from the two locations indicates that the most sea turtle rich diverse location was in Pangandaran Coast, at Batu Hiu beach area with five species of sea turtle, in contrary Pangumbahan Coast only has one species of sea turtle (Table 2). Those locations are the locations that enrich with the proper conservation management. It is possible that many other beaches along the southern java coastal line has the potential for sea turtle nesting but are not yet discovered by the local stakeholder including government and the local people.

Table 2 Turtle species that found in the area of interest

No	Beach	Turtle species
1	Batu Hiu	Green Sea Turtle, Olive Ridley Sea Turtle, Hawksbill Sea Turtle, Loggerhead Sea Turtle, Flatback Sea Turtle
2	Pangumbahan	Green Sea Turtle

The result from parameters identification shows that the characteristic of Batu Hiu and Pangumbahan coastal area are quite similar. The beach on those two locations has the flat to the slightly flat slope. That condition is very suitable for turtles because it is hard for the sea turtle to move at the steep slope beach. The beach distance from the shoreline to the sea turtle nest at both locations were more than 25 meters. The distance is important in order to prevent their eggs submerged by the tides. The grain size in both coastal area are almost similar, which is classified as sandy texture. Sandy texture is the best material for a turtle nesting area. A beach that arranged by debris material is not suitable for turtle nesting area based on another discovery [14]. The size of sand in Batu Hiu is finer than Pangumbahan. The grain size of Batu Hiu is 0,243 mm and categorized as Fine sand, while Pangumbahan is 0,296 mm and categorized as Sand. The material with >90% of sand is suitable for sea turtles spawning ground [1].

The other statistical processes have resulted as its sortation, kurtosis, and skewness. The material in both locations has material which moderately well sorted. This condition indicates if sedimentation processes had various size of sand material from the smallest such very fine sand and the other bigger size such as coarse sand. That various size of material causes the sedimentation sorted moderately well. The sortation shows if the materials were part of the marine distal area. The relation between its grain size in each location and its statistical data also shown by the classification of kurtosis and skewness class. Batu Hiu's kurtosis class categorized as platykurtic. It means the statistical distribution graphic inclined flat and seems similar to the others. The Batu Hiu's skewness class also categorized as symmetric which show the balance of its variation between the fine and or even for the coarse material. While Pangumbahan's kurtosis class categorized as Mesokurtic. It shows if the statistical distribution graphic had a middle peak, not so flat nor pointed, so the distribution of particles in each size is a balance. Pangumbahan's skewness class categorized as Fine skewed which show the variation of size materials were dominated by fine sediments. The coastal geomorphic characteristics on both locations can be seen in Table 3.

Table 3. Coastal geomorphic characteristics on the sampling area

Parameters	Batu Hiu	Pangumbahan
Slope	Flat – slightly flat	Flat
Beach wide (m)	28	33
Beach length (km)	2	2,3
Grain-size	0,243 mm	0,296 mm
Material texture	Fine Sand	Sand
Sortation	Moderately well sorted	Moderately well sorted
Kurtosis	Platykurtic	Mesokurtic
Skewness	Symmetric	Fine skewed

The other characteristic of geomorphology for sea turtles spawning ground was not only measured in the land area especially for the process in the coastal area. In terms of the waves, the furthest distance that wave could reach in the high tide was also measured in this research, because the waves mainly affected sea turtle when it crawled to the surface. The type of wave breakers shows the relation between wind and coastal morphology. The type of wave breakers is influenced by several parameters include beach slope, wave height, and wave-length. Those parameters determine the amount of energy that hits the beach area. The calculation of Galvin Formula in both locations shows the type of wave breaker is Surging. Surging wave has a large impact energy on the bottom of breaker zones so it could lift and carry the material to the beach area due backwash process. The energy possibly to reduce during the distance when the wave spread on the beach. This energy could help the sea turtle to get the land for spawning their eggs. The characteristic of oceanographic in the sampling area can be seen in Table 4. Both of Batu Hiu and Pangumbahan has a straight shoreline with flat morphology. This condition indicated that those location also susceptible for tsunami hazard because the coastal area with flat topography and straight shoreline tend to has a high class for tsunami hazard [15].

Table 4. Oceanographic characteristic on the Sampling Area

Parameters	Batu Hiu	Pangumbahan
Wind Direction	320°	225°
Average wind speed at 2 m above (m/s)	2,6	1,6
Average wind speed at 10 m above (m/s)	3,27	2,01
Wave periodic	21	8
Wave length (m)	688,18	99,87
Wave height at the measurement time (m)	0,6	0,5-1
Wave height by Galvin formula (m)	0,33	0,13
Wave breaker height (m)	0,86	0,27
Coefficient of wave breaker	0,000023	0,000049
Type of wave breaker	Surging	Surging

The additional aspect of the research is the land cover especially vegetation. The area along both research site was mainly covered by the particular coastal vegetation type such as sea pandanus (*Pandanus tectorius*). The vegetation gave benefit to a sea turtle in terms of protecting their spawning area from the threats such as predators and the scorching sun. Also, the vegetation roots help to make the ground more stable. According to the local stakeholders that in charge to the sea turtle nesting, sea turtle profoundly felt safe if they're laid their eggs near the vegetation because the vegetation itself could cover the sea turtle while they laid the eggs. The existence of the vegetation was identification by using the UAV and verified on the field check. Fig. 2 showed the aerial photo of that location in 2016.

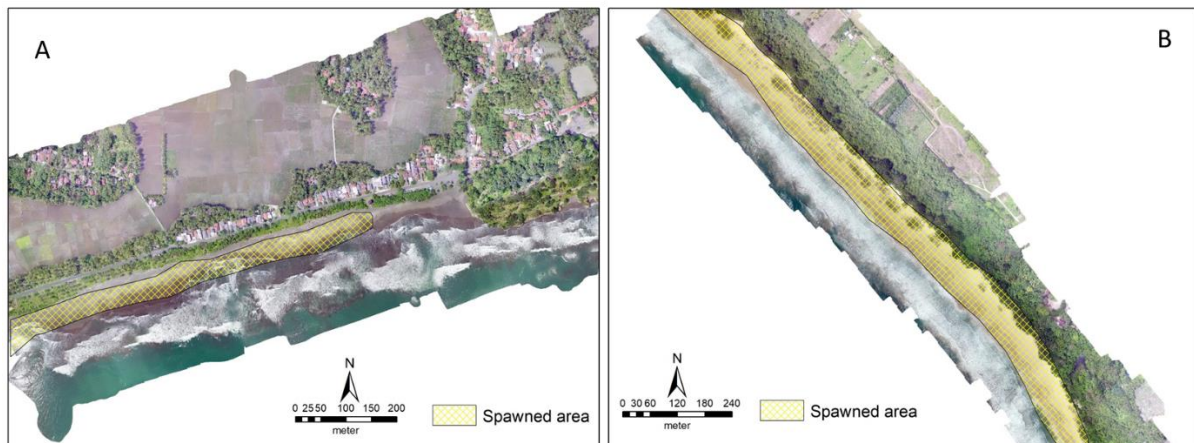


Fig. 2. Aerial photo of Batu Hiu and Pangumbahan in 2016

The result of the characteristic measurement in the two sampling areas is able to adopt as the basic reference to look for any other potential area in West Java that might have not been discovered yet as the sea turtles nesting ground. This identification can be performed as the first step for sea turtle conservation planning especially in southern coast of West Java. Based on the suitable characteristic for sea turtle showed in Table 2 and 3, most of the shore in West Java is not suitable for the sea turtles nesting. However, there are nine potential shores that could be developed as the sea turtle nesting conservation because those places have a similar geomorphic characteristic with the sampling areas (Fig. 2). Those locations need to be proved by identifying the existence of sea turtle nesting habitat. That identification might be less precise since in facts the turtles have been laid their eggs for long period on the shore that was supposedly not suitable according to the parameters above, but nobody might be has not discovered it yet. This becomes interesting because it can be used as suggestions for the next research and complete the characteristic for the suitable sea turtle nesting area. This founded is expected to be used as the first step for sea turtles conservation, especially based on the physical condition on that certain coastal area. The map on the Fig. 3 displays the hypothesis regarding to the the possible and suitable spots for the sea turtle spawning ground in western part of south Java sea.

4. Conclusion

Geomorphological characteristics of the coastal area that suitable for sea turtles nesting can be arranged based on the measurements at the sampling sites, Batu Hiu and Pangumbahan. Both locations are taken because it has been a role as a conservation area where considered successful. The classification result of the coastal geomorphic characteristic for sea turtles nesting is generalized to assess the beaches in the southern sea of West Java and produced nine potential locations as sea turtles nesting. This step can be used as a starting point for the conservation planning for potential areas that need to be observed in advance of the existence of the turtle habitats.

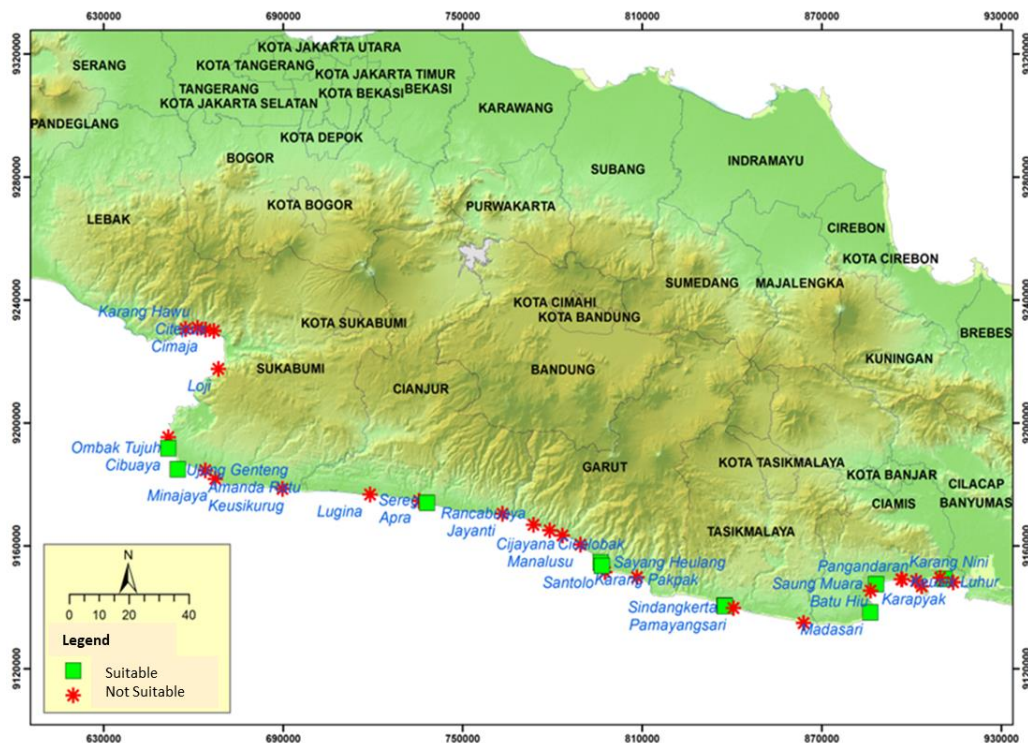


Fig. 3. Map of potential sea turtles nesting location on the southern coastal of West Java based on geomorphological characteristics

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