Evaluation of environment carrying capacity as a coastal tourism using GIS in Sepanjang Beach, Indonesia

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Abstract. The rapid pace of population growth in coastal areas and increasing the need for natural tourism can have a negative impact on the quality and quantity of natural resources and the environment in Sepanjang Beach, Gunungkidul regency. The phenomenon of seawater tidal waves led to a number of buildings along the beach experiencing heavy damage. The purpose of this research is to know the environment carrying capacity seen from the aspect of land capability and land suitability aspects as a tourist area, as well as providing recommendations that are right on Sepanjang Beach. The methods used are spatial analysis methods using geographic information systems (GIS) and scoring methods to determine the environment carrying capacity and land suitability. The results of the calculation of the environment carrying capacity based on the aspect of land capability were obtained by 2 classes of land capability namely moderate and good. Whereas seen from the results of the suitability of the beach recreation category shows if Tourism Suitability Index (TSI) has a value of 94% which means it is appropriate. However, it is necessary to arrange the gazebo building to use upland land in the form of alluvial karst plain.

1. Introduction
Population growth and tourism needs every year are increasing. This will cause a decrease in the quality and quantity of environmental carrying capacity of the land, water, and air [1]. Yogyakarta Special Region is one of the provinces in Indonesia that has a high tourist attraction both from the cultural aspect and the natural panorama. One of the regencies in the province of Yogyakarta special region namely Gunungkidul Regency in 2017 can attract as many as 3,246,996 tourists consisting of 21,067 foreign tourists and 3,225,929 tourists. Most of the number of tourists who visit Gunungkidul Regency are usually on the beach area [2]. The Coast is a gathering area between land and sea, inland to coastal areas covering the land area both dry and water-flooded which are still influenced by the nature of marine properties such as tides, seawater, and saltwater subsidence [3]. The coastal area of Sepanjang Beach, Tanjungsari District, Gunungkidul Regency has a beautiful natural panorama with white sand and wide beach stretching up to 579.56 meters. However, there is a factor in the coastal tourism sector that is the threat of tidal waves.

Based on Badan Meteorologi Klimatologi dan Geofisika (BMKG) data, this beach is entered into areas that are prone to tidal waves. Based on Gunungkidul Regency Regulation Number 6 of 2011 about the spatial plan for efficacy area into strategic area II tourism (KSP II) where development of the beach is intended as a tourist area in the form of beaches with Tourism supporters in the form of...
culinary processed seafood. Therefore, it is necessary to assess the potential land resources for its various uses [7]. The core of land evaluation is to compare the requirements requested by the type of land use that will be applied, with the properties or quality of land owned by the land to be used [8]. Meanwhile, the environment carrying capacity seen from the threshold of ability is the value of the Capacity of land as an ecosystem in accommodating and holding land from damage caused by the use of it [9]. Evaluation of environment carrying capacity based land capability is done by the scoring method characteristics of the land characterization of land capacity used are permanent or difficult deterrent factors can be changed namely texture of the soil, slope slopes, drainage, groundwater depth, the level of erosion that occurs [10]. Tourism conformance analysis uses a conformity matrix based on parameters to support tourism activities [11].

The methods used to evaluate land suitability are Geographic Information Systems (GIS). Analysis using ArcGIS 10.2 software to manage data, whether in the form of images/maps or tables, as well as understanding the linkages between the two with this system, a variety of map analysis and table-based (tabular analysis) can be done quickly, easily, and accurately [12]. The purpose of this research is to evaluate the environmental support of land-based capabilities and beach suitability as a recreational tourism area. The output that is expected from the research is the recommendation of the arrangement and management to make a reference by the government in realizing the economy in the tourism sector is not only beautiful but safe from disaster risk.

2. Methods

2.1. Surveying and mapping
The research site is located on the beach along, which is administratively located in the village, Tanjungsari District, Gunungkidul Regency, Special area of Yogyakarta. Geographically, the research site is located at UTM coordinates 451900 mE – 452700 mE and 9100400 mS – 9100900 mS. The survey method is used to obtain data from a certain place that is natural and will facilitate researchers to obtain data to be processed to solve problems that are the final goals of research [13,14]. Mapping is done to present the data on topography, land use, rock units, soil type, and slope. Equipment used in the study is a 1:2000 scale map that includes a map of topographical map, soil type map, rock map, land use map, GPS (Global Positioning System), geological compass, geological hammer, sample bottle, anemometer, Double Ring Infiltrometer and ArcMap software 10.2.

2.2. Laboratory analysis
This method is used to determine recharge quality and soil texture. Groundwater samples used are water wells around the tourist area of Sepanjang beach. The parameters measured are the parameters of DHL (electrical power supply). While Soil texture analysis is used for the evaluation of land support capacity. The samples used for scoring land capabilities were taken at 9 point sampling based on landform land forming land use. The value of R is calculated using the method of the ratio of chloride-carbonate to know the level of water infiltration located in wells in the area of research locations with formulated

$$R = \frac{CL^-}{CO_3^-+HCO_3^-}$$  \hspace{1cm} (1)
Where $\text{Cl}^-$ is the chloride ion concentration (mg/Litter), $\text{CO}_3^{2-}$ is carbonate ion concentration (mg/litter), and $\text{HCO}_3^-$ is bicarbonate ion concentration (mg/Litter) \cite{15}. The value of $R$ obtained is then classified according to the table of the relation of $R$-values with seawater infiltration level to prove that the water in the well-sourced from seawater intrusion with value < 0.5 (freshwater ground water, 0.5-1.3 (seawater infiltration occurs slightly, 1.3-2.8 (moderate seawater infiltration), 2.8-6.6 (seawater infiltration occurs somewhat high), 6.6-15.5 (high seawater infiltration) and 15.5-20 (seawater) \cite{16}.

2.3. Scoring analysis
Mathematical methods are used to obtain the result of the value of environmental support in the tourist area of Sepanjang beach. Land capability consists of soil texture, surface tilt, drainage criteria, groundwater depth, erosion criteria. \cite{17}. Classification of land capability scoring is score 5-9 (very bad condition), >9-13 (bad conditions), >13-17 moderate condition with some limiting factors, >17-21 (good carrying capacity) and >21-25 (excellent with high carrying capacity). While in the field of the decipherment of land as a tourist area beach recreation category there is 6 factors barrier. Parameters types of beach scoring with white sand (4), white sand coral (3), black sand, steep corals (2), and mud, rocky, steep corals (1). Scoring of beach width with value > 15 m (4), 10-15 m (3) 3-10 m (2), and <3 m (1). Scoring of water base material with material sand (4), sandy corals (3) muddy corals (2) and mud (1). Scoring of beach slope with slope value <10 % (4), 10-25 % (3), >25 % (2), and >45 % (1). Scoring of cover crop is coconut, open ground (4), shrub, low savanna (3), tall shrub (2) and mangrove, settlement, port has score (1). Scoring of freshwater availability with distance <0.5 km (4), >0.5-1.3 km (3), >1-2 km (2), and >2 km (1). Classes of suitability is divided into 3 class with score 77.78 – 100 (suitability), 55.56-77.77 (conditional suitability) and <55.56 (un-suitability) \cite{11}.

3. Result and discussion
The results of the environment carrying capacity based on land capability the soil has a type of texture in the form of sand, sandy loam and sandy clay on the form of Gisik land and the shape of the Karst hills with the use of garden land. The slope in the research site is steep (30-50%) And very steep (> 50%) In the Karst Hills, Medium (8 – 30%), karst alluvial plains and ramps slope (2-8%) and flat (0-2%) and flat slope (0-2%). The drainage criteria have a slow category with an infiltration value of 1-20 mm/hr in the coastal area and are on the land and beach. Groundwater depth based on measurements in all five wells are in the range of 3.53 to 4.96 meters which belong to the category very well. The level of abrasion or erosion based on the measurement and stage of the studio, in Sepanjang Beach has moderate category erosion vulnerability. However, the tidal range and wave height tend to be low, thus the value of the erosion vulnerability in the field of the Gisik indicates that the current. For detail see in figure 1.
Figure 1. Map of (a) land use and land sampling water, (b) topography, (c) slope, (d) soil texture, (e) infiltration rate, (f) rock type, (g) soil type, and erosion in Sepanjang beach, Gunungkidul Regency.
Based on the results of an overlay map of eight such as land use, topography, slope, soil texture, infiltration rate, rock type, soil type and erosion rate in Sepanjang beach, land capability parameters there are two criteria of moderate land capability and good land capability. The results of land capability are in the form of karst hills and valleys and forms of the area of the Gisik and karst alluvial plains, for more detailed results can be seen in Figure 2.

![Map of Land Capability as a Coastal Tourism Area in Sepanjang Beach](image)

**Figure 2.** Map of land capability as a tourism area Sepanjang beach, Gunungkidul Regency.

**Table 1.** Scoring of suitability land as a beach recreation category.

| Parameter                     | Value | Result          | Score | Total |
|-------------------------------|-------|-----------------|-------|-------|
| Beach type                    | 5     | White sand      | 4     | 20    |
| Wide beach (m)                | 5     | 579.56 meters   | 4     | 20    |
| Water base material           | 5     | Sand            | 4     | 20    |
| Slope of the beach (%)        | 4     | 0-2 %           | 4     | 16    |
| Beach land closure            | 3     | Open ground     | 4     | 12    |
| Freshwater availability of distance (km) | 3 | 3,8 km | 1 | 3 |
| **Total**                     |       |                 | **91**|       |

The results of the scoring of suitability land as a beach recreation category in table 5 indicate that the value of more than 91 shows that the Sepanjang Beach of Gunungkidul Regency suitability to make the tourist area of the beach. Management instruction in the area of Sepanjang Beach, Gunungkidul Regency can be done with two approaches namely technology and vegetation. The technological approach was done by building a revetment aiming to protect the area behind the revetment of the wave attack and the wave runoff to the ground. The revetment is created at the research site using a type of concrete block, cavity, and ladder [18]. The engineering of vegetation is done by planting an intermittent *Annona squamosa* plant with a *Prunus cerasus* plant. The *Prunus cerasus* plant has a long rooting with a thick stem. This planting can be used as a tsunami controller [19]. It is based on the regional regulation of Gunungkidul Regency which mentions that building in coastal areas potentially affected by tidal waves/tsunami is only permitted if located in the tsunami control forest.
4. Conclusion
The results of environment carrying capacity based on land capability Sepanjang Beach as tourism area there are two results of moderate land capability class and good land capability. While the analysis of land suitability area Sepanjang Beach as a recreational area of the beach shows a value of 91% based on the tourism suitability index has been suitable as a beach recreation area. The direction of processing is by the manufacture of revetment and engineering vegetation using the Annona squamosa plant and Prunus cerasus plant.

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