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Distribution Patterns and Settlement Density Using Nearest Neighbor Analysis and Kernel Density Analysis in DIY Coastal Areas

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ABSTRACT

DIY's coastal area is one of DIY's development priorities by establishing the site as an economic corridor that impacts physical development, such as settlements in the coastal area of DIY. This study aims to analyze the distribution and density of settlements. The method used in research is a quantitative descriptive and Geography Information System approach. The analysis used in this study is Nearest Neighbour Analysis (NNA) and Kernel Density Analysis with an analysis tool in ArcGIS 10.5. The results of the NNA show that the three districts located on the coast of DIY have the same distribution pattern characteristics, namely, the clustered pattern, which means the NNA index value is <1 or the T value ranges from 0-0.80. The results of the kernel density analysis show that the most significant density is found in Kulon Progo Regency, precisely in Wates District, and Bantul Regency, precisely in Srandakan District. At the same time, for Gunung Kidul Regency, it is less significant, and the density is only centered on one density point. Several factors cause settlement density, including physical factors (topography, slope, soil type, and clean water sources), accessibility (proximity to transportation routes and proximity to the city center), availability of facilities and infrastructure (electricity network, educational facilities, and health), and environmental factors (natural and human resources).

INTRODUCTION

The Coast of Java Island is one of the dynamic areas due to land, sea, and climatic processes that dominate one another (Ekosafitri et al., 2017). The diversity and complexity of the coastal area, both physically, biologically, chemically, and inhuman dimensions, make this area vulnerable to various changes (Bishop-Taylor et al., 2021; Brand et al., 2022).

The coastal waters of DIY are in the open sea category with a coastal horizon directly opposite the Indian Ocean, so the wave energy towards the coast is very influential on the dynamics of the coast (Purwantara et al., 2013). Meanwhile, the increasing number of residents yearly also affects development activities on the coast, such as settlements, fisheries, ports, tourism, and road networks, increasing ecological pressure on coastal ecosystems. (Chang et al., 2018; Gupta & Bavinck, 2017). The use of space in these activities does not pay attention to disaster aspects, so there is an overlapping between disaster-prone areas, residential areas, and other areas (Astjario, Harkinz Prabowo, 2012).

On the other hand, the world's coastal areas continue to experience increased development, marked by the increase in the number of settlements (Dawson et al., 2018). If settlements tend to develop in urban areas, settlements are starting to develop in several coastal regions of the world, both formally and informally (Venerandi et al., 2021). Developments lead to an increase in economic activity and activities (Hutama & Kristiadi, 2019). As a result of these activities, changes in coastlines in coastal

areas (Giaime et al., 2022; Rostika et al., 2016). Developments also continue to increase in coastal areas, a major problem experienced by world coastal cities where many people live in the area (Andr & Manuel, 2022), living as new growth centers (Dhali et al., 2019; Vertakova et al., 2015).

This dynamic also occurs in the DIY Coastal area, located in 3 regencies and 13 sub-districts currently functioning as a place of concentration of activities, be it settlements, trade, or other activities. DIY Vision 2017-2022 to meet the "Indian Ocean Century." Through this vision, the development of the DIY region leads to efforts to develop social and economic activities in the southern coastal area of DIY. Through this vision, the growth of the DIY Coastal area continues to occur and has increased activity encouraging the emergence of new activity centers (Yusliana & Devi, 2020).

The new activity centers are in the form of distribution or increase in activities carried out by individuals and communities, called settlement developments that cause a pattern of distribution in coastal areas (Lakshmi & Shaji, 2016; Zhang & Pan, 2020). Law No. 1 of 2021 defines settlements as part of the residential environment in the form of several housing units with complete infrastructure, facilities, and public utilities that have functioned as supporting activities in urban and rural areas. In addition, settlements also consist of 5 elements: nature, humans, society, networks, and the environment.

Generally, coastal settlements have the same shape and tendency so that the balance between the resources in the coastal area can be managed properly (Rempis et al., 2018). The settlements have an essential role in land development in urban and rural areas (Boone et al., 2021; Chang et al., 2018). On the other hand, important issues related to the development of residential areas need serious attention so that the development of the coastal regions can be more focused and sustainable (Jiang et al., 2015; Liu et al., 2020). Several studies that have been carried out related to settlements state that residents who live in residential areas in coastal areas tend to occupy illegal areas and are vulnerable to conflicts of interest from various parties. On the other hand, research was conducted by (Setioko et al., 2013).

In research conducted by (Jihad et al., 2020), typology-based tsunami modeling was used in coastal areas using process hierarchy analysis. His research indicates that the AHP method can provide stable results regarding the priority level of vulnerability and hazard in other regions with a coastal and settlement typology approach. In addition (Song & Li, 2020; Tanga et al., 2022) conducted research on patterns exploring the countryside in the Beijing region, which has undergone a dramatic transformation. The method used is a land transformation model using high military satellite imagery. The study results show that the regular spatial pattern is common continuously, but the spatial distribution varies in various stages. (Zapata Campos et al., 2022) also researched spatial patterns in rural China by using a new method, namely topography based on micro-geomorphic units. The results showed differences in the topographic gradient of the spatial pattern in the countryside were different. While the research conducted by (Alene, 2022) uses the pattern in Gondar-Ethiopia, the method used is descriptive statistics with a 4-dimensional approach, namely socio-economic, political and legislative, administrative, and demographic. The results show that the socio-economic dimension is the main factor in the formation of usage patterns.

From the research above, the spatial pattern influenced by the physical is influenced by the shape of the regional typology, and socioeconomic aspects influence the non-physical. Looking at some of these studies, there are empty gaps in the pattern, as seen in coastal areas. For this reason, researchers are interested in conducting research on research patterns with loci in the coastal region of DIY. The research location is chosen because the DIY coast is one of the priority areas for infrastructure development. Next, the

researcher will analyze the spatial pattern of settlements in the southern coastal area of D.I Yogyakarta by conducting a spatial study and digitizing the area to collect in group units. The unit of analysis used is all sub-districts in the coastal area of D.I Yogyakarta, which consists of four sub-districts in the district. Kulonprogo has three sub-districts in Bantul Regency and six sub-districts in Gunungkidul Regency. From the spatial pattern analysis results, the shape and factors that influence the pattern used in the coastal area will be known.

Based on the background of the distribution of settlements on the coast, it must be considered regarding its control and supervision so that it is by the DIY coastal spatial planning regulations. The problem of this research is how the distribution and density of settlements spatially in the coastal area of DIY; this study aims to identify and analyze the distribution and density of settlements spatially in the coastal area of DIY.

RESEARCH METHODS

This research covers the coastal area of DIY, which consists of 3 regencies, namely Kulon Progo Regency, Bantul Regency, and Gunung Kidul Regency, which includes 13 sub-districts specifically in the coastal area, including Wates, Temon, Panjatan, Galur, Srandakan, Sanden, Kretek, Panggang, Purwosari, Saptosari, Tanjungsari, Tepus, and Grisubo sub-districts.

Figure 1. Framework of Research

Figure 2. Map of Administrative

The method used in this research is descriptive qualitative-quantitative descriptive analysis with secondary data analysis base. The method used in this research with the Nearest Neighbor Analysis (NNA) analysis technique was used to determine the pattern of settlement distribution, and Kernel Density analysis was used to determine the density of settlements in the coastal area of DIY.

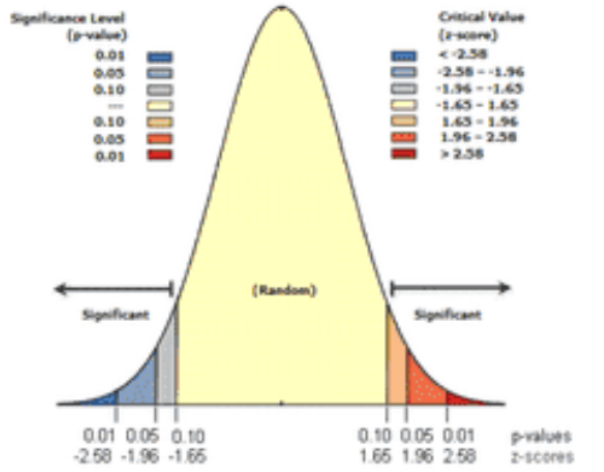

Figure 3. Nearest Neighbor Analysis Value Chart

Data Analysis

a. Settlements Distribution Pattern

Analysis of settlement distribution patterns using ANN. ANN (Average Nearest Networks) is the tool ArcGIS to calculate the nearest neighbor index based on the average distance from each feature to its nearest neighbor feature (ArcGis Help, 2017).

The observed mean distance expected mean length, nearest neighbor index, z-score, and p-value. The data has clustered values based on the z-score and p-vain the figure 1. These values are generated from the calculation of the nearest neighbor to identify the nearest neighbor with a clustered or spread pattern. The data has clustered values based on the z-score and p-vain the figure 1. Based on the graph above, if the z-score <-1.65 and a significant p value> 0.01, the settlement pattern formed is in groups./clustered and if not spread.

b. Settlements Density

Settlements density using analysis Kernel Density is a statistical approach to estimate the probability distribution function (Setiawan et al., 2017). The form of data distribution is not used as a problem that needs to be considered (Handayani & Rudiarto, 2011). Calculate The Kernel Density using Arc GIS is raster-based, so the grid size will significantly affect the level of detail in the calculation results because of the quality of the data (Chang et al., 2018; Chen et al., 2022). The area and distance between reference points and each reference point's combined volume early affect the calculation results' accuracy and depth (Cai et al., 2013).

The variables used in this study identify action data on the distribution of settlements (Persil) and administrative boundary data. The data aims to produce polygon parcel data into data described as data points. Expected output/result in Kernel Density analysis performed in Arc Gis 10.5. The following illustration is expected the figure 4.

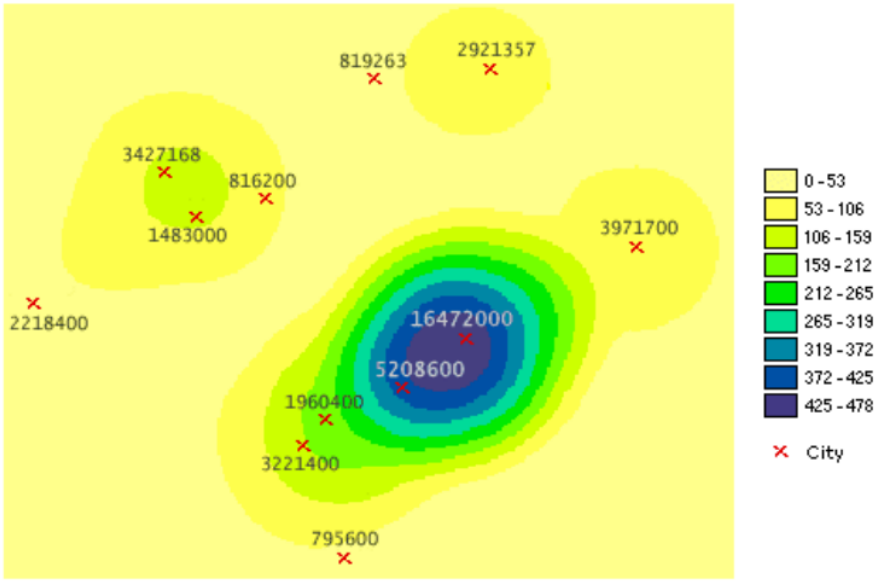

Figure 4. Illustration of Expected Results/Output
(Source: Arc. GIS Map Desktop Help Topic, 2021).

RESULT AND DISCUSSION

a. Distribution of Residential Areas in Coastal DIY

Identification of the distribution of residential areas in 3 coastal districts of DIY was carried out by digitizing the distribution of settlements through satellite imagery. The digitization process is done by digitizing parcel data from the Google Street folder obtained from the 2020 terra incognita application. In addition, building parcel data is obtained through automatic digitization results from OSM (Open Street Map), where the digitized information is in the form of building parcel polygon data.

Because the analysis process requires data in the form of points, the data on the distribution of settlements in polygons were converted into point form through the ArcGis 10.5 application with the Feature to Point tool. It can be used from several images of digitized maps in the 13 sub-districts.

The map depicting the distribution points of settlements has been obtained from digitizing the image map of the built-up area on the coast of DIY in 2020. The intended digitization is to get secondary data from the terra incognita application. The application provides an overview of the area in raster form, then digitizes the data for the settlement area, converted into vector data (shapefile) in the ArcGis 10.5 application. With this digitization method, researchers obtain data on residential areas/built-up land, which can then be used as material to analyze the distribution pattern of settlements using the ANN method and settlement density analysis using the kernel density method.

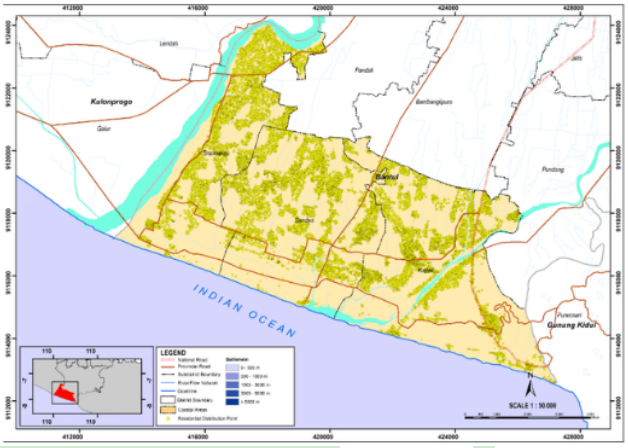

Figure 5. Map of the Distribution of Settlements in Bantul Regency

Figure 6. Map of the Distribution of Settlements in Kulonprogo Regency

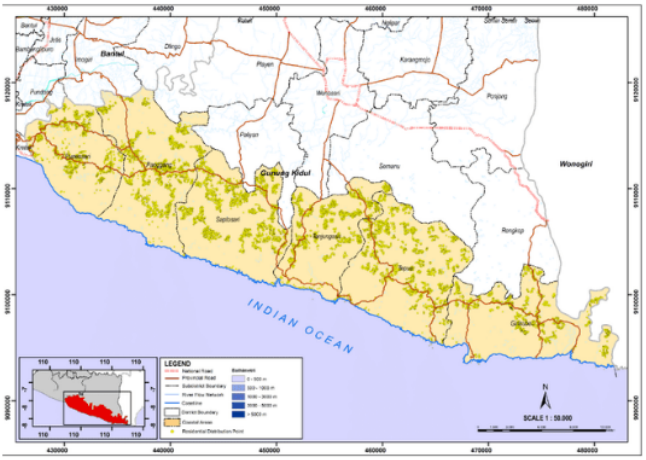

Figure 7. Map of the Distribution of Settlements in Gunungkidul Regency

b. Distribution of Settlement Patterns in the DIY Coastal Area

In calculating the distribution of settlements automatically in the coastal areas of DIY, the data is from data from the identification of the distribution of settlements (data on building parcels). The output is in the form of statistical information that shows whether the distribution pattern of settlements on the coast of DIY is clustered, random, or scattered. From the results of the ANN analysis, it is known that:

1. The distribution pattern of settlements on the coast of Bantul Regency is Cluster. The value obtained in the calculation shows that the value of T or NNRatio (Nearest Neighbor Ratio) is 0.457154. This value indicates that the value of T or NNRatio belongs to the category of 0.00-0.70 or ANN <1. This clustering pattern resulted from the observed mean distance (observed average distance) of 14.36 meters and the expected mean distance value of 31.41 meters. It can also be strengthened by the significance level of the z-score value of -177.36 and p-value of 0.00, where the Critical Value (Z-score) less than <-2.58 is significant to the significant value level. (P-value) which is less/equal to 0, 01, which means a pattern of settlement distribution in a clustered form. This clustered settlement pattern comprises house buildings spread over a certain distance.
2. The distribution pattern of settlements on the coast of Kulon Progo Regency is clustered. This is based on the value obtained in the calculation showing the importance of T or NNRatio (Nearest Neighbor Ratio) is 0.484216. This value indicates that the T or NN Ratio value belongs to the 0.00-0.70 or ANN <1. This clustering pattern resulted from the observed mean distance value (observed average distance) of 21.01 meters and the expected mean distance value of 43.40 meters. This can also be strengthened by the significance level of the z-score value of -183.27 and p-value of 0.00, where the Critical Value (Z-score), less than <-2.58, is significant to the significant value level. (P-value) which is less/equal to 0, 01, which means that there is a pattern of settlement distribution in a clustered form. This clustered settlement pattern comprises house buildings spread over a certain distance.
3. The distribution pattern of settlements on Gunung Kidul Regency's coast is clustered. This is based on the value obtained in the calculation shows the importance of T or NNRatio (Nearest Neighbor Ratio) is 0.354392. This value indicates that the value of T or NNRatio belongs to the category of 0.00-0.70 or ANN <1. This clustering pattern resulted from the observed mean distance value (observed average distance) of 39.10 meters and the expected mean distance value (expected average length) of 110.34 meters. This can also be strengthened by the significance level of the results from the z-score value of -153.67 and p-value of 0.00, where the Critical Value (Z-score), which is less than <-2.58, is significant to the significant value level. (P-value) which is less/equal to 0,

c. Analysis of Settlement Density in the DIY Coastal Area

The analysis used to measure the density of settlements in the coastal area of DIY is kernel density analysis, one of the tools in the ArcGIS application. The data used is the data from identifying the distribution of building parcels in the coastal area of DIY, where the building parcel data in the form of polygon data is converted into data points. Then the results obtained are divided into high and low classes. The results of the Kernel Density analysis show that:

1. The settlement density level in Bantul Regency is significant in Srandakan District, and the density distribution is evenly distributed. This shows that almost all the area's land is used for settlements. In addition, it can be proven, based on population density data on the

coast of Bantul Regency, that it is explained that Srandakan District has a settlement density of 1,705 people/km2. Meanwhile, the Sanden Subdistrict with a density value of 1,380 people/km2 has an uneven distribution, followed by the Kretek Subdistrict with a total settlement density of 1,152 people/km2 with an uneven distribution of settlement density/only concentrated in one point.

2. The settlement density level in the Kulon Progo Regency looks significant in Wates District. On the other hand, the distribution of settlement density is uneven/only concentrated in one area, which shows the northern part of the Wates District is an area with significant density. In addition, based on population density data in 2020, the highest population density in Kulon Progo Regency is in Wates District, which is 1540 people/km2. Wates District also influences this as the capital of Kulonprogo Regency, followed by Galur District area with a settlement density of 1005 people/km2, Panjatan subdistrict 877 people/km2, and Temon subdistrict 811 people/km2. The description of the kernel density map above explains.
3. Tepus District with a total density of 352 people/km2, the density is significant towards the west opposite the northern part of Tanjungsari District, then Panggang District with a comprehensive settlement density of 297 people/km2 with a significant density distribution towards the center and followed by Purwosari District with a total density of settlement of 293 people/km2 with a significant distribution of density towards the center and the north. Based on the results of settlement density data obtained from BPS, the density level on the coast of Gunung Kidul Regency is still below the value of 1000 people/km2 compared to areas in Kulon Progo and Bantul Regencies. The settlement density level in Gunung Kidul Regency shows that the distribution of settlement density is uneven/only centered on one point, and the density value is less significant. In this case, the highest density level in Gunung Kidul Regency is in Saptosari District, with 450 people/km2. From the map image from the kernel density analysis above, the density distribution in Saptosari District is significant. There are only 3 points, followed by the Tanjungsari District area of 411 inhabitants/km2, whose distribution is more concentrated at the northern part.

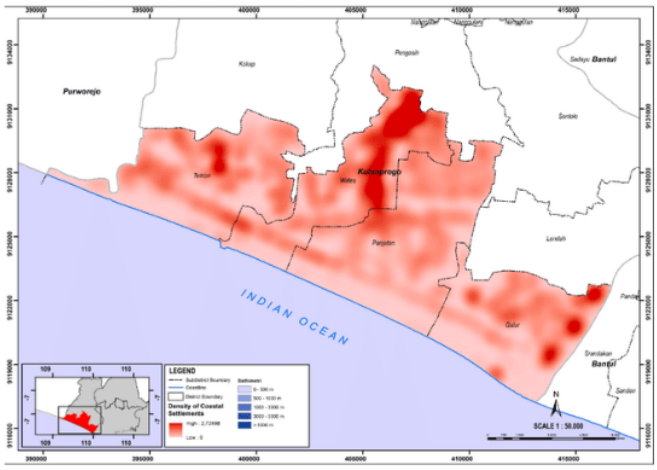

Figure 8. Settlements Density in Kulonprogo Regency

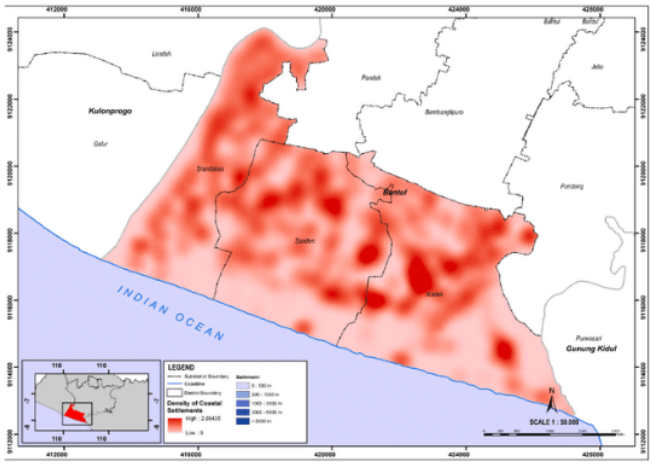

Figure 9. Settlements Density in Bantul Regency

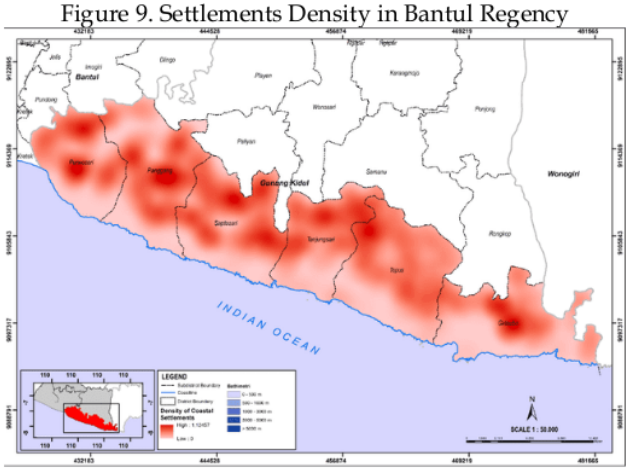

Figure 10. Settlements Density in Gunungkidul Regency

Meanwhile, for Girisubo District, with a total density of 273 people/km2, the density level is more significant centrally, or there is 1 point of settlement density. Then Panggang District with a total settlement density of 297 people/km2 with a significant distribution of density towards the center, followed by Purwosari District with a comprehensive settlement density of 293 people/km2 with a significant distribution of density towards the center and north. Meanwhile, for Girisubo District, with a total density of 273 people/km2, the density level is more significant centrally, or there is 1 point of settlement density.

Then Panggang District with a total settlement density of 297 people/km2 with a significant distribution of density towards the center and Purwosari District with a total settlement density of 293 people/km2 with a significant distribution of density towards the center and north. Meanwhile, for Girisubo District, with a total density of 273 people/km2, the density level is more significant centrally, or there is 1 point of settlement density.

CONCLUSION

The ANN analysis shows that the overall pattern of settlement distribution in Coastal DIY has the same characteristics as the distribution of settlements, namely the clustered distribution pattern. This result is

obtained because the calculation of the ratio (ANN) or index (T) value obtained is less than the significance value, which is at the ANN value <1, or the T value is in the range of 0-0.8

The results of the kernel density analysis show that the most significant density is found in Kulon Progo Regency, in Wates Subdistrict and Bantul Regency, and in Srandakan District. At the same time, for Gunung Kidul Regency, it is less significant, and the density is uneven/only centered on 1 point of density.

Several factors cause settlement density, including physical factors (topography, slope, soil type, and clean water sources), accessibility (proximity to transportation routes and proximity to the city center), availability of facilities and infrastructure (electricity network, educational facilities, and health), and environmental factors (natural and human resources). The aspect of the occurrence of clustered settlement patterns and the development of settlement density which is relatively linearly beaded on the coast of DIY, it is the same as the settlement density level.

The occurrence of settlement patterns will affect the settlement density level in the DIY coastal areas. Therefore, it is necessary to plan the other regions' development so that the settlement density growth can be spread evenly in the coastal regions of DIY.

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