Conference Paper

Analysis of Road Network Growth Patterns As Supporting System of Industrial Park Accessibility

Yudo Prasetyo, Nurhadi Bashit, and Dicky Nur Krisnha

Department Geodetic Engineering Faculty of Engineering Diponegoro University Jl. Prof Sudarto, SH, Tembalang, Semarang

Abstract

Development growth around the industrial area has increased from year to year to meet the ideal industry criteria ranging from environmental, economic, physical and other aspects. Physical development affects accessibility so that it accelerates production and distribution by increasing the road network. Road network monitoring needs to be carried out to see its effect on the accessibility of industrial park. Therefore, this study analyzes the growth pattern of the road network as a support system for industrial area accessibility. This research was carried out in the Kendal Industrial Park in Kaliwungu, South Kaliwungu, and Brangsong Regencies. The research method uses the Remote Sensing method and Geographic Information System (GIS). Satellite imagery was digitalized on Worldview-2 (0.5 Meter) and SPOT-7 (1.5 Meter) satellite images with multitemporal 2010 and 2019. The digitization results were calculated on the total length of roads from 2010 to 2019. Road growth patterns were analyzed using spatial statistical analysis shown by Ellipse's Standard Deviation. The growth of road net growth in Kendal Industrial Park from 2010 to 2019 is 45,645.392 meters or 45.645 kilometers. Road growth in the 3 sub-districts in the study area is heading north where in the north there is the Kendal Industrial Park which has a lot of road construction to support access to the Kendal Industrial Park or to other areas that are more effective and efficient.

Keywords: accessibility, spatial analysis, road network, kendal industrial park

Corresponding Author:
Yudo Prasetyo
yudo.prasetyo@ft.undip.ac.id

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1. Introduction

1.1. Problem Background

Central Java is one of the Provinces in Indonesia which continues to actively develop in the field of development in order to improve economic levels with the aim of being economically independent in Indonesia and other sectors. In another perspective, there is an important problem that needs to be considered, namely the domination of development that occurs in the Kendal Regency which converts vegetation land into built-up land. This development has resulted in changing surface physical properties and influencing climate. Focusing on industrial park areas, an industrial parks in Indonesia were first developed by the government through BUMN in the 1970s as a reaction to the needs of industrial land [1]. Industrial zones do provide a variety of positive impacts, one of which is to improve welfare and economic levels and to open jobs [2]. But on the other hand, we need to examine the carrying capacity system to see its potential in the future. The analysis of road network growth is done by a combination of Remote Sensing and Geographic Information Systems (GIS) methods. Digitization is done on Worldview-II and SPOT-7 satellite imagery with multitemporal in 2010 and 2019. The next digitization process will be overlapping so that the road growth in the initial development planning period is known from 2010 to 2019. Furthermore, spatial analysis will be carried out to identify the direction of the pattern of road growth with the growth of the industrial park.

1.2. Research Hypothesist

As for the formulation of the problem in this study are as follows:

1. What is the growth rate of the road network around the Kendal Industrial Park in the period 2010 to 2019 through digitizing multitemporal high-resolution images and spatial analysis of GIS?

2. What is the direction of road network growth in the area of Kendal Industrial Park through spatial analysis Standard Deviational Ellipse?

1.3. The Objective of Research

The purpose of this study is to look at the pattern of road growth and analyze the direction of road growth as the carrying capacity of the Kendal industrial area using high-resolution images.

1.4. The Scope of Research

As for the scope of this research are:

1. The study was conducted in 3 sub-districts namely, Kaliwungu sub-district, southern kaliwung and brangsong.

2. Determining the direction of road network growth is seen based on the direction of road growth and is done by doing a spatial analysis of the Standard Deviational Ellipse.

3. Road growth figures obtained from digitization above high resolution satellite images in 2010 and 2019.

4. Field data validation for road digitization data is carried out by the tracking method using a Handheld GPS and measurement of road width in the field using a tape measure.

2. Methodology

2.1. Industrial area

The definition of industry according to Law No. 5 of 1984 concerning Industry is an economic activity that processes raw materials, raw materials, intermediate goods, and funds or goods become objects that have economically higher economic value, including industrial design and engineering activities [3]. However, the industrial area of Indonesia is the heart of industrial activities that are equipped with supporting facilities and infrastructure that are developed and managed by industrial companies that have obtained Industrial Area Business Licenses [4].

2.2. Road Definition

According to Government Regulation No. 34 of 2006 in clause 1, road is a transportation infrastructure that includes all parts of the road, including buildings and auxiliary equipment intended for traffic, which are on the surface of the land, above the surface of the land, below the surface of the land and or air, and above air surface, except railroad tracks, truck roads, and cable roads [3]. Road classification is based on its function in Government Regulation No. 34 of 2006 grouped into 4 namely arteries, collectors, local, and environmental road, but based on the road net system is divided into 2 namely primary and secondary. Road network is an important aspect in carrying capacity of people's lives, especially in the socio-economic field.

2.3. Digitizing Process

Digitizing is part of the digital mapping process. In general, it can be defined as the process of converting analog data into digital format. Certain objects such as roads, houses, rice fields and others that were previously in raster format become vector objects. In a high-resolution satellite image, it can be converted into a digital format with a digitizing process that can be done in two ways, namely digitizing on-screen and digitizing using a digitizer. The on-screen digitization process is digitization which is carried out on a computer monitor screen by utilizing various geographic information system software [5].

2.4. Standard Deviational Ellipse (SDE)

SDE is mainly determined by three steps: average location, dispersion (or concentration) and orientation. The Standard Deviational Ellipse tool creates a Class Output New feature that contains elliptical polygons. The attribute values for these elliptical polygons include X and Y coordinates for the center, which means two standard distances (long and short axes), and elliptical orientation. When the underlying spatial pattern of features is concentrated in the center with fewer features towards the periphery (spatial normal distribution), the standard deviation of one ellipse polygon will cover around 68 percent of the features; standard two deviations will contain about 95 percent of the features; and three standard deviations will cover around 99 percent of the features in the cluster.

The central tendency is the center of the mean and dispersion refers to the spread from the center of the mean bounded by the ellipse. SDE is a graphical representation of standard deviations along the X and Y axes centered on the average geometric data of all locations.

3. Data Processing

3.1. Geometric Correction

Geometric correction is performed using the image to image method on the SPOT-7 image with a basic image of Worldview-2. Worldview-2 imagery is used as a reference because it has a higher spatial resolution compared to SPOT-7. Geometric correction is done so that the geometry of the two images is the same so that later it is used for road network calculations.

3.2. Digitizing on Screen

Digitization is one of the stages of the process in this study which aims to form road vector data derived from raster data (satellite imagery). In this process, the raster data used are Worldview-2 satellite imagery data in 2010 and SPOT-7 in 2019 with spatial resolutions of 0.5 meters and 1.5 meters respectively. The object of the road is digitized according to the class of road according to its function, namely arterial road, collector, primary and secondary local.

3.3. Topology Making

Digitizing that has been done is certainly not spared from mistakes. Data is very large, making it difficult for researchers to examine errors one by one and take a long time. Therefore, ArcGIS 10.4 provides topology features which are capable of detecting errors in vector data. Usually, topology aims to maintain data integrity through searching for errors in data. The topology features in ArcGIS are also capable of automatically repairing errors using topology tools and topology rules. The results of the topology error check can be seen in Figure 1.

Figure 1: Check the topology result error.

3.4. Field Validation

Field validation is done to see the truth of the digitization results that have been made to the actual reality of the field. The results of the validation aim to see whether there is an error in the classification or not, as well as provide additional information about the actual conditions in the field. This stage will provide additional accuracy regarding the digitization results that have been made to the conditions in the field. Field validation has an important role to evaluate the results of digitization that has been done. Field validation using GPS handhelds and measuring tape. The handheld GPS is used to determine the position of the road and the measuring tape is used to measure the length and width of the road so that it can know the actual length and road in the field.

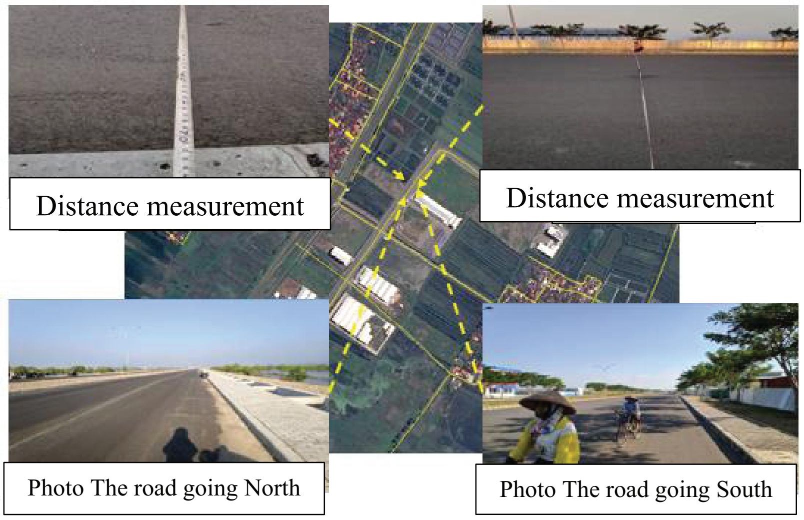

Figure 2: Validation.

3.5. Calculation of Road Length

The path length calculation is done using ArcGIS 10.4 software through a statistical feature that can be opened via the attribute table in the feature class that will calculate the path length. At this stage the length of the road is calculated in 2010 and 2019 based on the digitization results.

3.6. Direction of Road Network Growth

Road growth analysis is done using the Standard Deviational Ellipse (SDE) method on the tool provided by ArcGIS 10.4. This tool is part of the spatial statistics tool owned

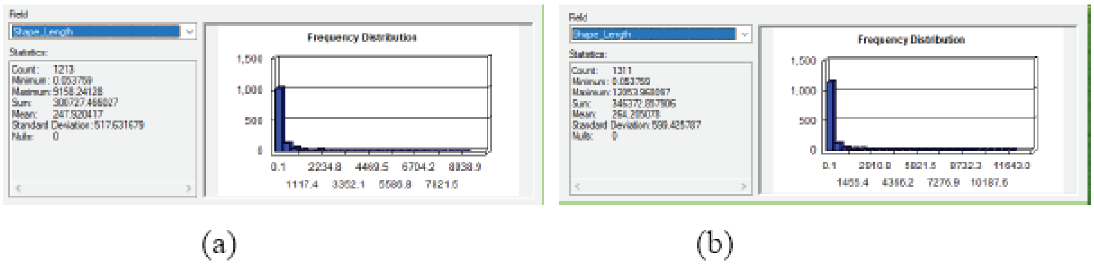

Figure 3: Statistical road length statistics for 2010 and 2019.

by ArcGIS 10.4. SDE has the principle of determining the direction of spatial tendency (directional) by using an elliptical model as discussed in the literature chapter.

From the road distribution data, after the SDE model is formed, the results obtained for each road class are presented attached. In this section SDE results will be presented for local road classes in 2010 and 2019 only, because those who experience significant changes in direction of growth are only found in the local road class and even new classes of roads, namely toll roads, appear.

4. Results and Analysis

4.1. Analysis of Geometric Correction Results

Geometric correction is a correction that is used to improve accuracy by using control points or Ground Control Points (GCP). GCP in question is a point that knows its coordinates precisely and can be seen in satellite imagery such as the end of a crossroad or other unique place. 16 GCP points are used to improve the accuracy of an image. Using 16 GCP points because the geographical conditions of the Kendal Regency are quite varied, such as the existence of rice fields, forests, ponds, settlements and others. The method used to measure geometry quality is image to image with the base map used as a reference is Kendal District Worldview-II.

Table 1: Geometric Correction.

Jenis Citra	RMSE GCP
Worldview-II 2010	0,024614
SPOT-7 2019	0,023938

In Table 1 shows that the value of RMSE $\leq$ 1 pixel, the image is considered to have fulfilled the requirements so that processing can be carried out at a later stage.

4.2. Analysis of Road Digitizing Results

The results of the digitization process are road vector data on satellite imagery around the Kendal Industrial Park (KIP), namely Brangsong, Kaliwungu and Kaliwungu Selatan districts in 2010 and 2019. 2019 digitalization results are a continuation of the digitization results in 2010, so the 2019 road data must be already included road data for 2010. The results of road digitalization can be seen in Figure 4 and Figure 5.

Based on Figures 4 and 5 it can be seen that the road network has increased from 2010 to 2019. Figure 5 shows visually the results of digitization of each class of road experience a growth in the length of the road occurring in the Local Primary and Secondary Local Road Classes. This is due to the development and growth of spatial planning in 3 Districts, most of which have developed into residential areas, thus requiring new local roads to facilitate access to community mobilization.

On the arterial class and collector roads tend to remain, only the development of the width of the road. This is because functionally, this path does not require changes in designation or function. Besides the issue of authority is a strong reason for the construction or addition of this road network. What is interesting is the emergence of new road classes, namely toll roads, which is one of the government's infrastructure development programs to connect one island of Java, this is a form of road construction authority programmed by the state or national program.

Another thing with local roads is that the authority is basically held by the government, but the implementation of the development is the local community or housing area developers.

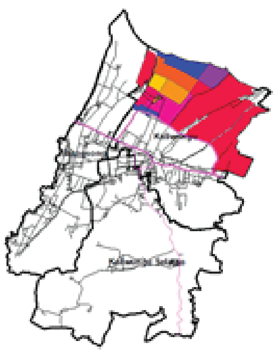

Figure 4: Results Of Digitizing The Road In 2010.

In 2010 this location was still a plantation and rice field area, but land function changes occurred in 2019 due to the construction of residential areas, the location of the road was changed but still connected with other road networks. From this it can also be

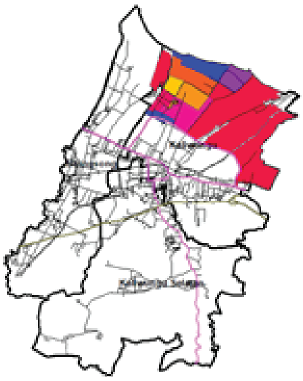

Figure 5: Results Of Digitizing The Road In 2010.

analyzed that the existence of an interest can change or influence the growth of the road network.

4.3. Analysis of Topology Making Results

The results of checking the error topology are found in the existing Error Report where each rule is notified of the number of errors that occur. The rule must not have gaps has 352 errors on the 2010 road layer and 284 on the 2019 road. Errors that occur in general are undershoot and overshoot. The quality of digitized data will not be good and affect the results of the calculation of the length of the road later if this is not corrected. Trim command for cases of overshoot and extend for undershoot cases. Some cases that do not allow automatic editing will be done manually editing until all data is considered free from errors.

4.4. Analysis of Road Calculation Road Length

Changes in the length of roads around the Kendal Industrial Park area can be seen in Figure 6. Note, Based on the results of calculations in Table 2, the length of the road in 2010 was 297757,218254 meters and in 2019 along 346372,857906 meters where this value obtained from calculating the length of the road for all classes that have been digitized. Therefore, the road network in 3 Subdistricts around KIK experienced growth in road length from 2010 to 2019 amounting to 48615.639652 meters or if in kilometers 48.616 kilometers.

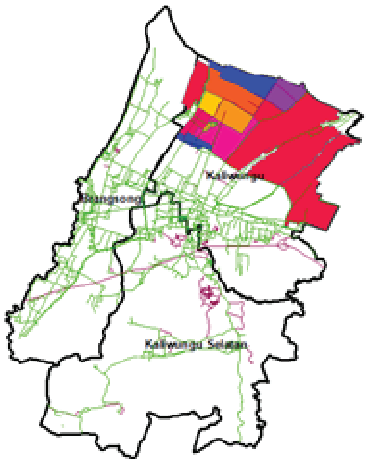

Figure 6: Results Of The Overlay Digitized Road Data.

Table 2: Length Of Road Based On Class Road.

Road Length 2010		Road Length 2019		Growth
Kelas Jalan	**Length (m)**	**Kelas Jalan**	**Length(m)**	**Length (m)**
Highway	0	**Highway**	13655.790	13655.790
Arteries	16794.886	**Arteries**	16794.886	0
Collector	11996.395	**Collector**	11996.395	0
Primary Local	86265.565	**Primary Local**	89016.123	2750.558
Secondary Local	173757.562	**Secondary Local**	205966.853	32209.291
Railroad	8942.811	**Railroad**	8942.811	0
Total	**297757.219**	**Total**	**346372.858**	**48615.639**

4.5. Analysis of Road Network Growth Directions

Road growth analysis is done using the Standard Deviational Ellipse (SDE) method on the tool provided by ArcGIS 10.4. This tool is part of the spatial statistics tool owned by ArcGIS 10.4. SDE has the principle of determining the direction of spatial tendency (directional) by using an elliptical model as discussed in the literature chapter.

From the road distribution data, after the SDE model is formed, the results obtained for each road class are presented attached. In this section SDE results will be presented for local road classes in 2010 and 2019 only, because those who experience significant changes in direction of growth are only found in the local road class and even new classes of roads, namely toll roads, appear. SDE results for local road classes in 2010 and 2019 are presented in Figure 7 and Figure 8.

Observe the direction of road distribution in 2010 when viewed from the long axis of the ellipse towards northeast and southwest. This is due to the basic form of 3 sub-districts in the industrial area, so that the distribution of roads also follows the basic form of the 3 sub-districts. When compared with the north, SDE which is formed is far inclined towards the east which shows its spatial tendency to have a slightly eastward direction in the north and west in the south. The direction of the spatial tendency will be seen from the value of the SDE processing that has been done.

In the rotation column the primary and local secondary road classes indicate the orientation of the long axis of the ellipse produced. The rotational value is 71.458601 or at $71^0$27'30.96 "and 39.132772 or $39^0$7'57.98" so that it becomes $110^0$25'28.94 "which is calculated from the number 12 on the hour hand. So the most dominant direction of spatial tendency is to the southeast according to the long axis rotation value of the SDE ellipse. The results of this spatial tendency direction can represent the direction of road growth seen from road distribution.

Figure 7: SDE Road Features 2010.

Figure 8: SDE Road Features 2019.

If we look at the map that has been overlain, the road distribution in 2010 and 2019 that have been added to the ellipse Figure 9, shows that road growth also occurs in the south but not as much as around KIK. The direction of this growth is the direction of growth from 2010 to 2019 because on the 2019 road data there are also 2010 road data as shown in Figure 10. Road growth occurs in several residential areas, not only in the industrial parks. So this can be ascertained that any development in both industrial and residential areas has a big role in the construction of road infrastructure.

Figure 9: Road Distribution Overlay With The Addition Of SDE.

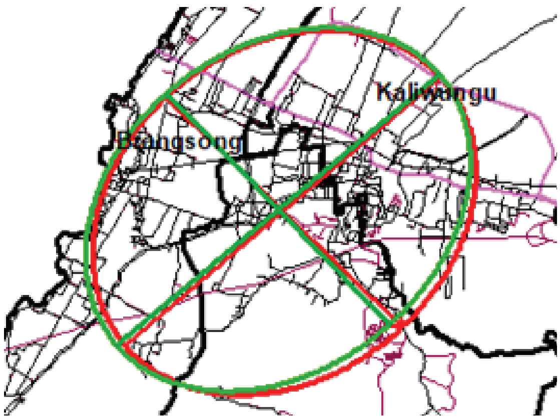

Figure 10: The Ellipse Looks Slightly Shifted To The Lower Right Of The 2010 Elliptical Position.

5. Conclusion

Regarding the data processing and analysis that has been carried out in this study, the following conclusions are obtained:

1. Road growth rates in the study area from 2010 and 2019 amounted to 48615,639 meters or 48,616 kilometers. The length of the road experiencing significant growth is found in the local road class (primary and secondary).
2. The direction of growth in the Kendal industrial area is towards the southeast when viewed from the growth of the road where in the north there is Kendal industrial area which is a spatial growth magnet in the 3 sub-districts and in the east there are several new residential areas which are spatial growth magnets in 3 of these sub-districts.

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