Geographic Information System For Mapping Potential of Traffic Congestion (Case Study : Setiabudi Street - Perintis Kemerdekaan Street, Semarang City)

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Abstract. Rapid population growth in major cities Indonesia causes transportation problems such as traffic congestion. This happens because the rapid population growth rate is not balanced by the development of road infrastructure. Unbalanced transportation growth with road construction causes traffic congestion such as in Setiabudi Street, Semarang City. One solution related to traffic congestion and traffic accident is the need for policy related to traffic arrangement. Therefore, we need accurate data and an integrated information system between the factors causing the traffic congestion with spatial data. So this research purpose is creating the map of potential traffic congestion. Field surveys were conducted by collecting information on road conditions, volume of transportation and the causes of traffic congestion in each segment of the road. The results of the survey were analyzed by Geographic Information System (GIS) using clustering method to make the potential map of traffic congestion. The analysis of this study resulted in the conclusion that the intersection of Sukun to the inner direction of the city experiencing traffic congestion along 600 meters while the intersection that does not experience traffic congestion is at the intersection of Ngesrep.

Keywords : Traffic congestion, GIS, Clustering

1. Introduction
Rapid population growth in major cities Indonesia always accompanied by transportation problems such as traffic congestion. This happens because the rapid population growth rate is not balanced by the development of road infrastructure. Other factors causing traffic congestion such as existing road conditions are getting damaged due to weather factors and vehicles crossing roads exceeding capacity. Increased traffic congestion in big cities causes the potential for greater traffic accidents. Traffic accidents are frequent in Semarang City, according to Satlantas Polres Semarang, during the year 2015 has occurred as many as 491 traffic accidents in Semarang District, especially the Semarang - Solo Street [4]. While in the city of Semarang, in the year 2013 recorded as many as 164 people killed by traffic accidents [7].
One type of transportation that is suspected to often cause traffic congestion and traffic accidents is a freight transport. Freight transport with a load that exceeds capacity causes the vehicle to run very slowly to give impact to other road users during crowded conditions. It certainly can cause to traffic congestion and prone to traffic accidents. Traffic accidents that occurred in the city of Semarang recently, especially in Sub-district Ngaliyan, Prof. Hamka Street, there has been a successive accident that starts from a container truck that can not control its speed on the road derivatives, so that crashed into other vehicles around it [5]. One solution related to traffic congestion problems and traffic accidents is the need for policies related to traffic arrangements so that complete information is needed related to factors that cause traffic congestion and traffic accidents. Information related to factors causing traffic congestion and traffic accidents will be easier to use if based on geospatial information because of not only textual or historical data but using spatial data.

Geographic Information System (GIS) is a system used to capture, store, manipulate, analyze, organize and display all types of geographic data [1]. In this case, this method can be used to store, analyze, organize and display geographic data related to the length of roads experiencing traffic congestion so that it can be used to take policies related to traffic management.

2. Material and Methods

2.1 Materials

In this paper using primary and secondary data as follows:

| NO | Data                                | Data Source | Type Of Data |
|----|-------------------------------------|-------------|--------------|
| 1  | QuickBird Image                     | Bappeda     | Digital      |
| 2  | The Semarang Urban Land Use Plan    | Bappeda     | Digital      |
| 3  | Field Survey                        | Field Survey| Manual and Digital |

2.2 Methods

2.2.1. Remote Sensing. Remote sensing is a science, technique, art to get information about an object, area or phenomenon through analysis of data obtained without direct contact with the object [3]. Simple sense of remote sensing is a person doing the process of reading the text on the book to get the information contained in the text [3]. The process of acquiring remote sensing data using sensors placed on satellite. Remote sensing data has resolution on remote sensing data depending on satellite. Resolution on satellite imagery is very important to be understood by the user of the image to know the data to be used as needed. The condition and quality of the image can be viewed based on image resolution information such as spatial resolution, spectral resolution, temporal resolution and radiometric resolution. The resolution contained in satellite imagery has characteristics generated by the sensor system on the satellites [8]. Remote sensing satellites experience the development of sensor capability in obtaining high resolution image data. High resolution satellite imagery is an image to obtain information of object detailed on the earth’s surface. High resolution image can be used to classify land use from the process of visual interpretation and classification image. Visual interpretation and classification image of high resolution image can produce good classification accuracy [9].

2.2.2. Geographic Information System (GIS). Geographic information systems are computer-based systems used to store and manipulate geographic information. Geographic Information System (GIS) is designed to collect, store, and analyze objects and phenomena in which geographical location is an important or critical characteristic to be analyzed. Thus, GIS is a computer system that has the following four capabilities in handling geo-referenced data [6]:
1. Input Data.  
This sub-system is responsible for collecting, preparing, and storing spatial data and its attributes from various sources. This subsystem is also responsible for converting and transforming the original data formats into a format (native) that can be used by the GIS device.

2. Output Data.  
This subsystem is responsible for displaying or generating output (including exporting it to the desired format) all or part of the database (spatial) in both softcopy and hardcopy forms as well as tables, graphs, reports, and maps.

3. Data Management.  
This subsystem organizes both spatial data and attribute data in the form of tables into a database system so that it is easy to be recalled, updated, and modified.

4. Data Manipulation and Analysis.  
This subsystem determines the information that can be generated by the GIS. In addition, this subsystem also manipulates (evaluation and use of mathematical functions and operators and logic) and data modeling to produce expected information. Illustration of the GIS subsystem can be seen in the figure 1.

![Illustration GIS subsystem](image)

**Figure 1.** Illustration GIS subsystem [6]

2.2.3. *Metode Clustering*. Cluster analysis is an algorithm used for grouping data by viewing objects that have intrinsic characteristics or similarities. Samples of data on a valid cluster have the same characteristics of each other than the different cluster samples. The clustering methodology is particularly suitable for the exploration of the interrelationships between samples to make an initial assessment of the sample structure. Human capability is competitive with automatic grouping procedures in one, two, or three dimensions, but most real problems involve grouping in higher dimensions. It is very difficult for humans to intuitively interpret data embedded in high dimensional [2].
3. Results and Discussion

3.1. Visual interpretation and digitization

Satellite images used in this study are Quickbird satellite images, so it is expected that the resulting map in this study can be generated on a large scale. Quickbird imagery can display objects on the surface of the earth with detail so easy to do manual interpretations. The process of satellite image processing is done by manually digitization road segment and land use that exist around the road. Digitization is done manually aimed to produce good results. In this case, the digitization is done on the Setiabudi Street – Perintis Kemerdekaan Street because it is the study area in this study. Digitization is performed only on roads and land use adjacent to the road. The land use around the road is one of the factors causing traffic congestion on a road segment. The result of digitization on screen can be seen in figure 4.

3.2. Mapping of traffic congestion by clustering method

Results from field surveys and digitization were spatially treated by clustering method, to obtain a potential congestion map. The classification itself will be divided into three clusters, which are very
traffic congestion, medium traffic congestion, not traffic congestion. The classification is based on the characteristic approach of each sample obtained in the field survey.

**Figure 4.** Map of traffic congestion

**Figure 5** Road segment has traffic congestion
Figure 4 shows a potential map of traffic congestion created by a geographic information system in order to directly see the visual form of a congested road segment. Road segments experiencing traffic congestion with very congestion class are found at the intersection of Sukun in the direction of entry into the city with a congestion length of about 600 meters. The length of traffic congestion is due to an increase in cars volume during the morning and afternoon. The intersection of sukun has increased the volume of cars as many as ± 300 cars on 2 lane road. Traffic congestion that occurs at the intersection of sukun is caused by the improvement of vehicle volume due to traffic lights and cars parked on the street and vehicles that want to get into the Transmart as well as other trades and services located in the area. Ngesrep junction is a road segment that does not experience congestion in the direction of entry into the city. In the morning and afternoon on Ngesrep junction is not experiencing congestion. The potential map of traffic congestion can be seen in figure 5.

3.3. Traffic Congestion Analysis on Road Conditions
Geometrically, the path of Perintis Kemerdekaan Street until Setiabudi Street has an average width of 15 meters road without roadside with 4 lanes 2 direction. In terms of pavement structure, road segment using pavement in the form of hotmix construction with good road pavement condition. Based on the road conditions have good enough condition and decent by passed so it can be called as the primary arterial road because according to road function. The condition of the road is not the main factor causing traffic congestion. According to the primary arterial road function, transportation past the road should be at high average speed as they pass but in reality, there is a traffic congestion on the Perintis Kemerdekaan Street to Setiabudi Street. Road conditions are not the main factors causing traffic congestion because road conditions are good enough and worth to pass.

3.4. Traffic Congestion Analysis on landuse
Transportation passing the Perintis Kemerdekaan Street to Setiabudi Street comes from within the city and the Banyumanik Toll Highway so there is a buildup of vehicles at the junction ADA Supermarket. In the road segment is often experiencing congestion due to the cumulation of public transportation in the form of inter-city buses that reduce passengers and raise passengers on the road as well as public transport vehicles parked. Based on the results of the field survey on Perintis Kemerdekaan Street to Setiabudi Street shows the use of land around the area of the road is a trade, services, military, and settlement.

Land use in the vicinity of the road is one of the factors causing the potential for traffic congestion. The use of land which is the main factor of traffic congestion is trade and services because vehicles that want to enter or exit the building takes time according to the type of vehicle. In this case, Junction of ADA Supermarket is often a traffic congestion on the road into the city or out of town. The buildup of vehicles is caused by parking of vehicles on the roadside causing traffic congestion. The Sukun Junction is congested due to the buildup of cars and motorcycles that want to enter into Transmart. Traffic congestion caused by vehicles that want to enter Transmart cut off the flow of roads so that the buildup of vehicles in front of Transmart. This causes traffic congestion at the junction of Sukun. Traffic on Perintis Kemerdekaan Street to Setiabudi Street needs to be arranged to avoid potential traffic congestion is more severe. Potential of traffic congestion on the road is always troubling road users who want to pass the road because of the growing number of vehicles that continue to increase each year. Traffic arrangements on the road need to be done so that road users feel comfortable when crossing the road. There needs to be a regulation on the curbing of vehicles parked along the road so as not to disturb other road users while crossing the road.

3.5. Traffic Congestion Analysis on the Semarang Urban Land Use Plan
Based on the the Semarang Urban Land Use Plan, Banyumanik is the main region of development to the south (Semarang District), this region serves as settlement areas, tourism, and military. The direction of development in Banyumanik area is caused the density of settlement in Semarang City so that the direction of settlement development is moving towards South Semarang (Semarang District).
Therefore, development settlement in Banyumanik Subdistrict continues to increase as well as other causes south of Banyumanik Subdistrict is the industrial area (Bawen Subdistrict). However, Banyumanik Subdistrict is expected to support the provision of settlement areas. The development settlement of Banyumanik Subdistrict caused the primary arterial road like Perintis Kemerdekaan Street to Setiabudi Street experiencing the traffic congestion. In the morning and afternoon, there is always traffic congestion on the primary arterial road is caused by the volume of vehicles passing through the road is very crowded. Based on the Semarang Urban Land Use Plan, Perintis Kemerdekaan Street to Setiabudi Street is a network of roads with primary arterial road function because this road is the entry of Semarang City that connects with other city limits such as Ungaran District. Therefore, Perintis Kemerdekaan Street to Setiabudi Street has a transportation system linking urban service activities centers such as markets, offices, trade and services, education and settlement.

Perintis Kemerdekaan Street to Setiabudi Street is a road connecting Banyumanik District development center (settlement, industrial, trade, and services) with the center of Semarang City which serves as a center of the office, trade, public service, education and densely populated residential center. Based on observations in the field of traffic flow on Perintis Kemerdekaan Street to Setiabudi Street are a mixed flow of private transport, public transport and heavy transport and motorcycles that quite a lot. Therefore, the accumulation of transport that pass by in the morning and afternoon causing traffic congestion on the road.

4. Conclusion

In this paper can be taken some conclusions on the process that has been done:

Based on the map of the traffic congestion on the Perintis Kemerdekaan Street to Setiabudi Street, traffic congestion divided into three clusters, which are very traffic congestion, medium traffic congestion, not traffic congestion. The class of roads experiencing traffic congestion with very traffic congestion class is located at the intersection of Sukun in the direction of entry into the city with a long congestion of about 600 meters and the class of roads does not experience congestion is located at the intersection of Ngserp in the direction of entry into the city.

The potential for traffic congestion on Perintis Kemerdekaan Street to Setiabudi Street is more due to land use that is located around of the road. The factors such as road conditions and vehicle volume are not the main factors of potential traffic congestion. Land use in the vicinity of Perintis Kemerdekaan Street to Setiabudi Street by the Semarang Urban Land Use Plan is a settlement but in fact, the use of land has been largely a trade and services. Supervision is necessary to supervise the development trade and services around of the Perintis Kemerdekaan Street to Setiabudi Street so that the potential for traffic congestion can be reduced.

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