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Accident Prone Area Database Analysis in Yogyakarta City

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Abstract

The need for transportation in Indonesia is increasing day by day. This is due to the high population growth, the rapid number of motorized vehicle ownership, as well as the construction of new settlements, which resulted in the need for transportation facilities always increasing. Transportation problems occur as traffic density increases, one of which is traffic accidents. As a first step in reducing the number of accidents, it is necessary to identify accident-prone areas. It is needed to compile a GIS-based traffic accident database that is informative. In this research, two methods of analysis are generally carried out, including analysis of traffic accident-prone areas and analysis in compiling a database based on geographic information systems. In this study, results were obtained regarding the characteristics of traffic accidents in the city of Yogyakarta which included the number of victims of traffic accidents during the period 2016 – 2020, as many as 3,530 people, with the type of vehicle involved in the most accidents being motorcycles, namely 3,671 vehicles. The type of front-rear collision is the most common type of accident and the age most often involved in accidents is in the age range of 20-29 years. Then based on the results of the analysis using three methods of determining DRK, including the equivalent accident number (EAN) method, the frequency method, and the z-score method, obtained five roads that are categorized as accident-prone areas, namely Jenderal Sudirman, Brigjend Katamso, HOS Cokroaminoto, Kusumanegara, and Magelang.

Keywords: *Database; Geographic Information System; Traffic Accident*

INTRODUCTION

Transportation is one of the pillars of the daily life of Indonesian people. Transportation supports improving the community's quality of life, increasing community productivity and the country's competitiveness in the international market, and realizing economic independence. The need for transportation in Indonesia is increasing day by day. This is due to high population growth, the rapid number of motorized vehicle ownership, and the construction of new settlements, which increase the need for transportation facilities (Ambarwati et al., 2010). Transportation problems occur as traffic density increases, one of which is traffic accidents. Traffic accidents can be caused by various factors, including driver factors, vehicle and road factors, and environmental factors (Oglesby & Hicks, 1982).

Yogyakarta is one of the big cities in the province of the Special Region of Yogyakarta. Geographically, the city of Yogyakarta is a potential area for the movement of traffic flows in the Southern Line of the island of Java. The line includes national roads and is an arterial road within the city and a link between cities. Due to this situation, the movement of road traffic in the city of Yogyakarta from year to year is quite high and tends to increase. Thus, the number of accidents will also be predicted to increase along with the increase in traffic movement. Based on data from the Yogyakarta City Traffic Unit, during the period 2017 - 2020, there were 2,554 traffic accidents. This

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data shows that there is a need for serious and comprehensive efforts to reduce the number of accidents because there are still many people who consider accidents as a factor of destiny. As a first step in reducing the number of accidents, it is necessary to identify accident-prone locations. In determining accident-prone areas, it is ideal to take historical data into account. Still, until now, there is no systematic data available for accident-prone areas in the city of Yogyakarta. In addition, traffic accident data at the Department of Transportation and the Yogyakarta City Police are still in the form of written documents, so it is necessary to develop a database to facilitate the management and search of accident data.

Databases based on Geographic Information Systems (GIS) have been widely used to facilitate the performance of policyholders. GIS is a geographic-spatial-based system on earth, where the GIS-based database is capable of processing data and advanced spatial analysis. Based on this, it is necessary to compile a GIS-based traffic accident database that is informative and able to accommodate the needs of policyholders to make faster and more accurate decisions in minimizing the number of accidents that occur, as well as preparing a program for handling accident-prone traffic locations.

LITERATURE REVIEW

Definition of Traffic Accident

A traffic accident, according to the Law of the Republic of Indonesia No. 22 of 2009 Article 1, is an incident on the highway that is unexpected and unintentional involving a vehicle with or without other road users resulting in human casualties and/or property loss. Traffic accidents always occur unintentionally involving at least one vehicle and can cause material losses, even fatalities, including dead victims, seriously injured victims, and lightly injured victims. According to (Oglesby & Hicks, 1982), motor accidents, like all other accidents, are immediate and unexpected events and generally occur very quickly. Moreover, the accident is the culmination of an ill-fated series of events. If this link is broken by various means, the possibility of accidents can be prevented. In general, there are three main factors that cause accidents: human, vehicle, road, and environmental.

Traffic Accident Characteristics

The characteristics of traffic accidents are divided into three groups, namely, mild, moderate, and severe (Jiwadiana, Sukarsa dan Srinadi, 2015). According to (Andriyati & Zain, 2013), the characteristics of the accident are divided based on the time, location, the vehicle involved, and the weather at the time of the traffic accident. Accidents, according to the number of vehicles involved, are divided into 3, namely, single accidents, multiple accidents, and multiple accidents.

Accident Prone Area

Identification of accident-prone traffic areas includes two stages, namely, the accident history of the entire study area is studied to select several locations that are prone to accidents, and the chosen locations are studied in detail to find the treatment carried out. Based on the length of the accident-prone areas (hazardous sites) can be grouped into two (Pusdiklat Land Transportation, 1998), namely:

- Blacksite/section is an accident-prone traffic section.
- Blackspot is a point on an accident-prone traffic section (0.03 kilometers to 1.0 kilometers).

Geographic Information System

According to (Setyawan, Nugraha dan Sudarsono, 2018) Geographic Information System or better known as Geographic Information System, is an integrated information system and is specifically used to manage various data that have information in a spatial form where this geographic information system technology can be used for investigations. Scientific research, resource management, development planning, cartography, and even data are also used to plan routes. Practically we can say that Geographic Information System is a computerized system that

can build, manage, analyze, store and display geographic information in the form of mapping where the user who creates the data and operates it is also part of the system.

A geographic Information System (GIS) is a special information system for data management with spatial information designed to work with geographic-coordinated data or, in a specific sense, is a computer system that can build, manage and display geographically referenced information, for example, data identified by location or a predetermined location, in a database.

RESEARCH METHOD

In this research, two methods of analysis are generally carried out, including analysis of traffic accident-prone areas and analysis in compiling a database based on geographic information systems.

Determination of Accident Prone Areas

In determining accident-prone areas, a comparison of three methods is used: the Equivalent Accident Number (EAN) method, frequency, and Z-score. Then a ranking is carried out based on the highest level of accidents. The EAN (Equivalence Accident Number) method is one method for calculating the accident rate by weighting the accident equivalence number referring to the cost of traffic accidents (Pignataro *et al.*, 1973). EAN is calculated by adding up the incidence of accidents for each kilometer of road length and then multiplying it by the weight value according to the severity level. The standard weight values used are Death (MD) = 12, Severe Injury (LB) = 6, and Minor Injury = 3 (Soemitro, 2005). By using the formula:

$$EAN = 12\,MD + 6\,LB + 3\,LR + 1\,K \quad \ldots\ldots (1)$$

Determination of accident-prone locations is based on the number of accidents per kilometer of road with a weight value (EAN) exceeding a certain limit value. This limit value can be calculated, among others, using the Upper Control Limit (BKA) method. The Upper Control Limit (BKA) value is determined using the following equation:

$$BKA = C + 3\sqrt{C} \quad \ldots\ldots (2)$$

The Accident Frequency Method is the most frequently used in identifying areas prone to traffic accidents. The calculation of the frequency method is the number of traffic accidents per unit of time or location. The following is the formula for determining accident-prone areas using the accident frequency formula.

$$fr = \frac{\sum nf\mathbb{f}}{t} \quad \ldots\ldots (3)$$

The Z-Score method is one of the methods used to identify accident-prone areas or black sites. This method is the simplest because it uses data on the number of events on each road segment. The Z value or Z-score is obtained using the following formula:

$$\mathrm{Zi} = \frac{\mathrm{Xi} - \mathrm{X}}{\mathrm{S}} \quad \ldots\ldots (4)$$

The standard deviation value (S) is the root of the sum of the squares of the average number of accidents per year minus the average number of accidents divided by the number of data (Hasan I, 2001).

$$S = \frac{\sqrt{\sum (X - \bar{X})^2}}{n} \quad \text{.....(5)}$$

The classification in determining accident-prone areas (black spots) is as follows: :

Table 1. Determination of Z-score

No	Z-score Value	Description
1	Positive (0)	Blacksite
2	Negative (-0)	Non Blacksite

A positive Z-Score value is a Z-Score value below the average level of the number of accidents, while a negative Z-Score value is a Z-Score value above the average level of the number of accidents. Road sections identified as accident-prone traffic areas (black sites) are roads that have a positive Z-Score value, and roads that are not identified as accident-prone areas are roads that have a negative Z-Score value.

Database Analysis based on Geographic Information System

The next step in this research is to compile a database of accident-prone areas based on a Geographic Information System (GIS) using the Arc.GIS program. GIS-based accident data analysis was carried out, among others, compiling spatial data and attribute data as well as compiling interfaces for accident-prone traffic areas.

FINDINGS AND DISCUSSION

Characteristics of Traffic Accidents in Yogyakarta City

Based on data from the Yogyakarta City Traffic Unit, the number of accident victims for the last 5 (five) years is 3,530 people. With the number of cases as many as 2,466 cases, the number of victims died 167 people; victims were seriously injured as many as 14 people, the victims who suffered minor injuries reached 3,349 people, and the victims were not injured as many as 723 people. The total material loss caused by traffic accidents reached Rp. 1,846,835,040. The highest number of accidents occurred in 2016, with 876 accident victims, while the highest material losses due to accidents occurred in 2016, with a total of Rp 575,400,000.

Table 2. Accidents in 2016 -2020 in the City of Yogyakarta

No	Year	Total			Total Victim	Material Loss
		MD	LB	LK		
1	2016	57	0	819	876	575.400.000
2	2017	30	8	485	523	357.450.040
3	2018	23	6	623	652	312.625.000
4	2019	37	0	779	816	350.710.000
5	2020	20	0	643	663	250.650.000
Total		**167**	**14**	**3.349**	**3.530**	**1.846.835.040**

The types of vehicles involved in the accident are classified into 4 (four), namely motorcycles, passenger cars, freight vehicles, and others. Included in other types of vehicles are types of vehicles other than those already mentioned and non-motorized vehicles. The following is the number of vehicles involved in accidents in Yogyakarta City in 2016-2020, as shown in the table below.

Table 3. Types of Vehicles Involved in Accidents in 2016-2020 in Yogyakarta City

Year	Types of Vehicles			
	Non-Motorized	**Motorcycle**	**Passenger Car**	**Freight Vehicle**
2016	54	915	177	11
2017	17	620	114	15
2018	28	679	96	12
2019	43	822	105	14
2020	25	635	87	8
Total	**167**	**3671**	**579**	**60**

The characteristics of accident victims based on education level are categorized into 6 (six), namely elementary school (SD), junior high school (SMP) equivalent, high school (SMA) equivalent, students, and others. The other levels of education are educational levels different than those four levels. The following is the classification of accident victims based on education level, as shown in Table 4.

Table 4. Education level of victims of traffic accidents in Yogyakarta City

No	Education Level	Year					Total
		2016	**2017**	**2018**	**2019**	**2020**	
1	SD	9	2	8	13	11	**43**
2	SMP	13	0	70	25	23	**131**
3	SMA/SMK	192	70	598	955	758	**2573**
4	D3	1	0	4	2	3	**10**
5	S1	15	3	32	28	19	**97**
6	S2	0	0	1	7	2	**10**
7	Others	2	7	22	121	110	**262**
Total		**232**	**82**	**735**	**1151**	**926**	**3126**

The type of traffic accident collision that occurred in Yogyakarta City by the Yogyakarta City Police was classified into 7 (seven) categories, namely single accident, front-front, front-rear, front-side, side-side, side-crash, and human collision. The following is the number of traffic accidents by type of collision as shown in the following table and graph.

Table 5. Types of collisions involved in traffic accidents in Yogyakarta City

Years	Types Of Collisions						
	Single	**Head On**	**Rear End**	**T-Bone**	**Pedestrian**	**Sideswipe**	**Side-Impact**
2016	50	68	158	99	91	6	146
2017	32	100	107	41	45	9	58
2018	15	60	112	77	62	0	105
2019	149	64	124	118	57	2	66
2020	106	47	108	56	37	1	81
TOTAL	**352**	**339**	**609**	**391**	**292**	**18**	**456**
%	**14.33**	**13.80**	**24.79**	**15.91**	**11.88**	**0.73**	**18.56**

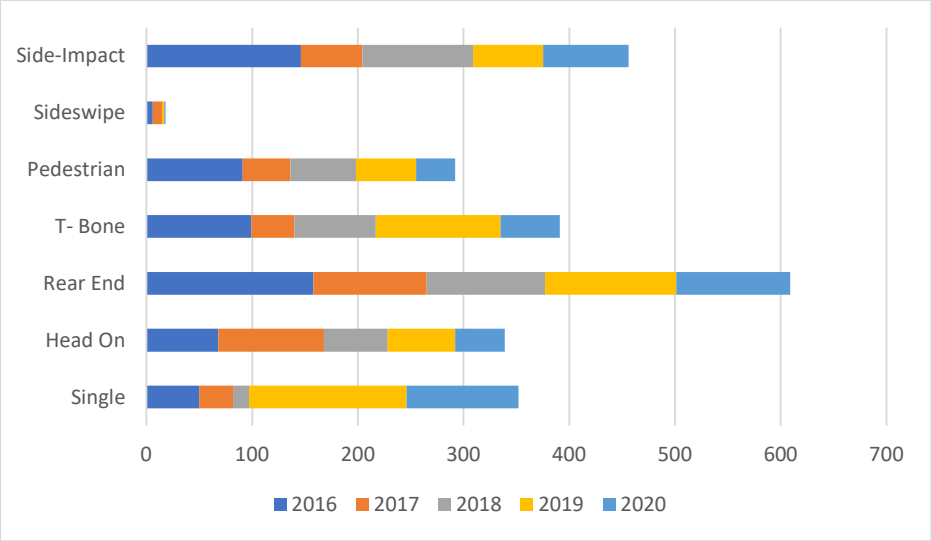

Figure 1. Graph of types of collisions involved in traffic accidents in Yogyakarta City

The age of the victims involved in the accident is classified into 6 (six) categories, namely 0-9 years, 10-15 years, 16-30 years, 31-40 years, 41-50 years, and more than 50 years. Determination of age categories based on data from the Traffic Traffic Unit of Yogyakarta City. The following is the age classification involved in traffic accidents in Yogyakarta City from 2016 to 2020.

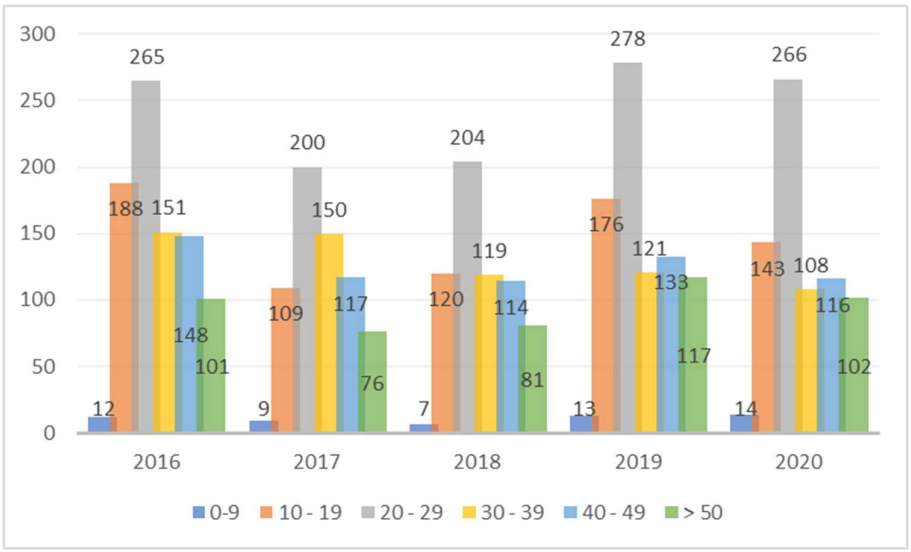

Figure 2. Graph of the age involved in traffic accidents in Yogyakarta City

The age of the victims involved in The age classification involved in the most accidents is the age group of 20-29 years with an average population of students, students, and new workers (fresh graduates) with a total of 1,213 people for five years. The age group with the least number of traffic accidents victims is 0-9 years, with a total of 55 people over the last 5 years. The age of the accident

victim is in the productive age because at this age they are doing a lot of activities and activities in the field.

Analysis of Traffic Accident-Prone Areas in the City of Yogyakarta

Equivalence Accident Number Method (EAN)

Based on the analysis of calculations using the EAN method on 10 roads where accidents have occurred in 2016 - 2020 in the city of Yogyakarta, 6 road sections have an accident-prone area category. The road sections include Jalan Jend. Sudirman, Hos Cokroaminoto Street, Brigjend Katamso Street, Magelang Street, Kusumanegara Street and Bantul Street.

Table 6. Determination of DRK with EAN Method

Street Name	Fatality Level			EAN			Total EAN	BKA	Note
	MD	LB	LR	MD	LB	LR			
Jend Sudirman	7	1	111	84	6	333	423	270,7	Blacksite
Hos Cokroaminoto	6	0	95	72	0	285	357	270,7	Blacksite
Brigjend Katamso	4	0	98	48	0	294	342	270,7	Blacksite
Magelang	6	0	79	72	0	237	309	270,7	Blacksite
Kusumanegara	5	1	80	60	6	240	306	270,7	Blacksite
Bantul	5	1	74	60	6	222	288	270,7	Blacksite
Letjen Suprapto	2	0	81	24	0	243	267	270,7	Non Blacksite
Parangtritis	5	0	53	60	0	159	219	270,7	Non Blacksite
KH Ahmad Dahlan	3	0	55	36	0	165	201	270,7	Non Blacksite
Kyai Mojo	2	0	57	24	0	171	195	270,7	Non Blacksite

Frequency Method

The results of the calculation analysis using the frequency method on 10 roads where accidents have occurred in 2016 - 2020 in the city of Yogyakarta, the roads that have the highest accident frequency are 6 blacksite roads, including Jend. Sudirman, Hos Cokroaminoto Street, Brigjend Katamso Street, Magelang Street, Kusumanegara Street and Letjen Suprapto Street.

Table 7. Determination of DRK Frequency Method

Street Name	Number of Accidents					Total	Description
	2016	2017	2018	2019	2020		
Jend Sudirman	35	9	30	19	26	119	Blacksite
Brigjend Katamso	28	12	17	22	23	102	Blacksite
HOS Cokroaminoto	42	8	23	19	9	101	Blacksite
Kusumanegara	10	27	25	24	0	86	Blacksite
Magelang	30	13	5	26	11	85	Blacksite
Letjen Suprapto	33	15	17	11	7	83	Blacksite
Bantul	22	16	14	13	15	80	Non Blacksite
Veteran	3	3	14	24	16	60	Non Blacksite
Kyai Mojo	15	0	12	23	9	59	Non Blacksite
Parangtritis	15	5	6	13	19	58	Non Blacksite

Z-score Method

The results of the calculation analysis using the Z-Score method on 10 roads where accidents have occurred in 2016 - 2020 in the city of Yogyakarta, the road sections that are designated as traffic accident-prone areas are 5 roads. The road segments are those roads, including Jalan Jend. Sudirman, Hos Cokroaminoto Street, Brigjend Katamso Street, Magelang Street, and Kusumanegara Street.

Table 8. Determination of DRK Z-Score Method

Street Name	Total Accidents					Xn	Ẋ	S	Zn	Description
	2016	2017	2018	2019	2020					
Jenderal Sudirman	35	9	30	19	26	119	35,7	47,22	0,755981061	Blacksite
Brigjend Katamso	28	12	17	22	23	102	18,7	47,22	0,39599008	Blacksite
HOS Cokroaminoto	42	8	23	19	9	101	17,7	47,22	0,37481414	Blacksite
Kusumanegara	10	27	25	24	0	86	2,7	47,22	0,057175038	Blacksite
Magelang	30	13	5	26	11	85	1,7	47,22	0,035999098	Blacksite
Letjen Suprapto	33	15	17	11	7	83	-0,3	47,22	-0,006352782	Non Blacksite
Bantul	22	16	14	13	15	80	-3,3	47,22	-0,069880602	Non Blacksite
Veteran	3	3	14	24	16	60	-23,3	47,22	-0,493399404	Non Blacksite
Kyai Mojo	15	0	12	23	9	59	-24,3	47,22	-0,514575344	Non Blacksite
Parangtritis	15	5	6	13	19	58	-25,3	47,22	-0,535751284	Non Blacksite

Accident Prone Area Database Analysis

In compiling a database, a map is needed to analyze road traffic accidents. To display the map to be analyzed, ArcGIS software is used. The following is a database display of accident-prone traffic areas in the city of Yogyakarta, which is presented in the form of a map.

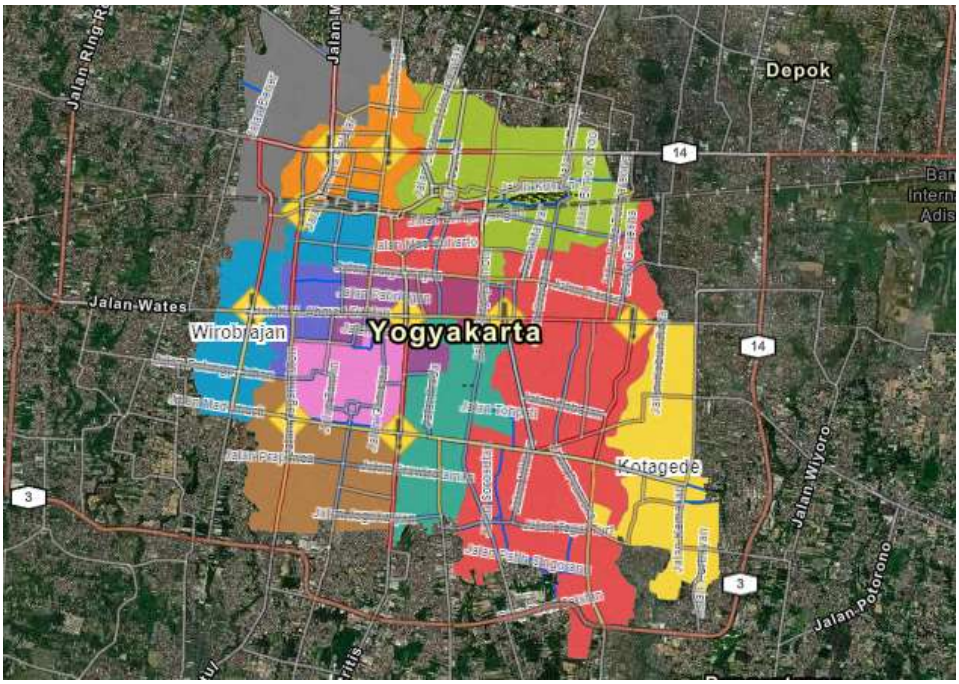

Figure 3. Accident Prone Location Map

CONCLUSION

In this study, results were obtained regarding the characteristics of traffic accidents in the city of Yogyakarta which included the number of victims of traffic accidents during the period 2016 – 2020, as many as 3,530 people, with the type of vehicle involved in the most accidents being motorcycles, namely 3,671 vehicles. The type of front-rear collision is the most common type of accident and the age most often involved in accidents is in the age range of 20-29 years. Then based on the results of the analysis using three methods of determining DRK, including the equivalent accident number (EAN) method, the frequency method, and the z-score method, obtained five roads that are categorized as accident-prone areas, namely Jalan Jenderal Sudirman, Jalan Brigjend Katamso, Jalan HOS Cokroaminoto, Jalan Kusumanegara, and Jalan Magelang. Compiling a database of accident-prone traffic areas is done using Arc software. GIS.

LIMITATION & FURTHER RESEARCH

Further studies are needed on evacuation routes based on geographic information systems handling traffic accident victims to reduce the fatality rate.

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