ISSN 2541-223X
Volume 4 2022

ACCIDENT-PRONE AREAS IDENTIFICATION AND HANDLING PRIORITIES ON SPECIAL REGION OF YOGYAKARTA PROVINCIAL ROAD SECTION

A N Jannah [1*], P J Romadhona[1,2], I Y Rahman[1], A Rahmawati[3]

[1]Universitas Islam Indonesia
[2]University of Leeds, UK
[3]Universitas Muhammadiyah Yogyakarta

Abstract.
The development of the Special Region of Yogyakarta requires transportation facilities and infrastructure that can accommodate the needs of local transportation services for people or goods movements that are safe, comfortable, and punctual. This research aims to identify the accident-prone areas on the Special Region of Yogyakarta provincial roads and provide recommendation of the handling priorities for government as a policy-making to reduce the number of accidents. Accident-prone areas were analysed with Kernel Density Analysis and Buffer Analysis using ArcGIS software then the areas were ranked using the Accident Equivalent Number method. The field survey is carried out at the top 3 accident-prone areas to analysed the types of accidents and the reasons of the accident resulting in the recommendation for stakeholders. The findings of this research are the top 3 accident-prone areas including Yogyakarta - Barongan road section (near Muhammadiyah Blawong Elementary School), Bantul - Srandakan road section (near Mangiran Market), and Bantul - Srandakan road section (near Pandak police office). There are several recommendations for handling, for instance signs and markings installation, geometric repairments, and the awareness of the road user community towards safe traffic that needs to be carried out continuously through various media.

Keywords: Accidents; ArcGIS software; Kernel Density Analysis

1. INTRODUCTION

The province of Special Region of Yogyakarta (DIY) has become a very important transportation network node as a connecting route among the cities on the southern coast of Java. The improving development of DIY from all aspects requires the existence of transportation facilities and infrastructure that can serve the needs of local transportation services for the movement of both people and goods within and among the regions that are safe, comfortable, and on time.

On the other hand, the rapid growth of motorized ownership, especially in the province of Special Region of Yogyakarta in recent years, as well as the population entering adolescence and the variety of types of vehicles have contributed to the poor road safety problem. This condition will continue to worsen with the increase in the number of motorized vehicles. DIY Central Statistics Agency [1] stated that the number of motorized vehicles in the Special Region of Yogyakarta in 2020 is 3,020,175 vehicles and in 2021 as many as 3,125,720 vehicles which represents a 3% increase in the number of vehicles from 2020 to 2021. The increase in population will put considerable pressure on the road

[1*] Corresponding author's email: 205111301@uii.ac.id
DOI: https://doi.org/10.20885/icsbe.vol4.art39

network and traffic control devices if not followed by improvements in road safety management, both in terms of infrastructure, vehicles, and human resources.
DIY Department of Transportation [2] noted that in 2018, Indonesia had an average daily accident of 299 accidents with an average death case of 80.75 victims, seriously injured cases of 36.48 victims, and minor injuries cases of 357.73 victims. Furthermore, the DIY region had an average daily accident of 12 accidents with an average death case of 1.22 victims, seriously injured cases of 0.06 victims, and minor injuries cases of 17.12 victims. Therefore, it is important to identify the area which vulnerable to a traffic accident. This research aims to identify the accident-prone areas on the Special Region of Yogyakarta provincial roads and provide recommendations for the handling priorities for government as a policy-making to reduce the number of accidents.

2. LITERATURE REVIEW

Several studies about traffic safety were conducted before. Angin and Ali [3] conducted research to identify the main causes of road traffic accidents in North Cyprus through local public opinions. According to the survey outcomes, it found that road factors and human factors are the main cause of the accident. Moreover, the driving behaviours which cause the major accident were negligent driving and over-speeding. While in Indonesia, Saputra [4] identified the characteristics of road traffic accidents. The result found that collision is the most common type of accident at 65.6% and the area with the most accidents is the island of Java where the province of DIY is located at 70.35%.
Research about the accident-prone area in Indonesia was carried out by Sugianto et al [5], Fahza and Widyastusi [6], Imtihan and Fahmi [7]. Sugiyanto et al [5] conducted a study in Purbalingga using the Equivalent Accident Number method and Upper Control Limit (UCL) method. The research revealed that there had been a deficiency of road infrastructure in the Tlahab Lor road section and the recommendation for stakeholders is by installing traffic signs and installing 4 vehicle maximum limit signs of 40 and 30 km/h. Fahza and Widyastusi [6] analyzed accident-prone areas with the Z-Score and Cummulative Summary (Cusum) methods. The results of the analysis show that the road segment that has the highest Accident Rate of death victims on the Surabaya-Gempol toll road. Imtihan and Fahmi [7] in their research used the Z-Score calculation method to analyse accident-prone areas in Praya City, Lombok Tengah Regency. Based on their analysis, Jalan H Tuan Lopan had a high accident rate and also the location of the accident-prone point (black spot) is located in Jalan Tuan H Guru Lopan at 1,000 kilometres to 2,000 kilometres.
Researchers worldwide also conducted studies about the accident-prone area in various methods. Yu, et al [8] analysed accident-prone locations on two-lane mountain highways in Tibet, China. They modelled drivers' visual lanes to quantify drivers' visual perception then used a probabilistic neural network (PNN) was formed to identify accident-prone locations to improve traffic safety on two-lane mountain highways. On the other side, Rizyee et al [9] had a different approach to determining the accident-prone area. The research used the DBSCAN clustering algorithm and Heatmap analysis in North Carolina USA resulting indication that most of the accidents took place almost in the middle of the city, and most accidents occur at the dusk on Friday and October.
The accident-prone area also can be determined by using Geographical Information Systems (GIS). Anderson [10] used Kernel Density Estimation to analyse the spatial patterns of injury-related road accidents in London, UK. They chose Kernel Density Estimation because it can determine the spread of risk of an accident and define an

ISSN 2541-223X
Volume 4 2022

arbitrary spatial unit of analysis. Wang [11] used point density analysis, buffer analysis, outlier analysis, and hot spot analysis to study the spatial pattern of global maritime accidents. Buffer analysis was used because it can identify geographic features of surrounding areas and the proportion of accidents along the coast.

3. RESEARCH METHOD

Accident data in this research was obtained from data recorded in the IRSMS (Integrated Road Safety Management System) of the Indonesian National Police obtained by the Yogyakarta Special Region Police. The data used was the point of 3 years of accident occurrence which has spatial coordinate information and information related to accident cases and victim information, both dead, serious injuries, and minor injuries. Accident-prone areas were analysed with Kernel Density Analysis and Buffer Analysis using ArcGIS software. Kernel Density Analysis is an analysis to estimate spatial data density to select locations with a dense level of event density with a radius of approximately 1 km. The buffer analysis used buffer parameters with a distance of 1 kilometre to 2 kilometres by looking at the distribution and collection of accident events resulting in several areas accident-prone. The areas were ranked using the Accident Equivalent Number method which is calculated by summing the accident events in one section of the road and then multiplying it by the weight value according to its severity. The weight values of each severity level are 12 for death, 3 for serious injuries, 3 for minor injuries, and 1 for material loss. Then, the field survey is carried out at the top 3 accident-prone areas to analyse the types of accidents and the reasons of the accident resulting in the recommendation for stakeholders.

4. RESULTS AND DISCUSSION

The research area was the road section which has the status of a provincial road in the Special Region of Yogyakarta. The provincial road was determined based on the Decree of the Governor of the Special Region of Yogyakarta No.118/KEP/2016 concerning the Determination of the Status of Provincial Road Sections. Based on the regulation, the length of provincial roads in the Special Region of Yogyakarta is 760,450 km with 97 road sections. Of 5 regencies, Gunung Kidul Regency has the longest provincial roads by 306,840 km in 34 road sections. On the other hand, Yogyakarta City does not have a provincial road section.

1. Accident-Prone Areas (APA)

Accident-prone areas on the provincial road in the Special Region of Yogyakarta were analysed with Kernel Density Analysis and Buffer Analysis using ArcGIS software. From the analysis, the accident-prone area was identified in 25 road sections as seen in Table 1.

ISSN 2541-223X
Volume 4 2022

Table 1. Accident-prone areas on the provincial road in the Special Region of Yogyakarta

No. of APA	Road section	No. of accident case	Death	Serious injuries	Minor injuries	Material loss
1	Barongan - Bibal	14	0	0	17	0
2	Bantul - Srandakan	43	2	0	51	0
3	Bantul - Srandakan	45	6	0	55	0
4	Bantul - Srandakan	37	1	0	44	0
5	Brosot - Toyan	16	2	0	28	0
6	Palbapang - Samas	27	5	0	30	0
7	Bantul - Srandakan	47	5	0	53	0
8	Sedayu - Pandak	17	1	0	19	0
8	Bantul - Srandakan	52	2	0	71	0
9	Yogyakarta - Bakulan (Parangtritis)	29	3	0	35	0
9	Bakulan - Barongan	23	4	0	21	0
10	Yogyakarta - Barongan	44	3	0	47	0
10	Barongan - Bibal	27	5	0	34	0
10	Bakulan - Barongan	32	3	0	33	0
10	Dawung - Makam Imogiri	8	0	0	8	0
11	Yogyakarta - Bakulan (Parangtritis)	39	2	0	55	0
12	Yogyakarta - Bakulan (Parangtritis)	42	0	0	51	0
13	Yogyakarta - Barongan	22	0	0	29	0
14	Yogyakarta - Bakulan (Parangtritis)	26	3	0	33	0
15	Yogyakarta - Kebonagung 1	31	7	0	30	0
16	Yogyakarta - Kebonagung 1	22	0	0	27	0
17	Yogyakarta - Kebonagung 1	27	2	0	36	0
18	Yogyakarta - Pulowatu	15	3	0	16	0
19	Yogyakarta - Kaliurang	16	1	0	17	0
20	Yogyakarta - Barongan	64	4	0	81	0
21	Sedayu - Pandak	37	1	0	46	0
22	Palbapang - Samas	35	6	0	38	0
23	Yogyakarta - Bakulan (Parangtritis)	42	1	0	54	0
24	Palbapang - Samas	26	0	0	31	0
24	Palbapang - Simpang Kweden	10	0	0	13	0
25	Prambanan - Piyungan	19	3	0	24	0

ISSN 2541-223X
Volume 4 2022

2. Top 10 Rangkings of Accident-Prone Areas

The 25 accident-prone areas from Table 1 then processed using the Accident Equivalent Number method to determine the top 10 rankings that will be carried out for further handling in the field. The top 10 rankings of accident-prone areas can be seen in Table 2.

Table 2. Top 10 rankings of accident-prone areas on the provincial road in the Special Region of Yogyakarta

No. of APA	Road section	Accident equivalent number	Rank
20	Yogyakarta - Barongan	291	1
3	Bantul - Srandakan	237	2
8	Bantul - Srandakan	237	3
7	Bantul - Srandakan	219	4
11	Yogyakarta - Bakulan (Parangtritis)	189	5
22	Palbapang - Samas	186	6
2	Bantul - Srandakan	177	7
10	Yogyakarta - Barongan	177	8
15	Yogyakarta - Kebonagung 1	174	9
23	Yogyakarta - Bakulan (Parangtritis)	174	10

3. Analysis of Accident-Prone Areas

A field survey was carried out at the top 3 accident-prone areas to analysed the types of accidents and the reasons of the accident resulting in the recommendation for stakeholders. The analysis will be discussed further one by one from the first to the third rank.

4.3.1. 1st rank: Yogyakarta – Barongan road section (accident-prone area number 20). The road section was located near Muhammadiyah Blawong Elementary School. The average daily traffic on this section of the road was 1088 passenger car units/hour and the average vehicle speed was 43.55 km/hour. It has 64 accidents with details of four dead cases and 81 minor injuries cases. Based on the accident type data that occurred along the Yogyakarta-Barongan Road section, most are caused by the type of front-back collision by 23.40%. The front-front type of collision is the second highest incident on this road section by 20.30%. Some of the factors that cause this type of accident are the driver's miscalculation when overtaking or driving too wide past the centerline of the road. Furthermore, the percentage of the accident type can be seen on Figure 1 and the accident map of Yogyakarta – Barongan road section can be seen in Figure 2.

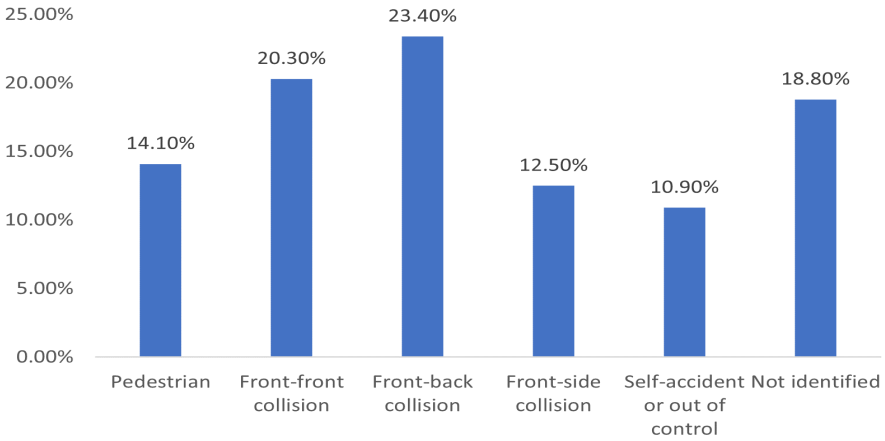

Figure 1. Accident type of Yogyakarta – Barongan road section (accident-prone area number 20)

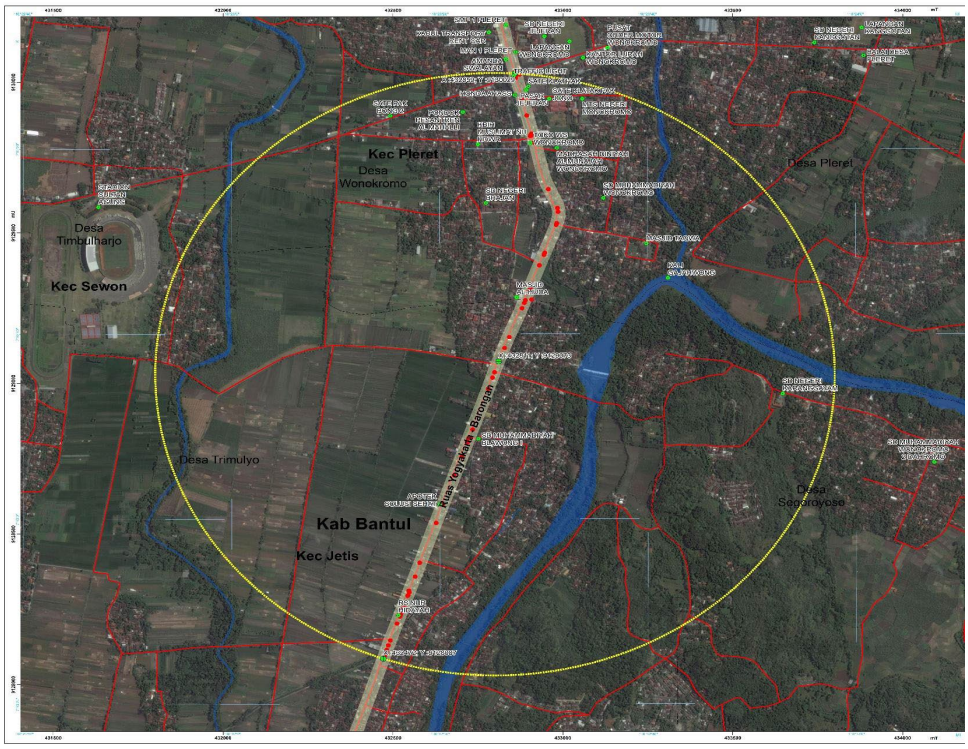

Figure 2. Accident map of Yogyakarta – Barongan road section (accident-prone area number 20)

Based on the field survey, the road lane was only 3.3 m and the absence of adequate signs for overtaking resulting high number of front-front collision accidents by 20.30% or 13 events. Furthermore, the road shoulder was only 1 m, so it cannot accommodate vehicles that stop emergencies which can also cause front-back type accidents by 23.4% or 15 events. Other findings, inadequate visibility can also result in a high front-side accident by 12.5% or 8 occurrences and the lack of signs along the segment of the road section surveyed may also cause a high number of accidents. Last, due to its geometric design, there was also a double turn that was prone to accidents and the loss of road markings on the turning.

4.3.2. 2nd rank: Bantul - Srandakan road section (accident-prone area number 3).
The road section was located near Mangiran Market. This road section has 2062 passenger car units/hour as its average daily traffic and the average vehicle speed was 53.95 km/hour. It has 45 accidents with details of six dead cases and 55 minor injuries cases. Based on the type of accident data that occurred along the Bantul-Srandakan road section, most of them are caused by not identified accidents. While the next dominant type of accident is the front-back collision type at 20.00% and followed by the front-front collision and front-side accident type at 17.80%. Some factors that cause this type of accident are the driver's miscalculation when overtaking or driving too wide past the road centerline. The next type is the type of accident that occurs because it hits pedestrians both on the side of the road and those who are crossing. Furthermore, the percentage of the accident type can be seen on Figure 3 and the accident map of Bantul – Srandakan road section can be seen in Figure 4.

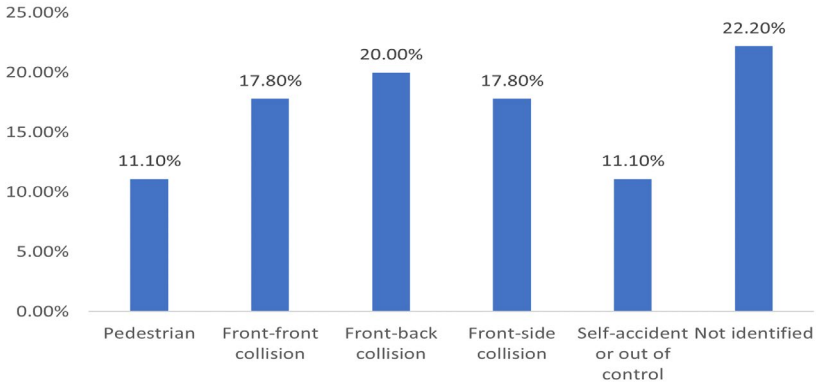

Figure 3. Accident type of Bantul-Srandakan road section (accident-prone area number 3)

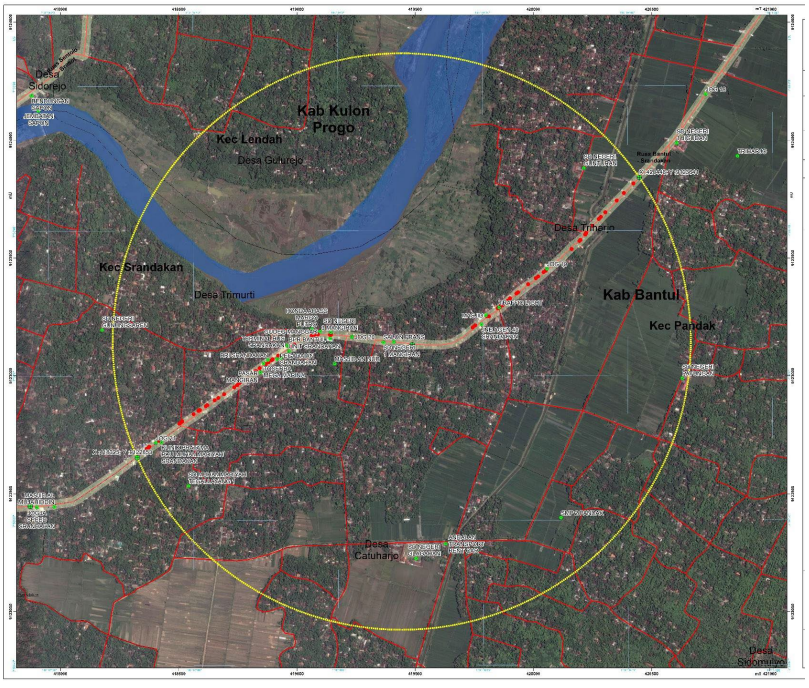

Figure 4. Accident map of Bantul-Srandakan road section (accident-prone area number 3)

Based on the field survey, the intersection between Srandakan Road and Kampung Bendo was quite dangerous because the intersection was on a turning and there are no signs from the West. The number of turns and intersections on this road section cause some accidents due to the lack of signs and lighting in the place. Furthermore, due to the large number of vehicles parked on the shoulder of the road, the obstacles on this road section become high. This condition can result in accidents, especially the front-back and front-front collision because the main road lanes are also used as vehicle parking areas.

4.3.3. 3rd rank: Bantul - Srandakan road section (accident-prone area number 8).

This road section was located near Pandak police office. The average daily traffic on this section of the road is 2062 passenger car units/hour and the average vehicle speed is 61.28 km/hour. It has 69 accidents with details of three dead cases and 90 minor injuries cases. Based on the type of accident data along the Bantul-Srandakan road, most are caused by front-back collision type accidents at 30.80%. Then followed by the type of front-side collision accidents by 23.1%. Some factors that cause this type of accident are the driver's lack of caution when turning and the lack of calculation when overtaking. Moreover, some drivers are driving passing the centerline of the road. The next type is the type of accident that occurs because it hits pedestrians both on the side of the road and those who are crossing. The percentage of the accident type can be seen on Figure 5 and the accident map of Bantul – Srandakan road section can be seen in Figure 6.

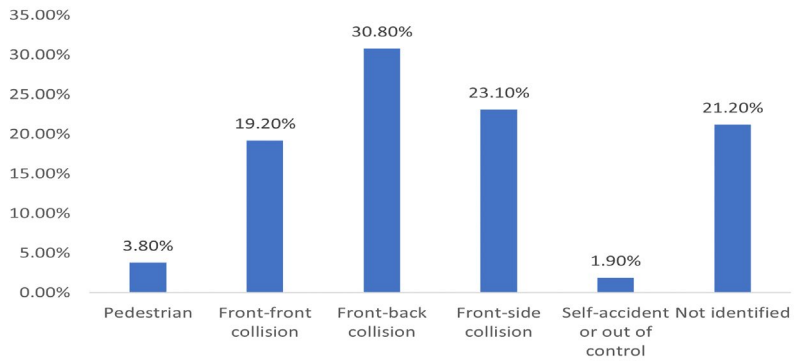

Figure 5. Accident type of Bantul-Srandakan road section (accident-prone area number 8)

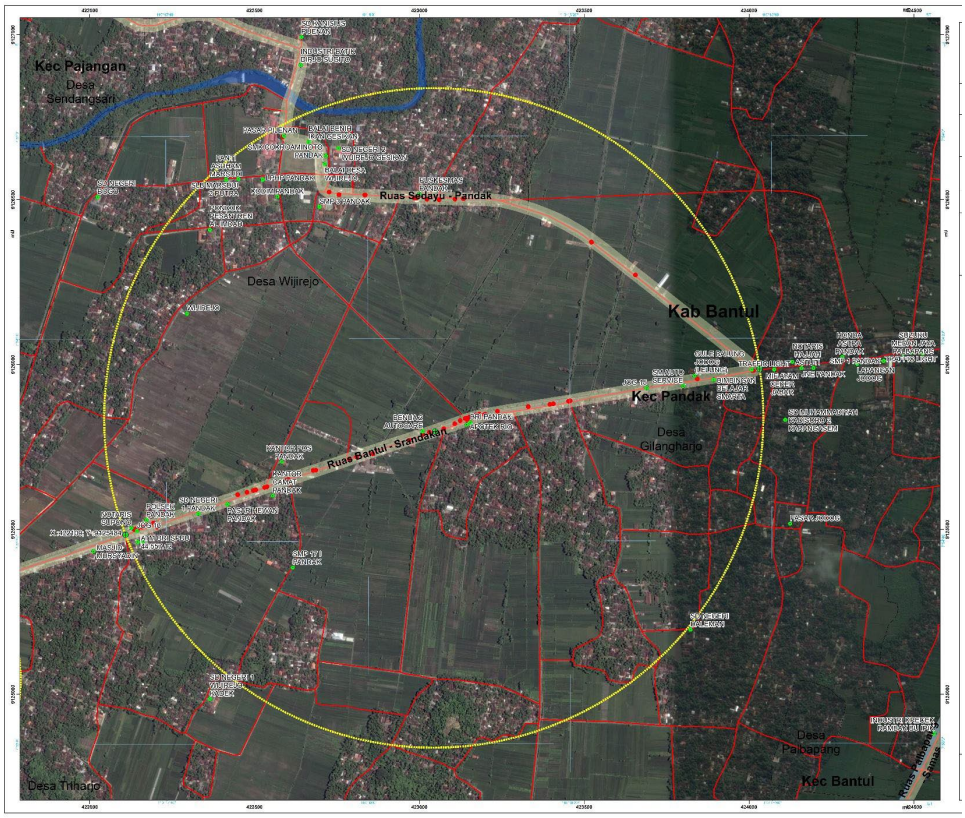

Figure 6. Accident map of Bantul-Srandakan road section (accident-prone area number 8)

The field survey found that the road lanes was only 3 m and the absence of adequate signs for overtaking can cause many front-front collision accidents by 19.2%. Limited visibility, lack of signs along the segments of the road sections surveyed, and the presence of sharp turns resulted in a high number of accidents on this section of the road.

4.4 Recommendation

Based on the field survey and the analysis of the accident-prone areas, some recommendations were given to the stakeholders. There were several recommendations for handling, including the installation of signs, the installation of public street lighting, and the awareness of the road user community towards safe traffic that needs to be carried out continuously through various means and media. The recommendations for the top accident-prone area can be seen in Table 3.

Table 3. Recommendation for Yogyakarta – Barongan road section (accident-prone area number 20)

Conditions	Recommendation	Coordinates
Including accident-prone areas	Traffic voice, CCTV, traffic accident board installation	-7.869986302706138, 110.39088032777936
Right turn accident	Right turn signing installation	-7.873685706337549, 110.39205090938988
Poor visibility on right turn	Road shoulder utilization	-7.873791691347012, 110.39195568618517

Front-front collision, front-rear collision	Caution warning signs installation	-7.87382301814467, 110.39205466573716
	Rumble strip installation before the turn	-7.873791691347012, 110.39195568618517
Turning angle is too sharp	Geometric repairments	-7.873791691347012, 110.39195568618517
	Road shoulder widening	-7.873791691347012, 110.39195568618517
	Zebra cross and signing installation	-7.8748759389258804, 110.39195078439575
Accidents near mosque	Mosque warning installation	-7.876615542349321, 110.39131658177224
	Mosque warning installation	-7.877137547412482, 110.3910104832042
	Pedestrian crossing warning installation	-7.87656558145208, 110.39132701693032
	Pedestrian crossing warning installation	-7.877147884143996, 110.39101222240721
Accidents involving pedestrians	Pedestrian warning installation	-7.880703216657162, 110.38980676629286
	Pedestrian warning installation	-7.881282415848333, 110.38948490114876
Front-side collisions between vehicles, accidents in turning	Continuous marking (to prevent overtaking)	Along the road section
Unclear markings	Re-paint the markings	Along the road section
Vehicles out of control, narrow road for maneuver	Road widening (0.5 m each lane)	Along the road section

However, several physical handles such as signs installation, geometric repairments, or any infrastructure repairments are not enough to improve traffic safety if the awareness of the road users towards safe traffic is not increasing. Furthermore, Amri [12] evaluated that the effectiveness of the implementation of traffic safety improvement programs carried out by the Padang City Transportation Department has not been going well. As stated before, the main factor that causes traffic accidents is not only road factors but also human factors. So, it is important to promote traffic safety awareness continuously through various media and evaluate DIY traffic safety improvement programs for further studies.

5. CONCLUSION

Based on Kernel Density Analysis, Buffer Analysis, and Accident Equivalent Number method, the top 3 accident-prone areas are Yogyakarta - Barongan road section (near Muhammadiyah Blawong Elementary School), Bantul - Srandakan road section (near Mangiran Market), and Bantul - Srandakan road section (near Pandak police office). There are several recommendations for handling, including signs and markings

installation, geometric repairments, and the awareness of the road user community towards safe traffic that needs to be carried out continuously through various media.

6. REFERENCES

DIY Central Statistics Agency 2022 *Provinsi Daerah Istimewa Yogyakarta Dalam Angka* (Yogyakarta: DIY Central Statistics Agency)

DIY Department of Transportation 2021 *Studi Daerah Rawan Kecelakaan di Jalan Provinsi* (Yogyakarta: DIY Department of Transportation)

Angin M and Ali S I A 2021 Analysis of Factors Affecting Road Traffic Accidents in North Cyprus *Engineering, Technology & Applied Science Research* ***11*** issue 6 pp. 7938-7943

Saputra A D 2017 Studi Tingkat Kecelakaan Lalu Lintas Jalan di Indonesia Berdasarkan Data KNKT (Komite Nasional Keselamatan Transportasi) Dari Tahun 2007-2016 *Warta Penelitian Perhubungan* ***29*** no. 2 pp.179-190

Sugiyanto G, Fadil A and Santi M Y 2020 Penerapan Hasil Audit Keselamatan Jalan di Lokasi Rawan Kecelakaan Lalu Lintas *DINAMISIA: Jurnal Pengabdian Kepada Masyarakat* ***4*** no. 1 pp. 50-58

Fahza A and Widyastuti H 2019 Analisis Daerah Kecelakaan Lalu Lintas Pada Ruas Jalan Tol Surabaya-Gempol *Jurnal Teknik ITS* ***8*** no.1 pp.E54-E59

Imtihan K and Fahmi H 2020 Analisis dan Perancangan Sistem Informasi Daerah Rawan Kecelakaan Dengan Menggunakan Geographic Information Systems (GIS) *MISI (Jurnal Manajemen informatika & Sistem Informasi)* ***3*** no. 1 pp.16-23

Yu B, Chen Y, Bao S and Xu D 2018 Quantifying Drivers' Visual Perception to Analyze Accident-Prone Locations on Two-Lane Mountain Highways *Accident Analysis and Prevention* ***119*** pp.122–130

Rizvee M M, Amiruzzaman M and Islam M R 2021 Data Mining and Visualization to Understand Accident-Prone Areas *Proceedings of International Joint Conference on Advances in Computational Intelligence* pp.143–154

Anderson T K 2008 Karnel Density Estimation and K-Means Clustering to Profile Road Accident Hotspots *Accident Analysis and Prevention* ***41*** pp.359–364

Wang H, Liu Z, Liu Z, Wang X, and Wang J 2022 GIS-based analysis on the spatial patterns of global maritime accidents *Ocean Engineering* ***245*** 110569

Amri R 2020 *Efektivitas Pelaksanaan Program Peningkatan Keselamatan Lalu Lintas Oleh Dinas Perhubungan Padang* (Banjarmasing: Universitas Lambung Mangkurat Banjarmasing)

Acknowledgments

This acknowledgment is to Transportation Agency of Yogyakarta Province for the project funding support.