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Identification of Two-Wheeler Accident Blackspots across Different Category of Roads in and Around Bengaluru City: A Case Study

Vibhav.H. V [1], L. Durga Prashanth [2], Varun. R. G [3]

PG Scholar[1, 3], Assistant Professor[2]

R.V. College of Engineering, Bengaluru

Corresponding Authors' Email id: *vibhav47@gmail.com, durgaprashanthl@rvce.edu.in[2], varunrg50@gmail.com[3]*

Abstract

The developments in the domain of transportation have led to a steep rise in economic losses and human losses due to road traffic accidents (RTAs). Identification of such RTA blackspots is considered vital for the effective and efficient utilization of resources to enhance traffic safety features of a road network. The identification of blackspots is not a new concept and has been in practice for a while. Despite the extensive work done in the field, there is an extreme scarcity of studies dedicated to the identification of blackspots exclusively for two-wheelers. In the present study, general accident blackspots and exclusive two-wheeler blackspots are identified on five different stretches in and around the city of Bengaluru, Karnataka. The five stretches under study belong to four major categories of roadways. Three years of accident data (2017-2019) is obtained from the police stations and the features of the road are recorded through on-field surveys. The accident data is used to determine the Weighted Severity Index, which in turn is used to identify the blackspots. Thereafter, the Kernel Density tool is used in the ArcGIS software to locate blackspots on the map. The different characteristics of the blackspots are analysed such as time of occurrence of RTAs, type of collisions occurring in RTAs and the degree of involvement of the various categories of motor vehicles in RTAs along the stretch. The factors leading to RTAs along the blackspots are identified and suitable countermeasures are suggested.

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***Keywords**: - Blackspot, Road traffic accidents, Transportation, Two-Wheeler, Road safety*

INTRODUCTION

In today's world, there have been numerous noteworthy advancements in the field of transportation. This is the principal cause behind the rise in the number of road accidents and the loss of lives and property associated with it. A vast majority of such accidents occur in developing countries due to derisory road safety procedures. According to WHO's Global Status Report on Road Safety 2018, about 1.35 million people die and 50 million people endure non-fatal injuries annually as a result of RTAs. At present, injuries due to road accidents is in ninth position in the list of foremost causes of death across all age groups globally and are projected to be the seventh foremost cause of death by 2030.

From the past two calendar years, Karnataka holds top positions in all parameters in road accident count when compared with the other states in the country. As per the report 'Road Accidents in India-2018' released by the Ministry of Road Transport and Highways (MoRTH), road accidents have claimed the lives of 10,990 people. The report also said that in 2018, 21,277 people were grievously injured in Karnataka in road accidents, while 30,285 suffered minor injuries. Bengaluru, the capital of Karnataka, records 1,750 new vehicle registrations every day and the vehicle population in Bengaluru has crossed 80.45 lakh (Karnataka Ministry of Transportation Annual Report-2018). The kind of speed and the mixed nature of traffic in India mean that vehicles with superior speeds drive on the same road with two-wheelers of lower speeds, making them more accident-prone. Two and three-wheeler riders accounted for 40% of all traffic deaths in India in 2016, according to WHO's Global Status Report on Road Safety 2018. This is due to the lack of a protective exterior, exposing them to more injuries.

Identification of accident hotspots or accident blackspots is considered the primary step in road safety, as it facilitates the effective utilization of limited resources available for road safety. Overall, there is no universally accepted definition for accident blackspots and it varies from country to country. Usually, accident blackspots are defined as locations that attract relatively more accidents with respect to other similar

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locations on the road system (Elvik 2007) or sites which have an accident frequency greater than a defined minimum (Hakkert and Mahalel 1978).

The Indian Road Congress (IRC) describes blackspots as those stretches of roads of length 500 m, witnessing a minimum of five accidents or three fatalities in a calendar year. MoRTH describes blackspots as a road stretch of 500m in length in which either 5 Road accident (in all three years put together involving fatalities/grievous injuries) took place during last three calendar years or 10 fatalities (in all three years put together) took place during last three calendar years.

LITERATURE REVIEW

The very first use of conventional statistical methods for the purpose of blackspot identification was in the 1950s (Norden et al 1956). The general classification and ranking in such methods are on the basis of crash frequency or crash rates (Hauer 1996; Tarko and Kanodia 2004). These aforementioned methods can be effortlessly executed. However, it completely disregards the variations between the various severity levels such as injury causing collisions and fatality causing collisions (Bil et al 2013). The crash rate method ranks the blackspots by segregating the observed crash rates and locations. It is only effective for the ranking of sites, identical in nature. Numerous agencies utilize the basic ranking of crash rates or crash counts due to easy application and calculation. Crash statistics have proven to be a decent safety estimator but certain studies (Hauer 1980; Hauer and Persaud 1982; Persaud 1988; Persaud et al 1999) showed that such estimators present some bias to blackspot identification because it is subjected to the regression-to-the-mean (RTM) phenomenon, which involves the incorrect recognition of sites with randomly high crash frequency as being RTA blackspots and vice versa.

To overcome such shortcomings, the Empirical Bayes (EB) method was conceptualized. The Empirical Bayes (EB) method takes into account both the historical statistics of the desired section as well as data from similar sections. This method involves the development of a Safety Performance Function (SPF) to assess the probable amount of crashes. The crash estimations on road network are then linked with the detected crash counts to attain an enhanced estimate known as the EB estimate. The EB estimate exhibited increased precision, rectifies RTM bias and frequently outclasses the other existing

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techniques of blackspot detection (Cheng and Washington 2008) (Montella 2010).

The capability of EB to outperform other blackspot identification methods have been demonstrated time and time again by many well cited papers (Huang, Chin, and Haque 2009) However, the need for excessive computational resources for calculating different weights is considered a major drawback. Especially for those EB methods designed to consider different types of collision.

Full Bayesian (FB) method is an alternative of EB method. Hierarchical Poisson model is one amongst the proposed FB methods and its application is based on road intersection data but there has been no confirmation of its use on highway segments. Its main limitation is its failure in consideration of uncertainties based on time and its lack of application on highway segments (Yangzhou Chen, Jiang Luo, Wei Li 2014).

Geographic Information Systems (GIS) have gained extreme popularity as a spatial analysis tool to identify accident blackspots and to correspondingly rank them. It precisely displays the blackspots on the map and also stores the characteristics of each individual accident. GIS has the capacity to handle large amounts of assorted data, accident spot visualization and easy spatial analysis of traffic accidents (Erdogan et al. 2008; Lloyd 2010).Various authors have used Geographic Information Systems (GIS) technology.

In summary, it was observed that despite extensive studies being conducted on application of GIS to identify blackspots; there was a lack of research on application of GIS or any blackspot identification method to identify individual vehicle-type based blackspots. There is also a paucity of literature dedicated to identification of two-wheeler blackspots despite two-wheeler it was also observed that extensive research has been conducted to identify blackspots in different traffic conditions but there is a lack of work involving the identification and comparative of blackspots forming on different categories of roads.

STUDY AREA

Bengaluru is the capital of the southern Indian state of Karnataka and is the third most populous city in the country. Five different stretches have been chosen for the study, with each of them belonging to a different category of roads i.e. national highway, state highway, arterial ring road

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and Local Street. The description of each individual stretch is given below in **Table 1.**

National Highway 44 is the longest running national highway in India, with a total length of 3,806 KM. It passes through 12 states in the country. NH-44 was built by the Central Public Works Department (CPWD) and is currently maintained by them as well. A stretch of this highway connects Bengaluru in Karnataka and the border city of Hosur in Krishnagiri district, Tamil Nadu. This stretch of the NH-44 is called the Bengaluru-Hosur Road. Stretch-1 is the stretch of the Bengaluru-Hosur Road connecting Rupeena Agrahara and Veerasandra Junction.

State Highway 17 (SH-17) is a state highway linking the two major cities of Karnataka i.e. Bengaluru and Mysore. The overallspan of the highway is 149 kilometres. It was built and is maintained by the Karnataka Road Development Corporation Limited (KRDCL). It was inaugurated in 2003. The highway passes through the towns of Ramanagara, Channapatna, Maddur, Mandya and Srirangapatna (Seringapattinam), before entering Mysore. The 15 km stretch from Bangalore Central to Kengeri NICE Road Junction is known as Mysore Road.

Table 1 Specifications of the Different Stretches under Study

Sl. No	Stretch Name	Starting Point	Ending Point	Distance (KM)	Type of Road
1.	Stretch-1	12.917450 77.622786	12.839610 77.677298	10.5	National Highway (NH-44)
2.	Stretch-2	12.952319 77.540932	12.906963 77.474378	25	State Highway (SH-17)
3.	Stretch-3	13.131833 77.570469	13.336105 77.531394	10.5	State Highway (SH-09)
4.	Stretch-4	12.988980 77.507800	12.974422 77.551702	5.6	Arterial Ring Road
5.	Stretch-5	12.963535 77.577356	12.977438 77.574286	5	Local Street

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Stretch-2 is the stretch of the Mysore Road connecting KIMCO Junction and Doddabele Cross. The Bengaluru suburb of Yelahanka is connected to Hindupur in Andhra Pradesh by Karnataka State Highway-09. The highway is one of the primary state highways and has an overall span of 74.5 KM. The construction and maintenance of the highway was the responsibility of the Karnataka Road Development Corporation Limited (KRDCL) and was inaugurated in 2018.

Stretch-3 is the stretch of State Highway-09 extending from Avalahalli to Palnjogihalli. Magadi Road is an arterial ring road that connects Magadi to Bangalore City Railway Station and has a total distance of 43 KM. It traverses through the heart of West Bangalore and links Binnipete, Vijayanagar, Kamkshipalya, Sunkadakate, Golarahatti and Thavarekere. Stretch-4 extends from Prasanna Theatre Junction to Ashraya Hospital. Stretch-5 lies on A local road stretch which connects the locations Annapoorna Junction, Minerva circle and Tank bund roads which is in the centre of Bangalore city.

METHODOLOGY

The road accident data was collected for three years (2017-2019) from reports (F.I.R) maintained by the 12 police stations under whom whose jurisdictions the stretches are present. On-field features of the road such as geometric alignment, safety features etc. were recorded through photography and videography. The Weighted Severity Index method and the Accident Density method were employed to identify two-wheeler blackspots. The analysed information processed into ArcGIS 10.5 software for the identification of blackspot. It includes the steps like map scanning geo-referencing, digitization, assigning attributes.

DATA ANALYSIS

Accident data from each police station is segregated based on time of occurrence, date of occurrence, type of collision type of damage sustained by accident victims and type of vehicle involved. From this analysis, the degree of accident severity occurring along each individual stretch and the nature of accidents can be recognized. A total of 62 accidents occurred along Stretch-1 out of which 42 accidents involved two-wheelers. A total of 59 accidents occurred along Stretch-2 out of which 40 accidents involved two-wheelers. A total of 49 accidents occurred along Stretch-3 out of which 29 accidents involved two-wheelers.

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A total of 12 accidents occurred along Stretch-4 out of which 19 accidents involved two-wheelers. A total of 36 accidents occurred along Stretch-4 out of which 13 accidents involved two-wheelers. The analytical findings are presented in the figures below.

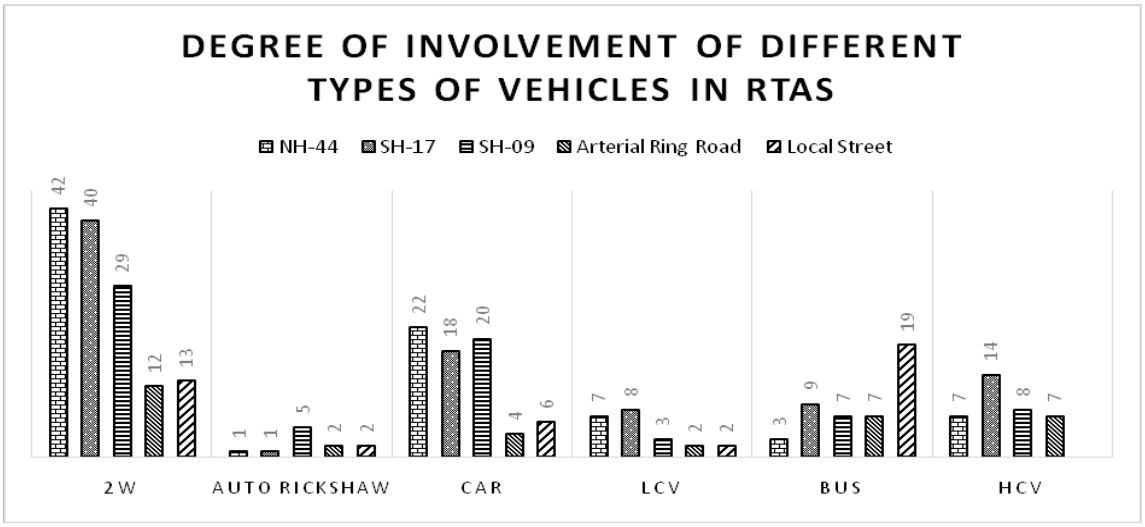


Figure.1: Degree of Involvement of Different Types of Vehicles in RTAs

It was observed from Figure 1, that two wheelers had the highest involvement in RTAs in 4 stretches and had the second highest involvement in Stretch-5.

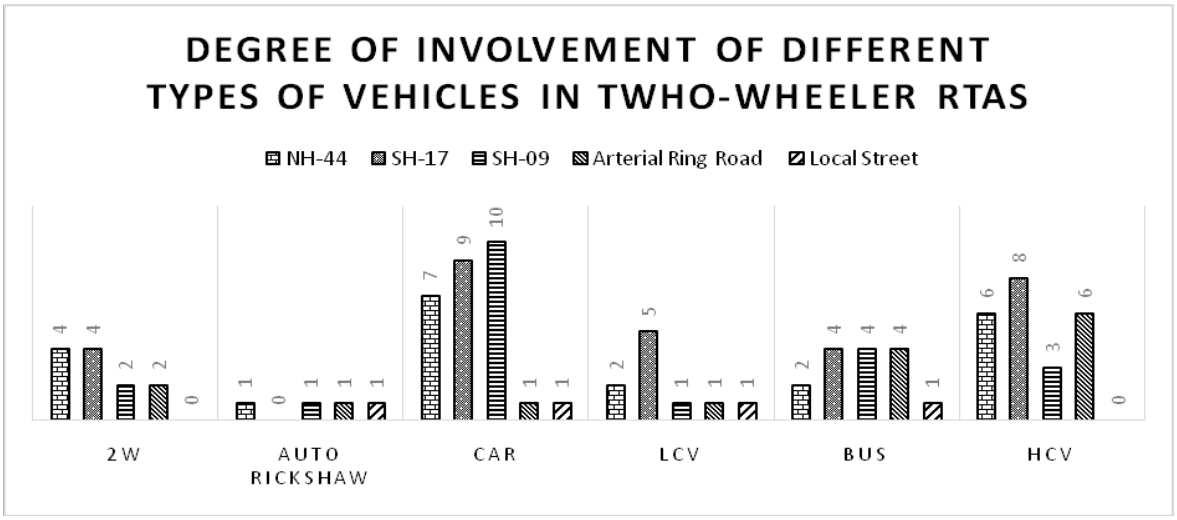


Figure.2: Degree of Involvement of Different Types of Vehicles in Two-Wheeler RTAs

As seen in Figure 2, Two-wheelers had the highest involvement in RTAs with other two wheelers in Sretch-1. Auto Rickshaws did not display any significant accident involvement with two-wheelers in any stretch. Stretch-3 witnessed the highest involvement of cars with

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two-wheelers in RTAs. LCVs had the highest involvement in RTAs with two-wheelers in Stretch-2. Buses had equal involvement in RTAs with two-wheelers in 3 stretches, but had negligible involvement in the remaining two stretches. Stretch-2 witnessed the highest number of RTAs involving HCVs and two-wheelers.

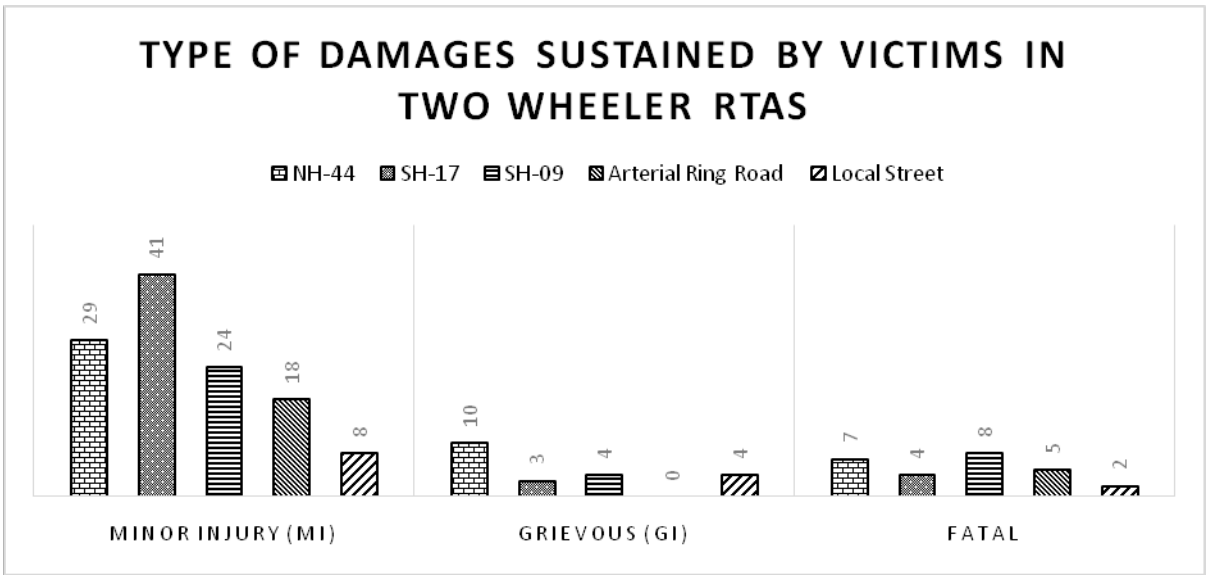


Figure.3: Degree of Involvement of Different Types of Vehicles in Two-Wheeler RTAs

From Figure 3, it was observed that the highest amount of minor injuries was on Stretch-2. Grievous injuries were highest along Stretch-1. Stretch-3 contained the highest number of fatalities in RTAs involving two-wheelers.

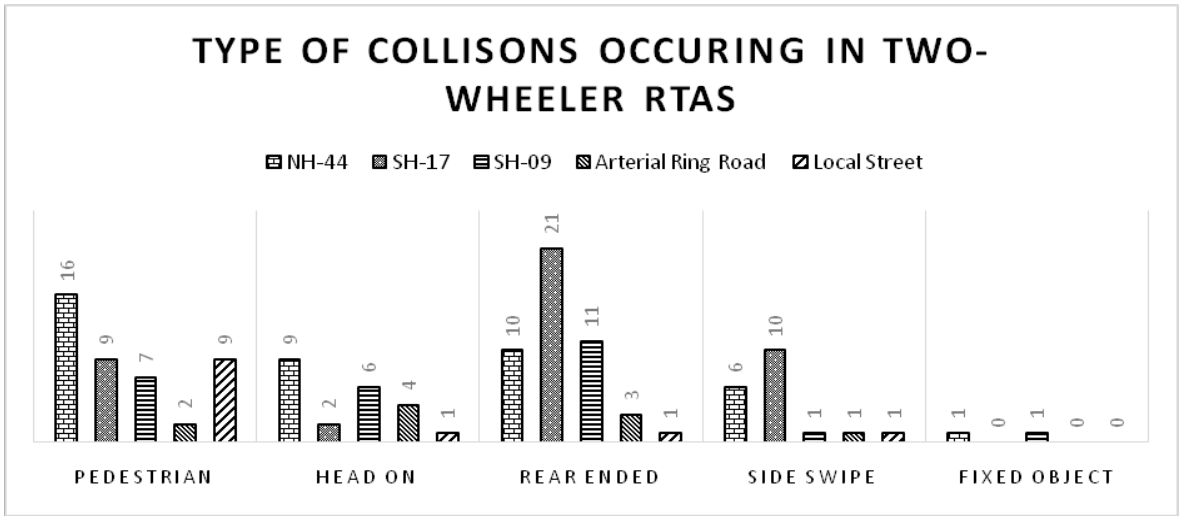


Figure.4: Type of Collisions Occuring in Two-Wheeler RTAs

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It was observed in Figure 4, that pedestrian and head on collision were highest in two-wheeler RTAs on Stretch-1. Stretch-2 had the highest number of rear ended and side swipe collisions in RTAs involving two-wheelers.

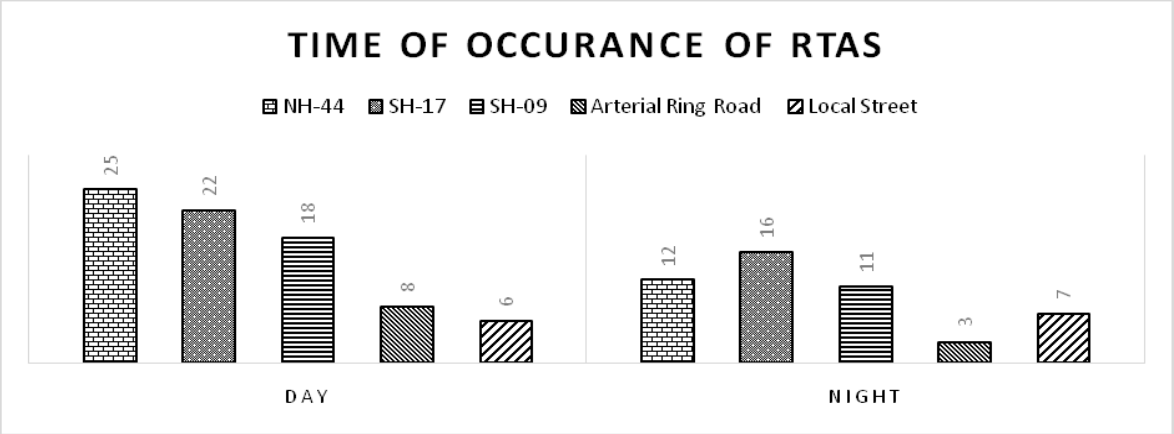


Figure.5: Time of Occurrence of RTAs

As per Figure 5, Stretch-1 had the highest day time accidents and Stretch-2 had the highest night time accidents. Day time accidents were higher on all stretches when compared to night time accidents.

Accident Density Method

Accident density calculation involves the determination of the number of accidents per unit length for a certain section of the highway.500m is considered the unit length. Predetermined no. of accidents is computed as the mean number of accidents that have occurred per unit length. The accident density for each stretch is presented below in Figure 6.

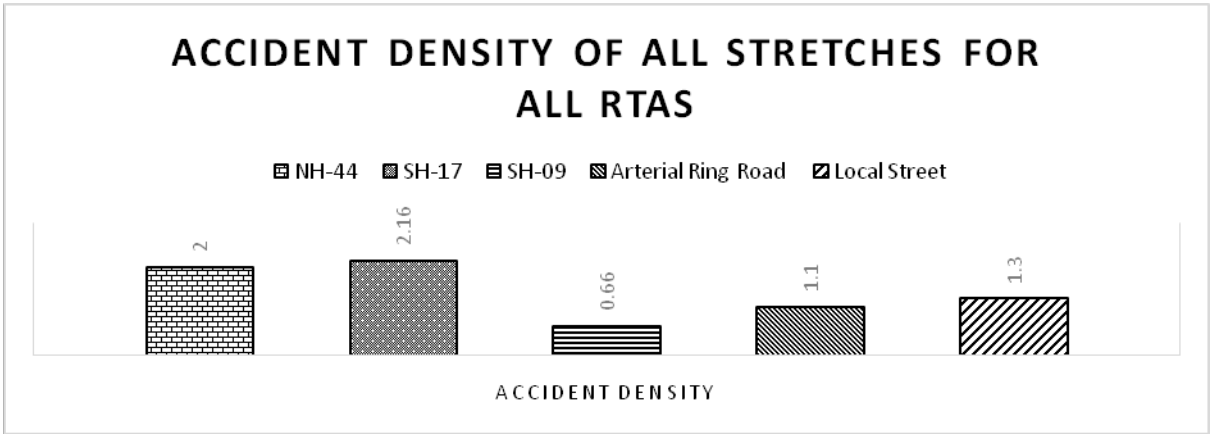


Figure.6: Accident Density of All Stretches for Two-Wheeler RTAs

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From Figure 6, it was observed that Stretch-2 had the highest two-wheeler accident density and Stretch-3 had the lowest two-wheeler accident density.

Weighted Severity Index Method

The WSI was calculated for each stretch by using the accident data for 3 years, collected from the respective police stations.

Weighted Severity Index (WSI), WSI = (41 x K) + (4 x GI) + (1 x MI)

Where, K is the number of fatalities due to two-wheeler RTAs along the stretches; GI is the number of grievous injuries; and MI is the number of minor injuries. Locations with WSI in excess of 40 are termed as blackspot. WSI values above100 were considered high severity blackspots. The identified blackspots and their rankings are provided in the tables below.

Table.2: Blackspots Identified on Stretch-1

Rank	Location	Fatal (K)	Grievous Injury (GI)	Minor Injury (MI)	WSI
1	Rupeena Agrahara	5	8	19	256
2	Singasandra	1	1	4	49
3	Veerasandra	1	0	1	42
4	Konnapanagrahara	0	1	4	8
5	Naganathpura	0	0	1	1

As per Table 2, Three two-wheeler blackspots were identified along Stretch-1 i.e. Rupeena Agrahara, Singasandra and Veerasandra. Amongst them Rupeena Agrahara was designated as a high severity blackspot with WSI of 256.

Table.3: Blackspots Identified on Stretch-2

Rank	Location	Fatal (K)	Grievous Injury (GI)	MinorInjury (MI)	WSI
1	Doddabele Cross	2	1	3	89
2	RV College	1	1	7	52
3	Mailsandra	1	1	2	47
4	Nayandhalli	0	0	22	22
5	KIMCO Junction	0	0	2	2
6	RR Gate	0	0	2	2
7	Madhu Petrol Bunk	0	0	0	0

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As per Table 3, a total of three two-wheeler blackspots were identified on Stretch-2 i.e. Doddabele Cross, R.V. College of Engineering and Mailsandra. None of the identified blackspots were of high severity as none of their WSI was above 100.

Table.4: Blackspots Identified on Stretch-3

Rank	Location	Fatal (K)	Grievous Injury (GI)	MinorInjury (MI)	WSI
1	Bashettihalli	4	0	6	170
2	Palanjogihalli	2	1	5	91
3	D Cross	1	0	8	49
4	Honnenhalli	1	1	2	47
5	Rajankunte	1	1	1	46
6	Avalahalli	0	1	1	5
7	Marasandra	0	0	1	1

As per Table 4, five two-wheeler blackspots were identified on Stretch-3 i.e. Bashettihalli, Palanjogihalli, D Cross, Honnenhalli and Rajankunte. Amongst them, Bashettihalli was designated as a high severity blackspot with WSI of 170.

Table.5: Blackspots Identified on Stretch-4

Rank	Location	Fatal (K)	Grievous Injury (GI)	Minor Injury (MI)	WSI
1	Ashraya Hospital	5	0	16	221
2	Prasanna Theatre	0	0	3	3

As per Table 5, Ashraya Hospital was the only blackspot identified along Stretch-5. It was also designated as a high severity blackspot.

Table.6: Blackspots Identified on Stretch-5

Rank	Location	Fatal (K)	Grievous Injury (GI)	Minor Injury (MI)	WSI
1	Tank Bund Road	2	0	5	87
2	Minerva Circle	0	3	2	14
3	Annapurna Junction	0	1	1	5

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As per Table 6, Tank Bund Road was the only blackspot identified on Stretch-5.

Locating Blackspots using Arc GIS

The blackspots were located using the Kernel Density in the ArcGIS software. The locations are provided in the figures given below.

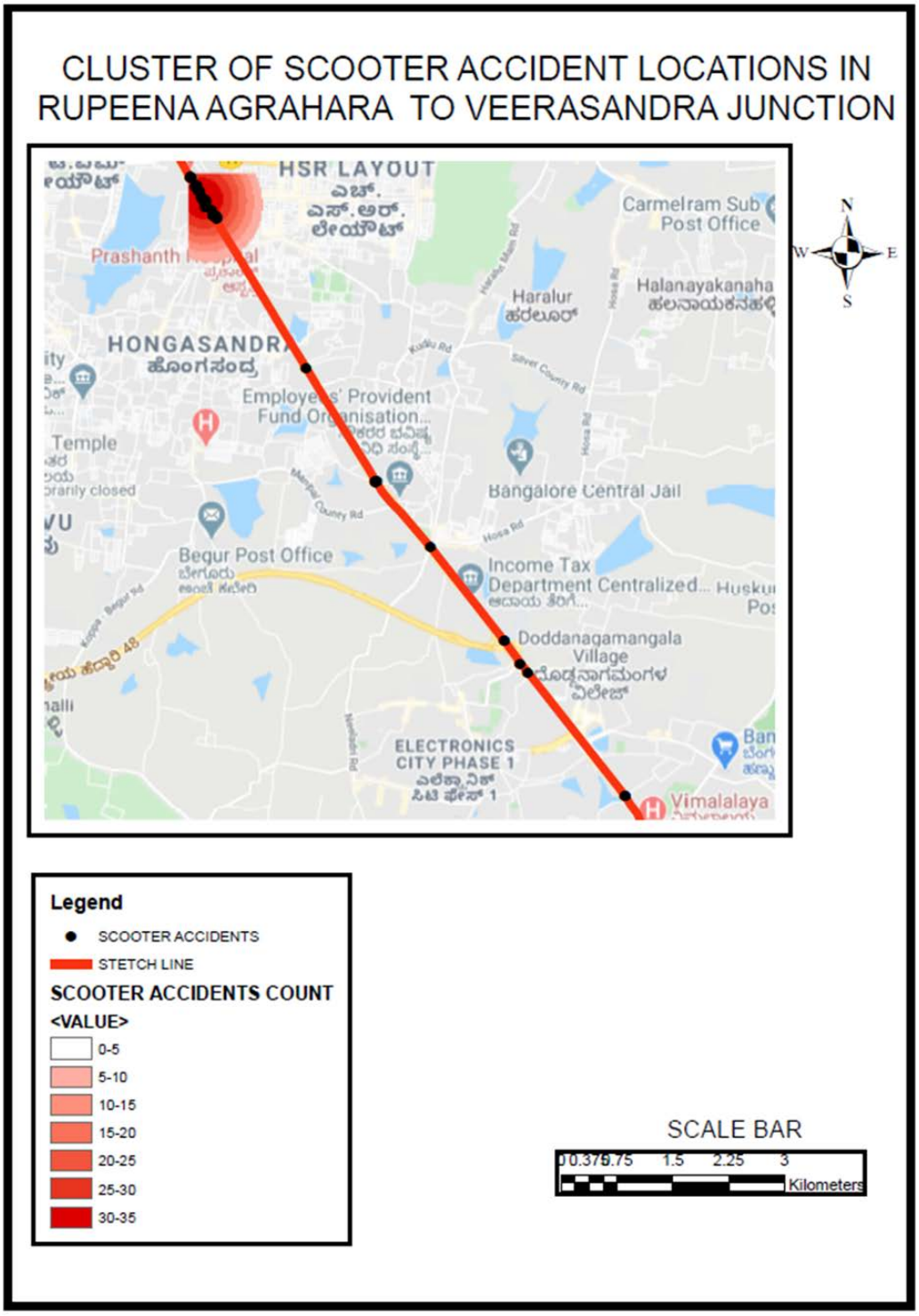


Figure.7: Location of Blackspots on Stretch-1

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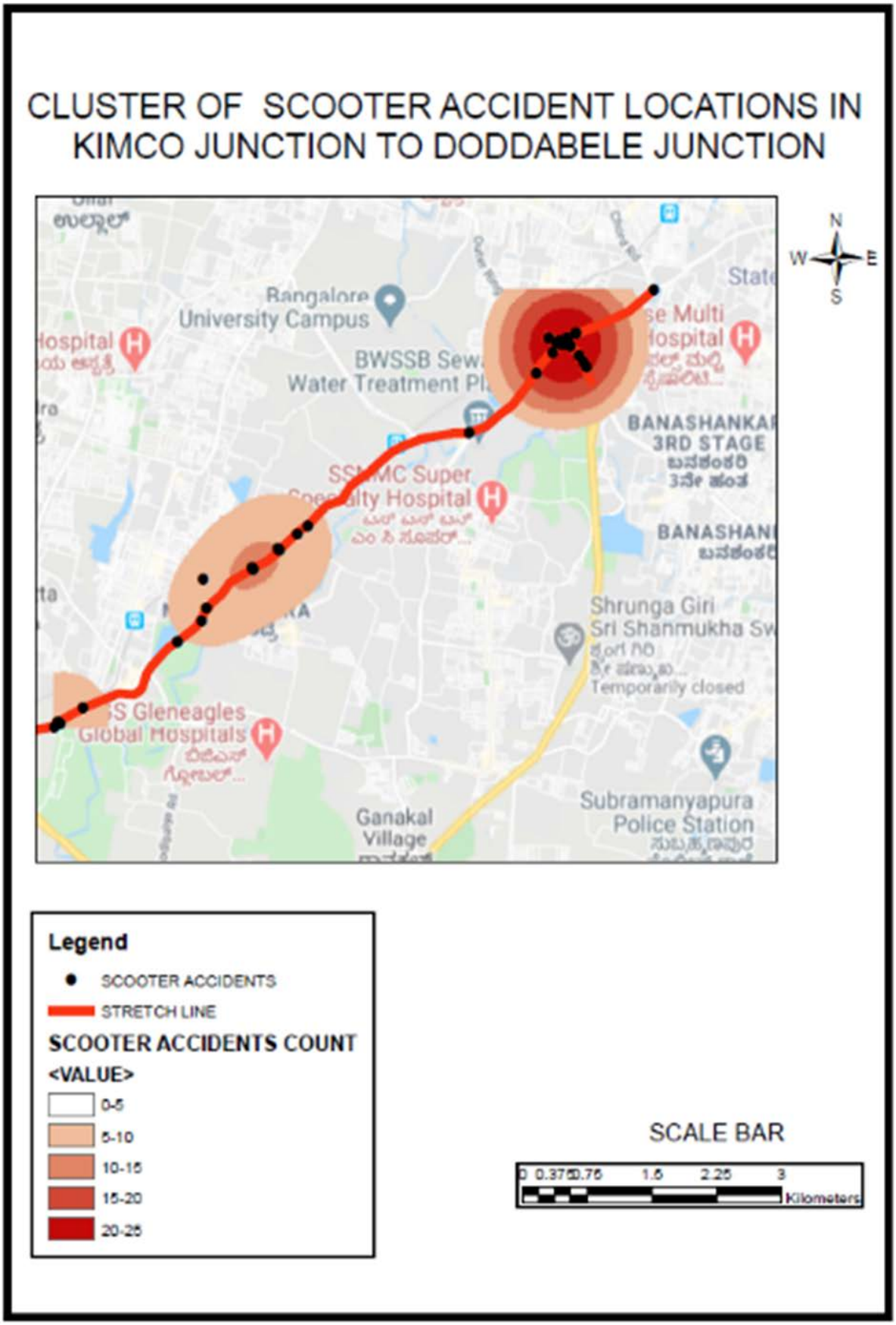


Figure.8: Location of Blackspots on Stretch-2

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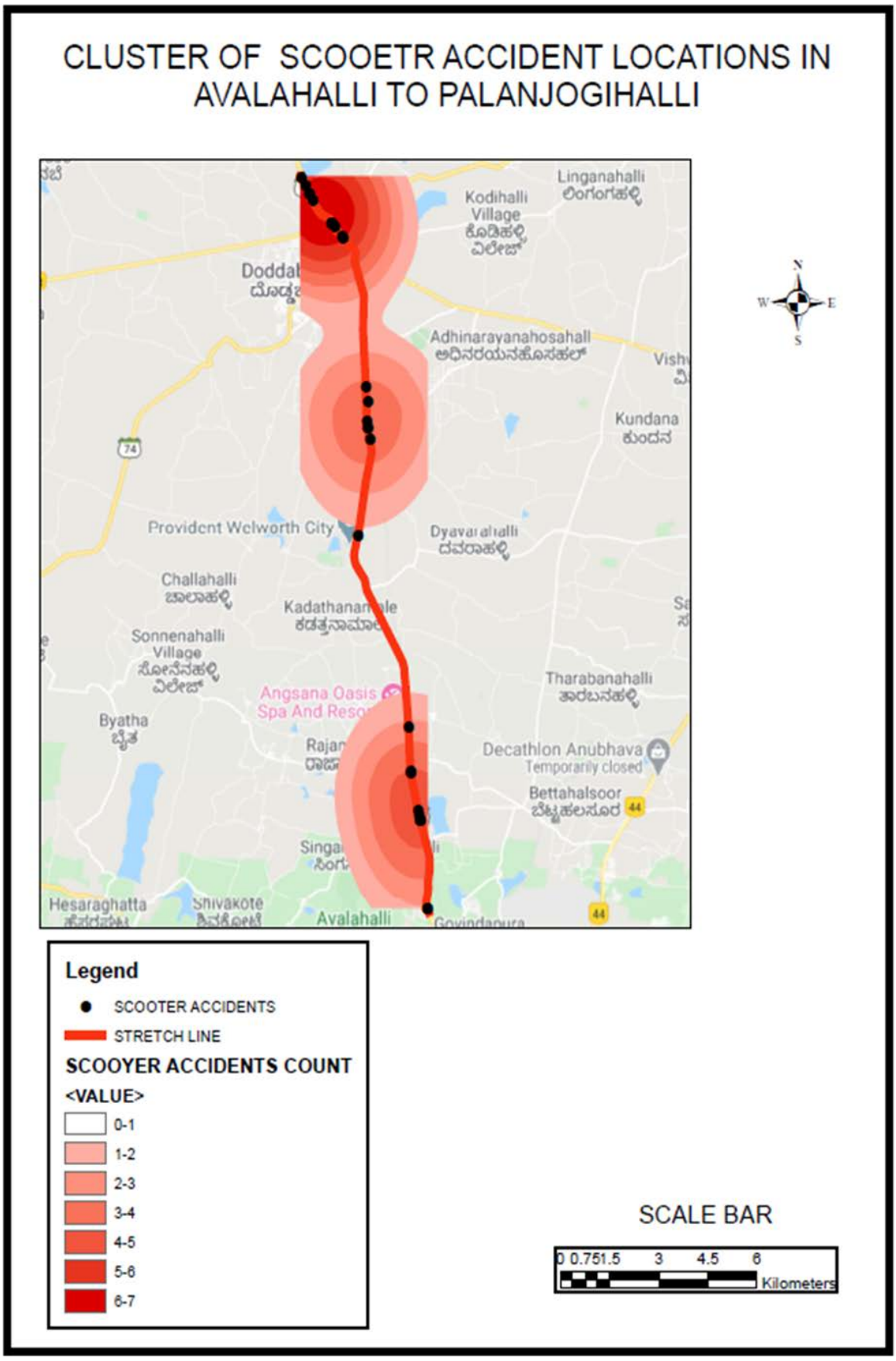


Figure.9: Location of Blackspots on Stretch-3

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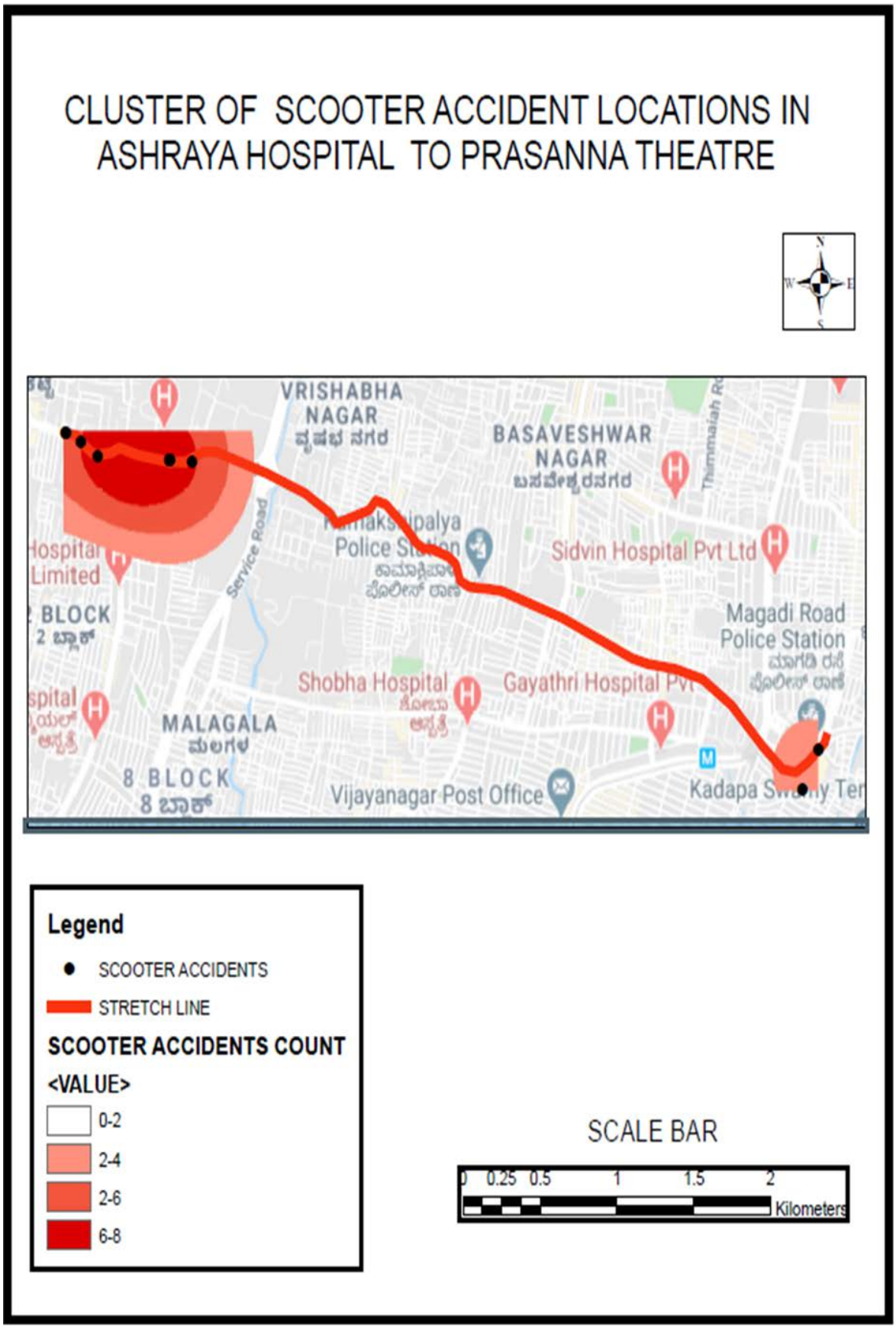


Figure.10: Location of Blackspots on Stretch-4

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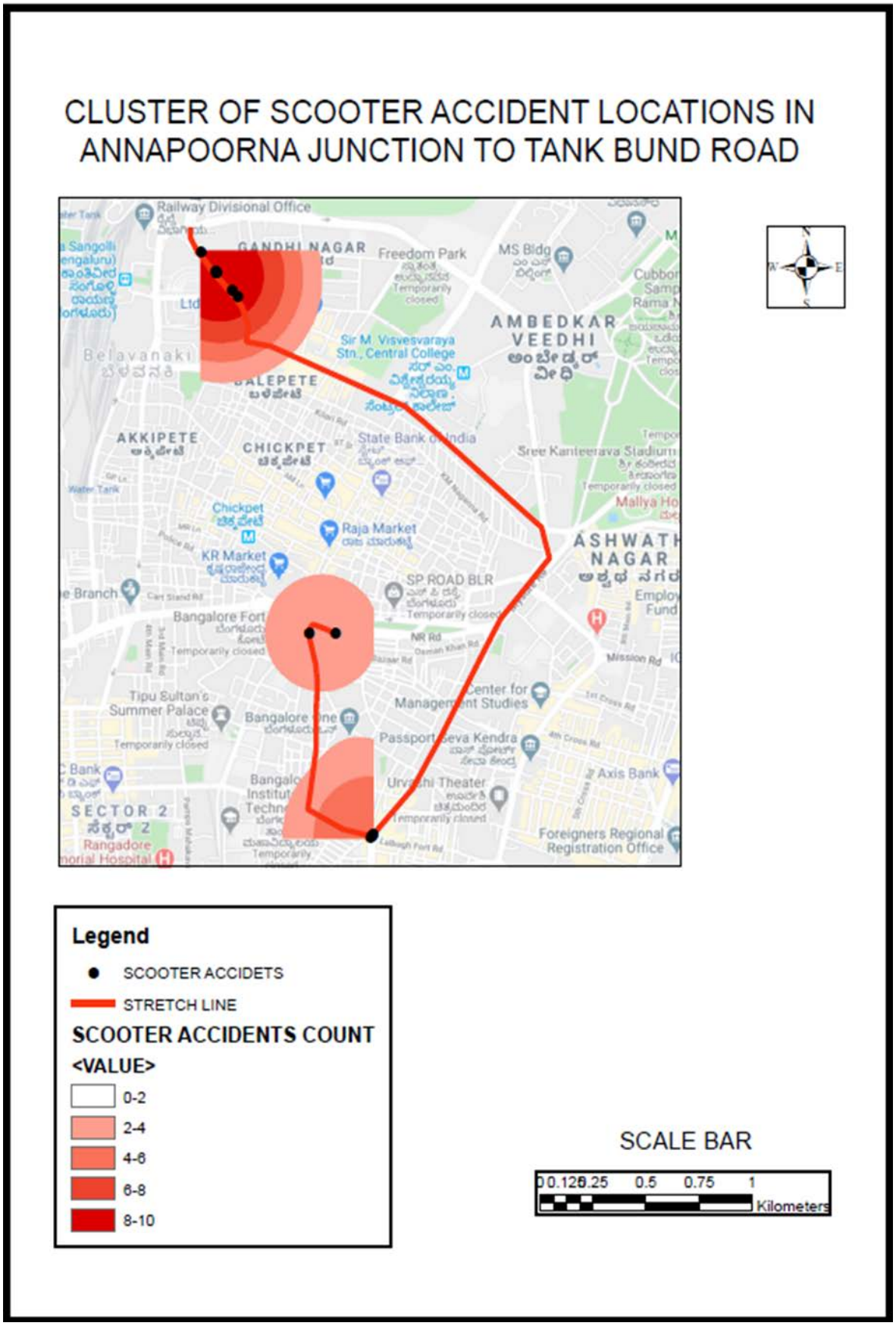


Figure.11: Location of Blackspots on Stretch-5

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SUGGESTION OF COUNTER MEASURES

- A lack of pedestrian crossing facilities was observed on all stretches. So, suitable pedestrian crossing facilities must be provided as per IRC 103-2012.

- Lack of bus bays, lack of shelter at bus stops and location of bus stops in close proximity to intersections were observed. Provide bus bay and shelter. Bus stops must be staggered and located at a distance of 75m away from intersections as per IRC SP 84-2014.

- Poor pavement markings or lack of pavement markings were observed on all stretches. Pavement marking resurfacing must be provided on existing marking surfaces as per IRC 35- 2015.

- Channelizing island should be provided at the turn to reduce conflict between local traffic and through traffic.

- Speed calming measures such as rumble strips or speed breakers must be provided within village limits in Stretch-3. As it is uneconomical to provide separate pedestrian crossing facilities for low pedestrian population levels present in villages.

- Pothole formation was observed on all stretches. Surface layer rectification must be provided on damaged sections present in all stretches.

RESULTS AND CONCLUSION

- It was observed that there are 3 blackspots for two wheelers present in Stretch-1. The stretch also demonstrated the highest number of two-wheeler and car RTAs. The stretch also had the maximum amount of grievous injury victims and the second highest number of minor injury victims and fatalities. Pedestrian collisions and head on collisions were highest along the stretch too. Through analysis, it could be concluded that haphazard pedestrian crossing, movement of two-wheelers in the wrong direction and high operating speed of vehicles were mainly responsible for the RTAs along the stretch. Suitable countermeasures are provided. The stretch also had the highest day time RTA count; this is probably due to high vehicle movement and pedestrian movement due to the commercial

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nature of the locality adjacent to the stretch.

- It was observed that there are 3two-wheeler blackspots present in Stretch-2. The stretch also demonstrated the highest number of HCV RTAs and LCV RTAs. The stretch also had the highest number of minor injury victims. Rear ended collisions and side-swipe collisions were highest along the stretch too. The stretch also demonstrated the highest number of night time RTAs; this is due to poor lighting along certain sections of the stretch.

- Stretch-5 had the highest number of bus RTAs and the stretch also had the highest accident density for all accidents. This was mainly due to the presence of the Kempegowda Bus Terminal adjacent to Tank Bund Road. This created high conflicts between buses and pedestrian crossing traffic.

- Police accounts of RTAs have a high probability of being unreliable as accident circumstances and characteristics are recorded based on biased and inaccurate eye witness accounts. Underreporting of accidents is also a major problem. So, it is highly recommended to install CCTV cameras at recognized accident blackspots to enhance data gathering capabilities and to also encourage better road user behavior.

- Future studies must integrate traffic data such as traffic volume or speed to better understand accident blackspots and their occurrence

- The suggested countermeasures must be applied. Thereafter, a before and after study must be conducted to test the effectiveness of the countermeasures applied.

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