# Accident Hotspot Identification on the Midnapore Kharagpur Development Authority Planning Area.

**Samrin Fatema, Abhisek Chakrabarty**

***Abstract*: Road accidents are a vital problem in our country for various reasons. According to WHO reports, approximately 1.25 million people died each year, and more than 50 million people injured in road accidents all over the world. Road accident is mostly human-made, and it's affecting your life negatively. Regarding, many studies or research has been performed to reduce road accident and identify the accident blackspot. This paper represents a methodology to find out the accident-prone zone, estimation of Kernel Density and black Site & black Spot identification of major roads Medinipur and Kharagpur development Authority (MKDA) planning area using of Geographical Information Systems (GIS). For this study, road accident data collected from Paschim Medinipur Kotwali Police station from 2016 to 2019. A kernel density estimation was created to identify black spots & black sites of the study area. Based on the result, suggestions are provided to improve the situation in the future.***

***Keywords: Hotspot, Black site, GIS, Accident Analysis, Kernel Density.***

## I. INTRODUCTION

The road traffic system is considered as the most complex and most dangerous system with which people have to deal every day. Road accidents are increasing day by day mainly because the pace of development of transportation infrastructure is somewhat less than that of other sectors such as real estates and industries. Road traffic injury is the eighth leading cause of death at the global level. According to the WHO Global Report on Road Safety 2018, India accounts for almost 11% of the accident-related deaths in the World. According to the "Road Accidents in India 2015"(Ministry of Road Transport and Highways), the total number of road accidents increased by 2.5% from 2014 to 2015. Road accident injuries have also increased by 1.4% from 2014 to 2015. According "Road Accidents in India 2018", West Bengal ranked at 11th in the country for total fatal Road Accidents. Geographic Information System (GIS) has made a noticeable impact in detecting road accident hot spots. Spatial attribute combines with statistical analysis presents a superior way to understand traffic accidents. GIS based techniques are relatively simple to use and can convert raw statistical and geographical data into meaningful information for spatial analysis, mapping and for identifying any factors contributing to accidents. GIS has been used for more than thirty years in various fields, but in transportation, it has recently been used. In addition to data and map connectivity, GIS can easily handle numerous types of data for conception. Many researchers have done their research in road accident analysis and provide suggestions to improve the situation in the future. Sandhyavitri and Wiyono, 2017 identified black spots and black sites road within the east cross highway of Sumatra, Ujung Tanjung – Bagan Batu, Indonesia, between 2009 to 2011. They also recommended the appropriate strategy for reducing the accident rates within road section. The road geometry has most important role to control accident. K and Ganeshkumar, 2010 used kernel density to identify the accident-prone zone in Kannur District of Kerala state using geographical information technique. They have used road accident data for the years 2006, 2007 and 2008 and measured road geometry to find out the causes for the accident. For road safety studies Identification of black spot is vital fields. Presently different highway agency and government have taken action to use GIS techniques for analyse accident data. Shad and Rahimi, 2017 used Kernel Density and GIS techniques to identify road crash black-spots including different types traffic crashes data based on their survey. Anchan, Basavaraja and Bhat, 2018 used LISS-III & PAN merged Satellite image and accident data to identify Black Spots through remote sensing and GIS. In the result, the reason of accidents is vehicle over speed, faults of the driver, climatic condition, bad over taking and improper highway design. They recommended suggestion to improve the situation in future. Raut, Nalawade and Kale, 2016 and Ghosh, Parida and Oraon, 2004 identified accident patterns considering spatial-temporal aspects at Dehradun city through GIS. They define the black spot zone yearly, monthly, vehicle type, and accident type wise. This study expresses that proper traffic management is required for future. Gattis, Alguire and Narla, 1996 Concentrate on roadside object effects on accident intensity with the focusing on pavement edge, vehicle weights, and accident severity. From the literature review, we understand that GIS can handle significant data effectiveness. Presently GIS application in black spot analysis has become a trend. However, interest is growing, both in GIS for accident location and analysis and in other non-GIS methods of accounting for the importance of traffic safety throughout the transportation community. In the present study, an effort is made to identify the black spot and black site with the help of remote sensing and Geographical Information System (GIS) based approach.

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This study also emphasizes on accident density with the help of kernel density.

## II. STUDY AREA

Midinapur and Kharagpur Development Authority (MKDA) planning area (Fig 1) has two major parts. One is Midnapore town, and the other is Kharagpur town. The congestion is a common problem in this place of daily life. The infrastructure, such as proper signaling, maintenance and enlargement of the road, is a matter of concern compared to the growing population of this place. Besides, illegal stalls are rapidly growing up beside the road, which has made the daily transportation very complicated. In the same way, the number of automobiles that are primarily responsible for congestion is overgrowing here. In the Midnapore Kharagpur development Authority (MKDA) planning area, there are many conjunction points of the different roads where the traffic signal is not available, and sometimes it doesn't work correctly. On the other hand, reckless driving and breaking traffic rules is a noticeable incident, which has made the accident-prone road zone.

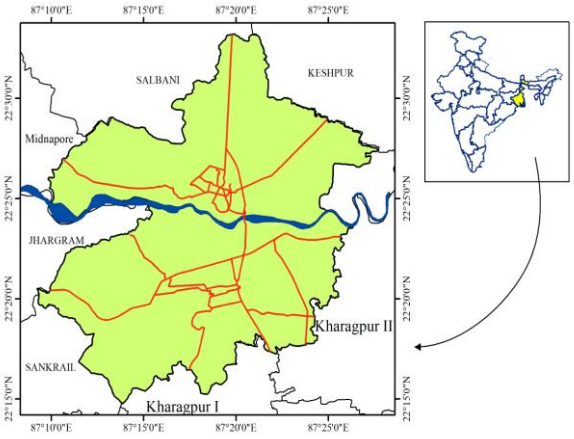



**Figure 1: Location map of the study area**

## III. METHODOLOGY

### A. Kernel Density

Identification of Black-site in GIS environment are including of accident location on maps and the spatial distribution of crash. There are many spatial tools to estimate the accident-prone zone or black sites. The most reliable useful method is Kernel Density Estimation (KDE) (Chaney and Ratcliffe, 2013). It has many advantages over clustering mean such as K-techniques. The main advantage can define the extent of risk, and it describes the cause of the crash, which increases the chance of events. On the other hand, the kernel density can determine the spatial distribution of the incident. It produces an equable region from each incident point and calculates the distance from every point to the reference location using a mathematical algorithm, then summing the value for all areas, including where the incident didn't happen. This process is repeated for successive points. (Sun et al., 2012). This process allows to deploy the kernel of each event, and the sum of these individual kernels gives the density estimate for the distribution of road crashes. (Fotheringham et al., 2000). Density is measured in two ways, simple and kernel (Anderson. 2009). The Kernel density applied on point distribution on a surface, and the linear kernel method estimate is used for the point density on a linear unit (Fotheringham et al., 2000).

$$D(a,b) = \frac{1}{ns^2}\sum_{i=1}^{n} k\binom{di}{s}$$

Where,

$D$ (a, b) = Density estimation at the location (a, b).

n = number of events.

s = size of kernel

k = kernel function

$d_i$ = distance between the location (a, b)

$i$ = the location of the $i^{th}$ event.

The kernel method draws a circular neighbourhood around each incident point, instead of contemplating a circular zone around each cell like the simple method. Then a mathematical equation is used that goes from 1 at the position of the feature point to 0 at the neighbourhood boundary (Bailey and Gatrell, 1995) (Fig.2).

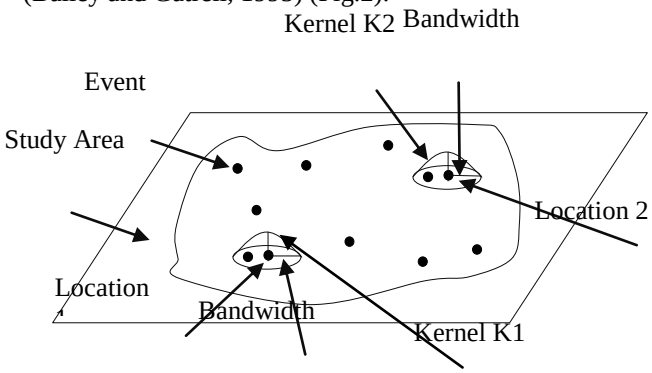



**Fig.2: Sketch of Kernel Density Method which is Employed in GIS Processing for this Research Source:(Bailey and Gatrell, 1995)**

### B. Accident Datasets and Map Preparation

This study utilized ESRI's Arc GIS 10.3 for analysis. The digital road map of Medinipur and Kharagpur Development Authority (MKDA) was imported in Arc Map and saved as a roads layer from Google earth. Imported digital map and data frame of Arc Map needed to have the same 'projected coordinate system. The coordinate system used for the present work is WGS 1984 UTM ZONE 45. The four years (2016-2019) accident data of study area were collected from Medinipur S.P office. The accidents locations were geocoded by giving X and Y coordinates to each location. For every geocoded point, a Feature Identity (FID)in a form of whole number is automatically created on GIS. Every point was attributed with detailed information such as type, landmark, date, time, vehicle type etc.

**Death Rate & Injuries Rate Analysis**

The ratio of total deaths to total population in a specified community or area over a specified period of time; often expressed as the number of deaths per 1,000/100 of the population per year.

$$DR = \frac{N_d}{N_a} \times 100$$

Where,
DR= Death Rate
Da = Number of deaths
Na = Number of Accident.

$$R = \frac{I_p}{N_a} \times 100$$

Where,
IR= Injuries Rate
Ip = Number of Injured persons,
Na = Number of Accident.

### C. Black Sites and Black Spots

A hazardous road or accidental road is comprised of three parameters. Which are hazardous routes/roads, hazardous sites (black sites), and hazardous spot (black spots) (Pusdiklat Perhubungan Darat, 1998).

**Black sites**

Black site is defined as a dangerous road section located within the hazardous road zones. The total length of the road was 185 km within the study. Abd. Kudus, 1995, stated that the black site has a numerical criteria of accident rate >0.003. However, the threshold level of accident rate is arguable, at some point the accident-prone sites (black site location) were found consistent for a certain road (Edisontoni, 2012). The following formula calculates the black site vulnerability value.

$$BS_i = \frac{A_{ac} \times 1000000}{TR \times 365}$$

Where,
BSi = Black Site [Accident rate in million accident per one million vehicles per kilo meter (accident/1,000,000 vehicles/km)]
Aac = Annual accident count
TR = traffic volume x road length

**Black Spots**

A black spot area is defined as a road section or route location where the traffic accidents have historically been concentrated (Homburger, Carter, E.C, 1978). The specific length of the black spot area is also arguable. According to Abd. Kudus, 1995, the black spot basic vulnerability value criterion in Riau Province was 0.736. Edisontoni, 2012 calculated the black spot vulnerability value (no dimension) may use the following formula

$$BS_p = \frac{A_{ac} \times 1000000}{Tv \times 365}$$

Where
BSp = Black spot (Accident rate)
Aac = Annual accident count
Tv = traffic volume.

## IV. RESULT AND DISCUSSION

### A. Kernel Density

It is a spatial analyst Method. Kernel Density Estimation (KDE) method was used for calculating the accident density within the study area. This method divided the whole study area into default number cells and applied a circular neighbourhood around each incident. Since it is a spatial analysis method, so it measures cell densities in a raster by using a sample of known points. This process can be expressed as a bivariate probability density function, a kernel function looks like a "bump," cantering at a known location and tapering off to 0 over a defined bandwidth or window area (Raut, Nalawade and Kale, 2016). Kernel Density Estimation shows the smoothing effect and can be applied only on the Points and Polylines. In this study, we found out the four years kernel density from 2016 to 2019 (Fig3). The density is detected in dark red colour for the accident location. From the results, we can see from 2016 to 2019 the accidental amount has been decreased.

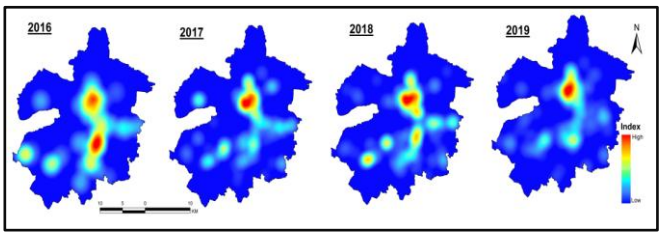
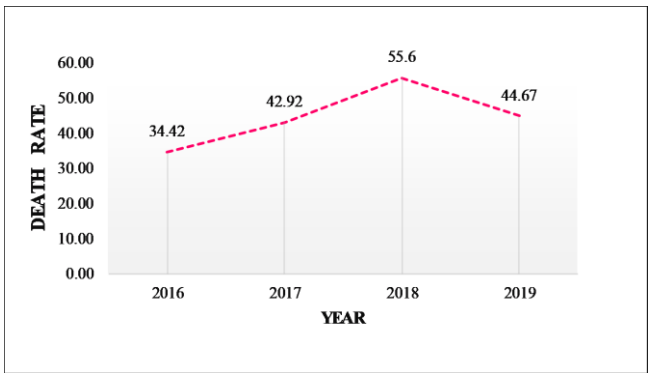



**Fig.3 - The Accident density identified by KDE Method**

**Table 1. The number of traffic accidents within MKDA planning area**

| Year | Occurrences | Victims (persons) | | |
|---|---|---|---|---|
| | | Fatal | Injury | Grievous Injury |
| 2016 | 215 | 74 | 174 | 38 |
| 2017 | 233 | 100 | 169 | 45 |
| 2018 | 250 | 139 | 182 | 63 |
| 2019 | 150 | 67 | 121 | 36 |


**Fig.4: Accident Based on Victims Conditions**



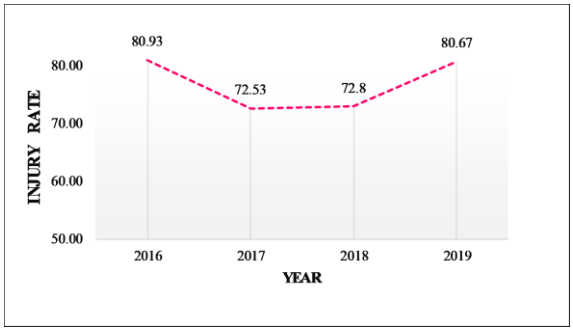



**Fig.5: Death rate and Injury rate of the study area.**

### Black Sites

In this research, we had identified the black site zone within the study road. Total twenty-six roads we analysed. Based on the black site vulnerability rate, these roads are classified into five categories that are very low, low, moderate, high, and very high (Fig 6). The very high black site was located at the national highway six (NH-6) section from Lachmapur to Guptamoni (within the study area). A total of 138 numbers incident happened from 2016 to 2019. The traffic volume of this road is 2649/per hour. It identified that the vulnerability value for this black site 0.62. Hence, based on this result, it was determined that this road section classified as a black site zone (Fig 7). From this study, other major roads also identified as another black site zone, which is NH-60 and Old Trunk road (OT road), that the vulnerability value for these black sites is 0.30 and 0.31.

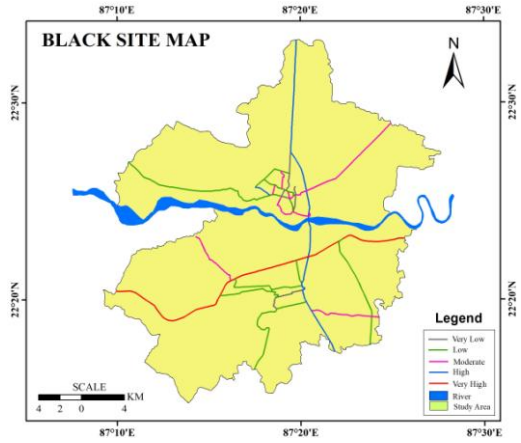



**Fig.6: Black site Map of the MKDA planning area**

(a)

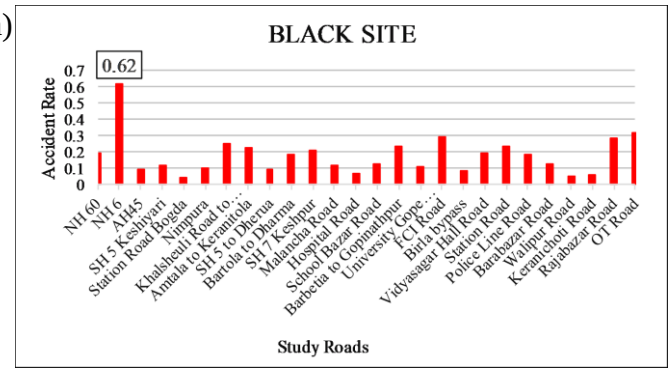



**Fig.7: Black site rate of the study roads**

### Black Spots

The black spot area defines a road part or section where traffic accidents have the previous record. In this research, study roads(twenty-six) are categorized into five classes, that's is very low, low, moderate, high, and very high (Fig 8) based on the black spot vulnerability rate. In the black site analysis, we had seen the National Highway six (NH-6) marked as a very high black site zone (Fig 7). But in black spot analysis, we found out the National Highway sixty (NH-60) has the highest accident spot (Fig 9c, d).

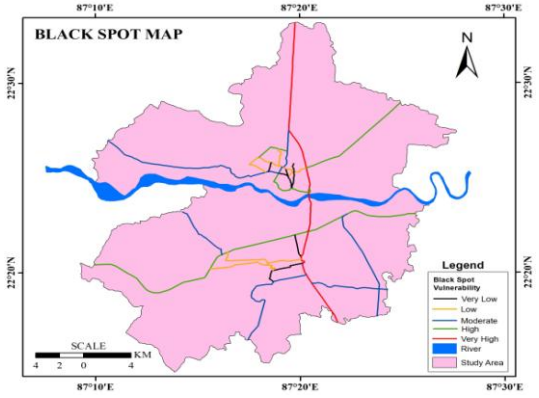



**Fig.8: Black spot Map of the MKDA planning area**

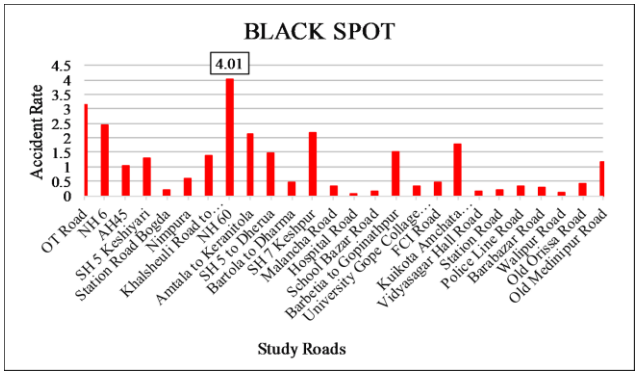
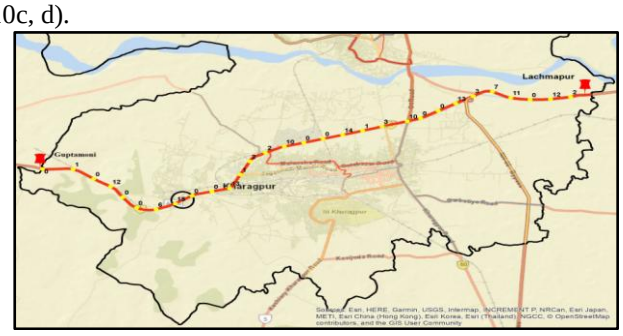
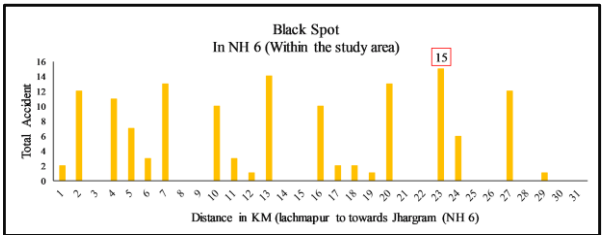



**Fig.9: Black spot rate of the study roads**

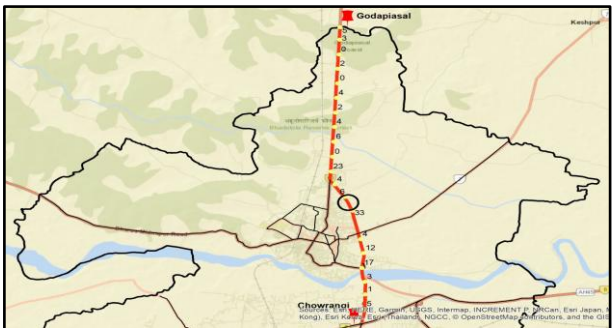
In the case of NH-6, we find that 15 of the 138 accidents occurred at the same location between 2016 to 2019, which is located between the Kalaikunda and Poradiha Bus Stoppage (Fig 10a, b). The NH-60 has two routes within the study area one is Chowrangi to Godapiasal, another is Chowrangi to Benapur. From Chowrangi to Godapiasal (NH-60) route, the total number of 134 accidents occurred, but 33 events happened at the same point in the period of 2016-2019. It is located between Dharma and Keranichoti bus stoppage (Fig 10c, d).



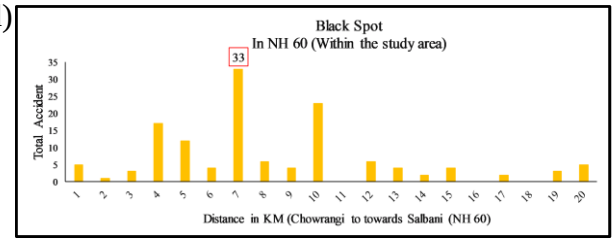
(b)



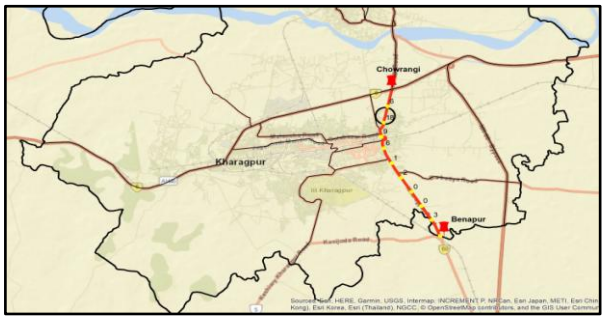

(c)




(d)




(e)




(f)

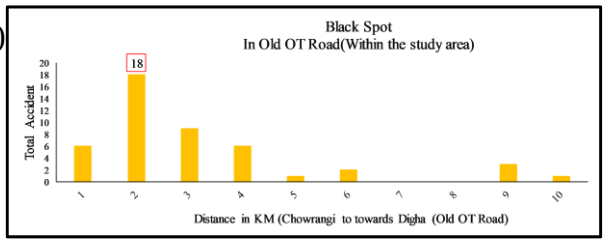



**Fig.10: Black spot identification: (a) NH-6 (c) NH-60 (e) OT road (NH-60), Total accident each KM distance: (b) NH-6 (d) NH-60 (f) OT road (NH-60).**

On the other hand, Chowrangi to Benapur (NH-60) route, 46 accident cases occurred between 2016 and 2019. But 18 incidents happened in the same road section, which is located between LIC more and Inda Collage More bus stoppage (Fig 10e, f). Hence, based on this result, it was determined that Chowrangi to Godapiasal (NH-60) road section classified as a black spot zone within the study area.

## V. CONCLUSION

The study was an attempt to find out the most vulnerable accident locations in the Midnapore Kharagpur Development Authority (MKDA) planning area using GIS techniques. A total of twenty-six roads are selected for the study, in which national highway, state highway, and district roads are included. The Black Spot Analysis method (Edisontoni, 2012) was used to find the accident locations. Based on the analysis, National Highway six (NH-6) and sixty (NH-60) were identified as the most vulnerable accident locations. From 2016 to 2019, out of a total of 848 accidents, 318 incidents have happened between the two roads. The highest black spot was found at National Highway sixty (NH-60), where 33 events happened at the same road parts in the period of 2016-2019. The black spot vulnerable value of this road is 4.01. The method is considered to be useful in identifying the black spots from sufficient secondary data. In addition to this study, were used kernel density to find out the accident density. From 2016 to 2019, Highest density has been found in the western part of Midnapore town, where NH-60 passes through. In this study, we also found another highest density where NH-6 passes, but from 2016 to 2019, this accident density decreasing slowly. The low density was found in the rest of the study area.

## VI. RECOMMENDATIONS

In this study, we had used GIS techniques, which is a powerful tool that allows updating geospatial data at any time. It can store, analyse, and retrieve the bulk of geospatial data. Therefore, it is here recommended that the local authority and other stakeholders use GIS technology for road transport service. From the primary survey, we found out many problems such as parking, traffic signal, travel time, vehicle speed, vehicle type, footpath stall, pedestrian, etc. The local authority should take action to improve transportation management; some roads needed parking zones, such as the "city centre" of both municipalities. Also, some areas should be restricted in the pick hour, the heavy vehicle should be prohibited, and other times they should decrease their speed. The most important things about the study roads are "Road width," which is very narrow in the city centre. The local authority should increase it or take other action to provide alternative routes or built flyovers. For the pedestrian, footpath should be constructed to avoid road accidents. Presently the state government has taken steps named "Safe Drive, Save Life" to curb accidents and road fatalities (Transport Department Government of West Bengal, 2016).

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