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Evaluation of accident black spots on roads using geoinformatics tools in Kozhikode district, Kerala

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Abstract: Road network are the life line for the movement of people and freight and plays an important role in the development of a region but road accidents cause heavy burden on financial and social setup of an economy. According to a WHO report, road accidents will become the fifth leading cause of death by 2030. Despite lot of effort from various agencies in curbing traffic accidents, they are on the rise in developed country in general and developing countries in particular. The locations in a road stretch where higher number of road accidents occur during three years are called Black Spots. Kozhikode district has registered maximum number of accidents as per a study conducted by the Kerala Road Safety Authority. The present study attempts to identify the most vulnerable accident black spots in Kozhikode district in Kerala state. The study utilized the secondary accident data for the past three years for the study area and accident prone locations were prioritized using Weighted Severity Index (WSI) method. Ten black spots (five each in rural area and urban area) were identified using WSI method. Detailed GIS based analysis taking road and traffic data collected from the ten accident spots were performed and the most vulnerable spots were identified. The study attempts to find out the causative factors for accident and suggests measures to prevent accidents in future.

Keywords: Accident black spots, GIS, GPS, Weighted Severity Index (WSI), Passenger Car Units (PCU), Average Daily Traffic (ADT)

1. Introduction

Traffic accidents are a major cause of death and injuries worldwide. Yearly 1.2 million people are killed and more than 50 million injured in road traffic accidents over the world (WHO, 2009). In India, nearly 8 lakh accidents (1.5 road accident every minute) take place, resulting in death of over 1.5 lakh people (one road accident death every 4 minutes) and causing injuries to another 10 lakh persons. In Kerala, the scenario is not different; there were 4,196 deaths and 43,735 injuries in a total of 39,014 accidents in the year 2015 (Kerala Police, 2015). Traffic accidents result in huge economic loss of about Rs 15,000 crores per year to the country, besides pain, grief and suffering caused to the families of the victims (Pillai and Joseph, 2011). To reduce the accident rates effectively, it is essential to concentrate on measures which improve the road safety and hence reduce the number of accidents and accident severity in particular. The identification, analysis and treatment of road accident black spots are widely regarded as one of the most effective approaches to road accident prevention. Traditional identification methods for accident prone locations are purely based on accident data reported by police. Important information such as the land categories, population density, roadway features, traffic characteristics and geographical characteristics in accident sites are not taken into consideration for analysis. GIS plays an important role in improving accident analysis process taking into consideration other important parameters including traffic and road conditions for efficient decision making.

Geographic Information System (GIS) is a specific integrated system of hardware, software and analysis tools designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. In a general sense, GIS is a tool which has been employed for integration of spatial and non-spatial data. GIS applications allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. GIS is used in almost all fields of studies, with users ranging from communities, research institutions, environmental scientists, health organisations, land use planners, businesses and government agencies at all levels.

2. Literature review

Highway agencies world over are using Geographic Information System (GIS) for analyzing accident data. Identification of problematic locations on roads is one of the most important elements in accident studies. A brief review of literature on the methodology followed for accident black spot identification and applicability

of GIS in accident investigation are summarized below.

Srinivasan et al., (1987) developed a scientific method for the identification and improvement of accident prone locations on national highways (NHs) in Kerala. Three methods were used in their study to identify the black spots viz., Quantum of accident method, Accident Prone Index (API) method and Weighted Severity Index (WSI) method. The study concluded that WSI method was most suitable in identifying black spots.

Mandloi and Gupta (2003) proposed a model to identify black spots on roads using GIS. A set of road and traffic parameters were used to find out accident-prone locations. Vulnerability of road for accident occurrence was carried out by considering different weights for different parameters and total weight was determined and accident spots were prioritized.

Deepthi and Ganeshkumar (2008) applied density function in the spatial analyst extension of the ArcGIS software to identify the accident prone areas in Kannur district. Both simple and Kernel densities were applied on three years' accident data in identifying the accident patterns. Based on the result, suggestions were provided to reduce the accidents in the future. Reshma and Sheikh (2012) prioritized the major accident spots or black spots in South Bangalore by assigning possible weights for various accident components using GIS. Nagarajan and Cefil (2012) used remote sensing and GIS to identify and analyze the black spots in Tambaram to Chengalpet stretch of NH - 45. The study used IKNOS images and GIS to identify eleven major accident locations. Liyamol et al. (2013) analysed the three years' accident data for Alappuzha district and applied WSI method to prioritize black spots in the study area. Further evaluation and analysis of the black spots were done using GIS software. Vyas et al. (2014), applied weighted severity index and GIS to identify black spots on SH-85 from Tavarekere to Magadi town in Karnataka State. WSI method was applied to locate accident black spots and GIS Software was used to analyze and prioritize black spots.

3. Scope and objectives

The main objectives of the study are

- To find out different methods to prioritize hazardous locations in the road stretch.
- To identify various traffic and road related factors causing accidents.
- To ascertain the accident black spots using GIS in the study area from data collected from field survey.
- Detailed analysis of the top ranked spots and suggest best suited improvement measures for each black spots identified.

4. Study area

Kozhikode district is taken up for the present study. The district is situated between latitudes of 11° 08' N and 11° 50' N and longitudes of 75° 30' E and 76° 8' E (Figure 1). It has an area of 2344 km2 and is bordered by the districts of Kannur to the north, Wayanad to the east, Malappuram to the south and Arabian Sea to its west. Kozhikode district has good connectivity within the district and to other parts of the country. The nearest airport - Karipur International Airport - is located 30km away from the Kozhikode city. Road network is the prime mode of transport, three National Highways NH-66, NH-766 and NH 966 pass through the district along with other State Highways and PWD roads.

The previous accident statistics of the district illustrates the need for detailed accident investigation. All National Highways (NH), State Highways (SH) and Other District Roads (ODR) running through the district were considered for accident black spot identification.

5. Methodology

The steps involved in the methodology, based on WSI and GIS, and used in the present study are explained as under:

5.1 Data collection

Primary and secondary data were collected for the study. Secondary data includes the collection of required accident data for the past three years from the concerned police department and Kerala Crime Records Bureau. Primary data collection includes road inventory data, traffic volume count, speed and delay study and spot speed survey from the identified accident prone stretches. Coordinate values for all the locations were determined using handheld GPS (Figure 2).

5.2 Analysis of secondary data using WSI method

Three years' accident data (secondary data) for Kozhikode district were analyzed to obtain the ten most accident prone locations (five each in urban and rural areas) using WSI method by assigning scores based on the number and severity of accidents at that particular location in the last 3 years (Table 1).

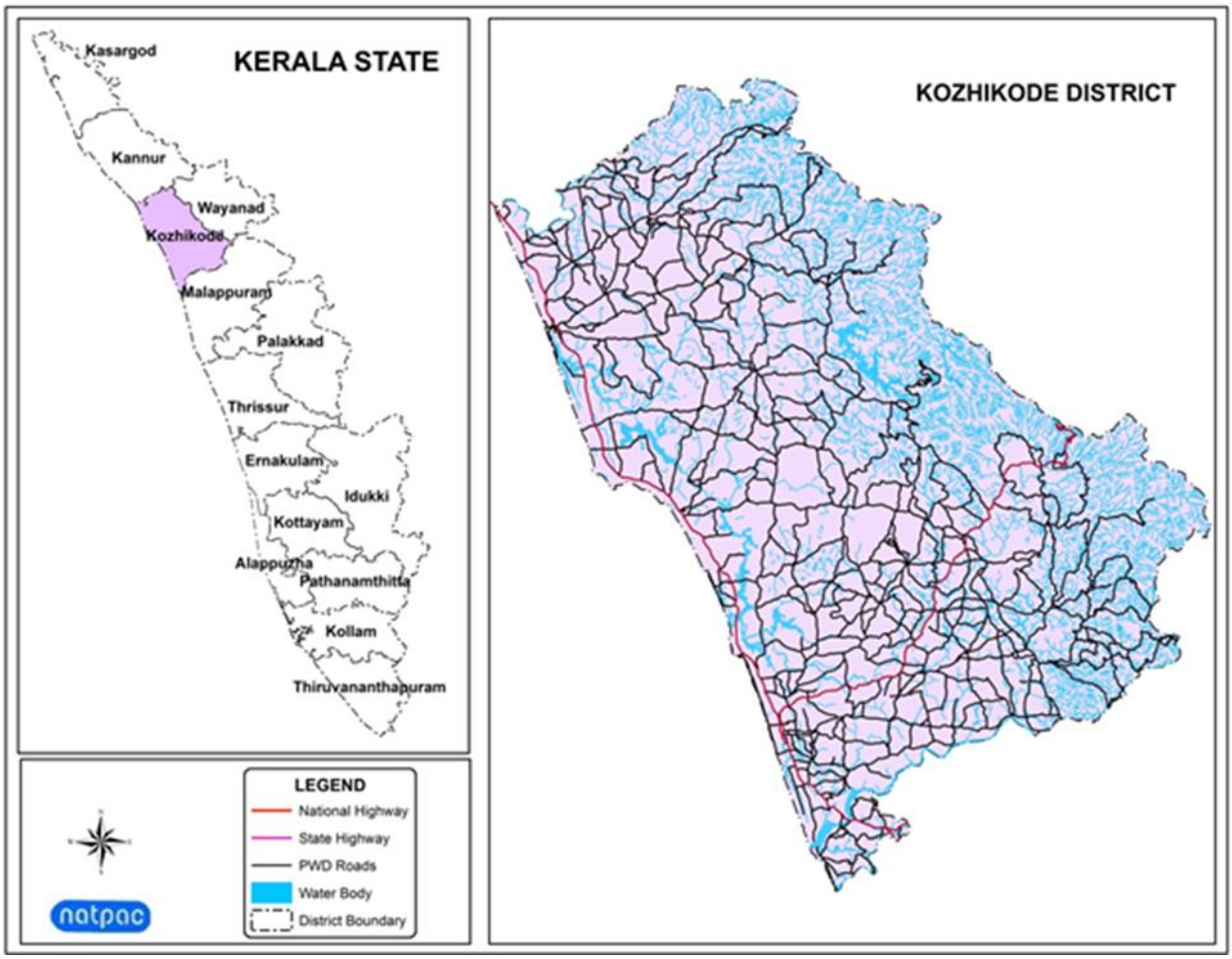

Figure 1: Location map of study area

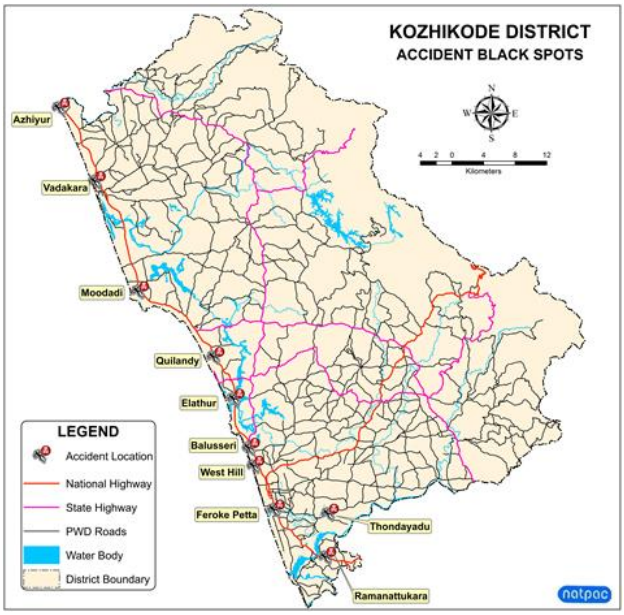

Figure 2: Accident location map of the study area

Weighted Severity Index (WSI),

$$WSI = (41 \times K) + (4 \times GI) + (1 \times MI) \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where, K is the number of persons killed; GI is the number of grievous injuries; and MI is the number of minor injuries.

Table 1: Top ranked accident spots

Place	Location	WSI value
Ramanattukara	Urban	1356
Feroke Petta	Urban	1040
Thondayadu	Urban	856
West Hill	Urban	545
Elathur	Urban	449
Quilandy	Rural	1334
Vadakara	Rural	584
Balusserry	Rural	566
Moodadi	Rural	549
Azhiyoor	Rural	495

5.3 Analysis of the primary data

Road inventory study, traffic volume count, speed and delay study along with coordinate recording using GPS were conducted at the above identified accident vulnerable spots for GIS based analysis.

5.3.1 Road inventory survey: Road inventory survey was carried out on the entire identified accident spots to measure the roadway geometric parameters like the roadway width, footpath width, median, shoulders, surface type, surface condition, edge obstruction, road markings, road signs, drainage facilities and adjoining land use.

Out of the ten study stretches, eight are National Highways, one is State Highway and one is PWD road. It was observed from survey that the carriageway width is insufficient in all the stretches to accommodate large heterogeneous traffic during the peak hours. Lack of median and insufficient shoulder width creates head on collision. Absence of foot path and illegally parked vehicles on the shoulders increases pedestrian accidents during night time. Smooth bituminous surfaces and insufficient drainage facilities result in skidding during the rainy season.

5.3.2 Traffic volume count: Four hour continuous traffic volume survey were carried out at ten spots in the district from 8.00 am to 12.00 noon to find out the number of vehicles passing through the spots during peak hour. Most of the traffic in this stretch comprises trucks carrying consumer goods, construction materials, container trucks and passenger vehicles. The peak hour traffic volume in terms of Passenger Car Units (PCU) ranges from 1000 PCU to 3000 PCU (Figure 3) at various accident locations.

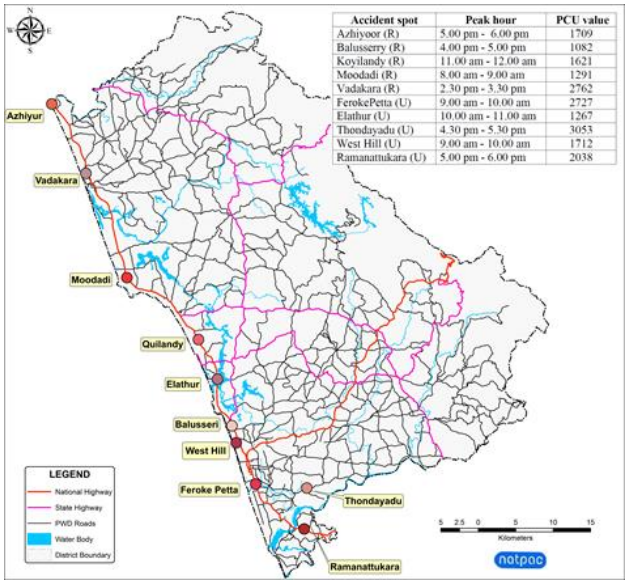

Figure 3: PCU value for identified accident spots

5.3.3 Speed and delay study: The speed and delay study was carried out by using moving observer method on entire identified accident spots to find out the average journey speed and delay of the traffic stream. It is impossible to conduct this study in a spot using the above method. So, stretches having 2 *km* length including identified accident spots (1 *km* length in each direction from the spot) were selected. During the study, time taken for each journey and time for delay were noted and the journey speed was calculated. The 'journey speed with delay is obtained by considering both running time and delay time of the moving car. The 'journey speed without delay' is obtained only by considering the running time of the moving car and it indicates the speed of the vehicle if there is no delay.

5.4 Analysis of identified black spots using GIS

Road network map along with attribute data pertaining to the study area were created in ArcGIS environment. Top ten accident spots derived from weighted severity (WSI) method were prioritized in GIS, to obtain the most vulnerable accident spots in the study area.

5.4.1 Prioritization: Prioritization involves assigning suitable weights to different factors so as to achieve a desired result. In this prioritization model, various factors, which tend to influence the occurrence of accidents on roads, are assigned weights on a particular scale in such a manner that the factors which tend to increase the probability of the accidents have lower weights (Table 2).

Table 2: Prioritization of accident black spots (GIS)

Factors	Possible variation	Weights assigned
No. of lanes in each direction	1 2 4	2 6 10
Width of Road (Carriageway)	< 6 m 6 – 8 m 8 – 10 m 10 – 12 m > 12 m	1 3 5 7 10
Type of Road	NH SH PWD Other Roads	1 4 8 10
Surface Type	Bituminous Concrete	4 10
Surface Condition	Good Fair Poor	10 6 1
Drainage Facility	Good Satisfactory Poor No Drainage	10 6 2 1
Vehicle Type	Heavy Vehicle Bus/Truck Car Two Wheelers	10 8 4 1
No. of Vehicles per Day	<10000 1000 - 30000 30000 -50000 > 50000	10 7 4 1
Shoulders	Paved Unpaved No	10 6 1
Edge Obstruction	Yes No	4 10
Median	Yes No	10 4

The final weight (Eq. 2), assigned to each road link is obtained by adding all the individual weights and normalizing the value using maximum weight. The maximum weight assigned in this case is 110.

Total weight = (Σ Individual Weights) x 100 / 110 …(2)

The classification of roads for occurrence of accidents is based on the final weights obtained by using Eq. 2. The road links with low final weight is considered as highly accident prone stretch (Table 3).

Table 3: Prioritization scheme

Final weight	Accident level
>60	Very Low
50 – 60	Low
40 – 50	Medium
0 – 40	High

6. Results and discussion

The values of the various road and traffic contributing to accidents were collected from the top ranked accident black spots based on WSI method and GIS analysis were carried out. The most vulnerable accident black spot stretch identified in GIS analysis are Elathur in Kozhikode urban area and Moodadi in Kozhikode rural area (Table 4). Over speeding of vehicles mainly causes accidents in these stretches (Figure 4). It is not considered in the prioritization scheme, but it was observed as the leading cause of accidents in these spots. Spot speed of vehicles passing through these study stretches exceed the permissible speed limit suggested by the Kozhikode traffic police.

It is essential to develop certain measures to mitigate the circumstances leading to the accidents in future. The measures suggested for the improvement of the above two most vulnerable black are explained below.

Elathur is a town which is recently added to Kozhikode Corporation. It is located about 12 km north of Calicut city on the Calicut-Kannur National Highway 17. The identified accident spot is a curved stretch having necessary lane width and shoulders. Undulating terrain combined with steep curves make this zone accident prone. The tendency of drivers to increase speed in these portions has resulted in fatal traffic accidents.

Figure 4: Location of vulnerable accident black spots

Table 4: Parameter values for accident locations surveyed

Accident Locations	No. of lanes in each direction	Width of Road (Carriageway)	Type of Road	Surface Type	Surface Condition	Drainage Facility	Vehicle Type	No. of Vehicles per Day	Shoulder	Edge Obstruction	Median	Total Weight
Ramanattukara	6	5	1	4	1	6	1	4	6	10	10	49
Feroke Petta	6	5	1	4	1	6	1	4	6	10	4	44
Thondayadu	6	5	8	4	6	10	1	7	6	10	10	66
West Hill	6	5	1	4	10	6	1	4	6	10	10	57
Elathur	6	3	1	4	1	1	1	4	1	10	4	33
Quilandy	6	5	1	4	1	2	1	4	6	10	4	40
Vadakara	6	5	1	4	1	2	1	4	6	10	4	40
Balusserry	6	5	1	4	6	6	1	4	6	10	4	48
Moodadi	6	3	1	4	1	1	1	4	6	4	4	32
Azhiyoor	6	5	1	4	10	6	1	4	6	10	10	57

The suggestions for improvement of Elathur zone are given below:

1. As per IRC 86 – 1983, median should be avoided where there are significant tidal flows of traffic and intense roadside development without frontage to roads. Both these conditions prevail in the area. It is therefore recommended, as a short terms measure, to provide median markings. As and when the road widening is implemented in the section four lane divided carriageway with 5 m median should be implemented.
2. This accident location lacks adequate shoulder width, as can be noticed in table 4, owing to which the location becomes vulnerable for accidents. It is therefore required to give a minimum paved shoulder width of 1.5 meters as per IRC standard.
3. Traffic calming measures should be adopted on the main road and vehicle traffic on side roads should be controlled.
4. Change the alignment of road on horizontal curves to enhance adequate sight distance.
5. Take suitable enforcement measures to reduce the speed of vehicles.
6. Provide adequate drainage facility.
7. Sign boards invisible to road users should be made visible.

Moodadi is situated in Quilandy taluk of Kozhikode district. Insufficient carriageway width, insufficient sight distance on the horizontal curves, over speed of motor cycles, drainage facilities, road markings, unscientific placement of bus stops etc. are the flaws identified in this stretch. The 85^{th} percentile speed of vehicles passing through this stretch divulge that most of the vehicle are over speeding in this stretch. The region has volume-to-capacity ratio (v/c) of 1.00 indicating the roadway facility is operating at its full capacity.

The suggestions for improvement of Moodadi stretch are given below:

1. Provide sufficient roadway width of 9 m (As per IRC: 73 – 1980) and paved shoulders of 1.5 m width on both sides of the roads.
2. As can be seen from the table 4, this location has edge obstruction therefore proper markings and signs should be provided on them example electric posts and other hazards present very close to the carriageway.
3. Provide separate bus bays for avoiding delay of other vehicles at the bus stops.
4. Provide necessary road signs and markings. Increase the number of lanes from two lanes to four lanes.
5. Provide footpath on both sides of the road for the safety of pedestrians.
6. Provide adequate drainage facility.
7. Take suitable enforcement measures to reduce the speed of vehicles.

Conclusion

The current study was aimed to identify, evaluate and improve the accident black spots in Kozhikode district making use of Weighted Severity Index method, Geographic Information System and site investigation. The overall methodology was found to be effective for attaining the above goals provided sufficient data is available.

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