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IDENTIFICATION AND ANALYSIS OF ACCIDENT BLACK SPOTS USING GEOGRAPHIC INFORMATION SYSTEM

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ABSTRACT

An Accident is a rare, multifactor event preceded by a situation or event wherein one or more road users failed to cope with road environment results vehicle collision.The location in a road where highest number of traffic accidents occurs is called a Black Spot. The recent study conducted by the Kerala Road Safety Authority (KRSA) found that, the maximum numbers of accident-prone stretches or the black spots are in Alappuzha and Ernakulam districts. The present study attempts to identify the most vulnerable accident black spots in these two districts using Geographic Information System. The study includes collection of secondary accident data and prioritizing the accident prone locations by using Weighted Severity Index (WSI) method. WSI method follows a system of assigning scores based on the number and severity of accidents in that particular location in the last three years. The evaluation of six identified black spots in Alappuzha district and ten in Ernakulam were done using ARCGIS 10.1 software package by incorporating field survey data.

1.INTRODUCTION

During recent years, road safety has become a major concern throughout the world. Road traffic accident is a pressing problem leading to fatalities and severely impacting the society. In Kerala, the scenario is not different; there were 4145 fatalities and 25110 grievous injuries in a total of 35216 accidents in the year 2011 (Kerala Police, 2012). The identification, analysis and treatment of road accident black spots are widely regarded as one of the most effective approaches to road accident prevention.

The capability of GIS to link attributes data with spatial data facilitates prioritization of accident occurrence on roads and graphically representing the results for better planning and decision making process. Accident –prone locations can be identified using GIS by analysing spatial characteristics about identified locations, and also able to figure out the underlying factors causing accidents. Reasonable

actions can then be initiated to improve safety in the accident-prone locations. In many developed countries, GIS has been widely used for analysing the accident prone locations or the accident black spots. Many academicians and even government agencies are working on building new tools and improving the existing scenarios for road safety analysis. In this study, GIS analysis is performed using ArcGIS 10.1 software.

A brief review of the various studies on black spot identification is given as follows.

Srinivasan et al. (1987) [1] 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, i.e. i) Quantum of accident method; ii) Accident prone index (API) method and iii) WSI method. The study concluded that the method based on WSI was found to be most suitable in identifying black spots.

Reshma and Sheikh (2012) [2] in their study prioritized some of the major accident spots generally referred to as black spots in South Bangalore by using ArcGIS software by assigning possible weights for various accident components.

Nagarajan and Cefil (2012) [3], used remote sensing (RS) & GIS for identification of black spots and accident analysis for a particular stretch of NH -45 starting from Tambaram to Chengalpet. Eleven accident locations were identified in the study using high resolution satellite map (IKONS) based on the non-spatial data collected from police department and the field survey conducted in terms of traffic volume and vehicle spot speed, and plotting of the study stretch using Arc GIS software.

Many highway agencies are using Geographic Information System (GIS) for analyzing accident data. Identification of problematic locations is one of the most important aspects in accident studies. The GIS based application combines the data collection capability, analysis and visualization. The GIS and Road Accident View System are a set of applications developed for managing accident database entries. Lim Yu LIANG et al (2005) [4], in their study use this developed system designed based on the University Putra Malaysia (UPM) community area and may be adapted very easily to any other places. The system was developed using Microsoft Visual Basic 6.0 in Windows XP platform. The database was designed in terms of textual format. They also record the location of accident on a map.

Binu B Pillai and Dr. Kurian Joseph (2011) [5], in their study on Causes and Consequences of Road Accidents in Kerala, pointed out the main causes of accidents in Kerala and suggested remedial measures. According to them, the main causes of road accidents in Kerala are Over speeding and unhealthy competition of vehicles, poor surface conditions, road cutting, lack of pedestrian crossing facilities, uncontrolled access streets and unmanned junctions, bad driving habits and lack of discipline by road users, haphazard parking on road side, absence of proper bus bay and shelter, visual acuity of drivers, encroachments/dumping of materials on road, and protruded lamp post, unscientific check barriers, speed breakers etc.

Srinivas Rao. B et al (2005) [6], conducted an accident study on NH - 5 Between Anakapalli to Visakhapatnam during the year 2003 and it runs through urban, semi urban and rural areas. The accident data for the last five years were collected from the concerned police station and analysed thereafter. Various traffic studies such as details of road Inventory, Signage inventory, Traffic volume, Pedestrian

volume count, Spot speed, Speed and Delay, Accident Study were also conducted for suggesting the improvement measures.

2. SCOPE AND OBJECTIVES

The objectives of this study are specifically given as following.

1. To develop a methodology to identify and prioritize hazardous locations and to find out the most vulnerable accident stretch.
2. To find out most vulnerable accident stretches in Alappuzha and Ernakulam districts by applying the methodology developed.
3. To identify various traffic and road related factors causing accidents and suggestion of possible improvements.

3. STUDY AREA

3.1. Alappuzha District

Alappuzha is one of the 14 districts in Kerala state gifted with bountiful natural beauty. The district lies between north latitude 9° 05' and 9° 52' and east longitude 76° 17' and 76° 48'.

3.2 Ernakulam District

Ernakulam District is located at centre of Kerala between latitude 10.00^0 N and longitude 76.33° 'E and covers an area of 305826 hectare.

4.METHODOLOGY

The following detailed methodology has been adopted for obtaining the various aspects of the present study. The steps involved in the study are explained in the following sections.

4.1. Data Collection

Primary and secondary data were collected for the study.

4.2. Analysis of secondary data using WSI method

Three years accident data (secondary data) for the two districts were collected from State Crime Records Bureau (SCRB), Trivandrum. The top ranked six accident black spots (Table I) from Alappuzha and ten from Ernakulam (Table 2) were identified using Weighted Severity Index Method (WSI) by assigning scores based on the number and severity of accidents in that particular location during the last 3 years.

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

Place	WSI Value	Place	WSI Value
Eramalloor Jn	1695	Kalavoor	1105
Karuvatta	944	Aroor	938
Chandiroor	923	Purakkadu	890

TABLE 2: TOP RANKED ACCIDENT SPOTS- ERNAKULAM

Place (Urban sector)	WSI Value	Place(Rural sector)	WSI Value
Kalamasser	2044	Angamaly	2128
Edappally	2018	Aluva	1393
Kakkanad	1813	Perumbavoor	1258
Palarivatto	1890	Karukkutty	1230
Vytila	1530	Mulamthuruth	828

4.3 Analysis of the Primary data

Road inventory study, traffic volume count, speed and delay study etc. (primary data collection) were conducted at the above identified accident black spots.

1) **Road Inventory Survey:** All the study stretches of Alappuzha district are National Highways. From the road inventory survey it is observed that, the carriage way width of all stretches varies from 8 m to 10 m. It is not sufficient for accommodating huge traffic and the width is not satisfying the standards of national highways.

The road inventory survey is carried out in ten identified accident stretches in Ernakulam urban and rural sector. Out of these ten accident stretches, five are NHs, two are SHs and three are PWD roads. There are about 16 T – junctions found in 2 km stretch in Edappally. This frequent T – junctions makes collision of fast moving vehicles with vehicles coming from the minor roads at these junctions. Footpath and drainage facilities are absent in all study stretches.

2) Traffic Volume Count: The traffic volume count gives the measure of how many vehicles pass through a particular location during a period of time. For any traffic infrastructure design and accident study peak hour traffic volume is necessary. In the present study, four hour traffic volume count was taken for all the spots and peak hour traffic in terms of Passenger Car Units (PCU) was found.

Traffic volumes for the identified spots are given in table 3and 4.

TABLE 3: TRAFFIC VOLUME - ALAPPUZHA

Accident Black Spot	Peak Hour Traffic Volume (PCU)
Eramalloor Jn	3,549
Kalavoor	2,058
Karuvatta	1,342
Aroor	2,785
Chandiroor	2,408
Purakkadu	1,335

TABLE 4: TRAFFIC VOLUME -ERNAKULAM

Accident Black Spot	Peak Hour	Accident Black Spot	Peak Hour
Kalamassery	4,726	Angamaly	2,797
Edappally	1,415	Aluva	1,713
Kakkanad	941	Perumbavoor	1,907
Palarivattom	4,239	Karukkutty	4,852
Vyttila	2,989	Mulamthuruth	668

3) Speed and Delay Study: The speed and delay study was carried out by using moving observer method on entire identified black spots in Alappuzha and Ernakulam districts to find out the average journey speed and delay of the traffic stream.

TABLE 5: AVERAGE JOURNEY SPEED-ALAPPUZHA

Place	Average journey speed (km/hr)	
	Without Delay	With Delay
Purakkadu	38.65	38.48
Kalavoor	34.86	34.48
Eramalloor Jn	35.68	34.89
Chandiroor	37.91	36.82
Karuvatta	36.86	36.07
Aroor	52.09	47.44

TABLE 6: AVERAGE JOURNEY SPEED-ERNAKULAM

Place	Avg. journey speed (kmph)	
	With delay	Without delay
Vyttila	33.47	30.26
Kalamassery	42.49	38.59
Palarivattom	42.59	22.62
Kakkanad	25.10	24.77
Edappally	28.57	26.07
Angamaly	44.34	42.66
Aluva	39.75	38.73
Mulamthuruthy	29.40	29.05
Perumbavoor	44.05	42.19
Karukkutty	47.85	47.85

D. Analysis of identified black spots using GIS

The map required for the desired road network for the study has to be digitized in a suitable form and certain specified road attributes to carry out prioritization are to be input to GIS. Then the identified black spots further prioritized using GIS.

1) Prioritization: The prioritization scheme used for the GIS analysis involves assigning suitable weights to different factors which tend to influence the occurrence of accidents on
identified study stretches in the district in such a manner that the factors which tend to increase the probability of the accidents have lower weights (Table 7) and applied in Eqn 2.

Final weight = (Σ Individual Weights) x100 /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 were considered as highly accident prone stretch (Table 8).

TABLE 7: FACTORS USED IN PRIORITIZATION WITH POSSIBLE WEIGHT

Sl. No.	Factors	Possible Variation	Weights assigned
1	No.	1	2
	Lanes Each direction	2 4	6 10
2	Width the road	< 6 m 6 – 8 m 8 – 10 m 10 – 12 m > 12 m	1 3 5 7 10
3	Type Road	NH SH PWD Other Roads	1 4 8 10
4	Surface type	Bituminous Concrete	4 10
5	Surface condition	Good Fair Poor	10 6 1
6	Drainage facility	Good Satisfactory Poor No drainage	10 6 2 1
7	Vehicle type	Heavy Vehicles Bus/Truck Car Two wheelers	10 8 4 1
8	No. Vehicles per day	<10000 1000 - 30000 30000 - 50000 > 50000	10 7 4 1
9	Shoulders	Paved Unpaved No	10 6 1
10	Edge obstruction	Yes No	4 10
11	Median	Yes No	10 4

TABLE 8: PRIORITIZATION SCHEME

Final Weight	Accident Prone
>60	Very Low
50 – 60	Low
40 – 50	Medium
0 – 40	High

5. RESULTS AND DISCUSSIONS

The various factors contributing to accidents were collected and values assigned to each factor according to their accident proneness. The final result obtained from the GIS analysis was represented in a map format using different colures which indicates the accident prone level of different locations. The most vulnerable accident stretches in Alappuzha district are shown in Figure 3.

Kalavoor is identified as the most vulnerable accident stretch of Alappuzha district. It is a village located at 10 km towards north of Alappuzha.

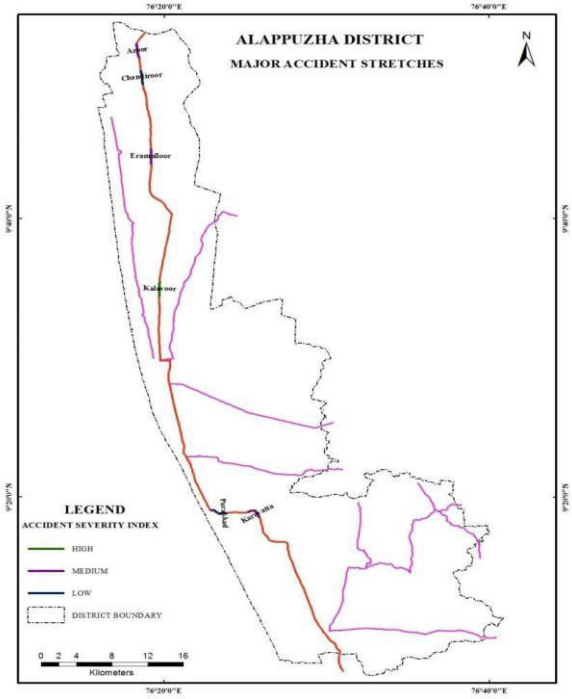

FIGURE 3: MOST VULNERABLE ACCIDENT STRETCHES IN ALAPPUZHA DISTRICT

The suggestions for improvement of Kalavoor zone is given below:

1. Increase the number of lanes from two lanes to four lanes.
2. Provide footpath on both the sides of the road for the safety of pedestrians.
3. Provide adequate drainages.
4. Provide separate bus bays for avoiding delay of other vehicles at the bus stops.
5. Take suitable enforcement measures to reduce the speed of vehicles.
6. Remove or repair potholes for the safety of road users.

The GIS analysis was also carried out in Ernakulam district. The most vulnerable accident stretches are given in Figure 4. *Kalamassery* in Ernakulam urban area and *Mulamthuruthy* in Ernakulam rural area were identified as highly accident prone stretches of Ernakulam district.

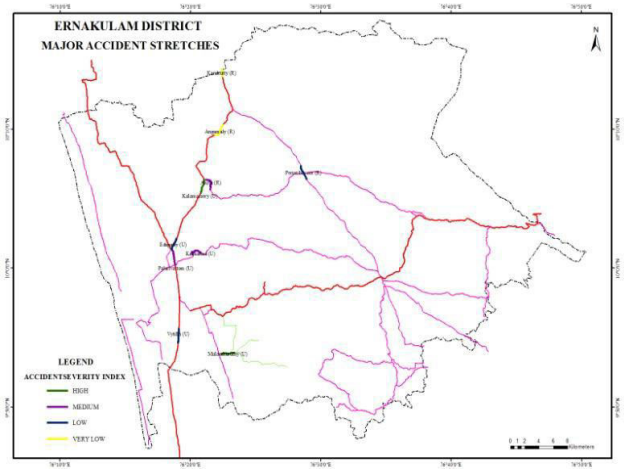

FIGURE 4: MOST VULNERABLE ACCIDENT STRETCHES IN ERNAKULAM DISTRICT

Kalamassery is a suburb of the city of Kochi and it is a concentrated region of industrialization. The suggestions for improvement of Kalamassery zone is given below:
1. Increase the width of the median to 3*m*.
2. Reduce number of U – turning and provide adequate length and width for median openings.
3. Provide footpath on both the sides of the road for the safety of pedestrians.
4. Provide adequate drainages.
5. Take suitable enforcement measures to reduce the speed of vehicles.
6. Some sign boards are hidden due to trees, make it visible to the drivers.
7. Provide separate bus bays for avoiding delay of other vehicles at the bus stops.
8. Provide necessary sign boards at T – junctions. Mulamthuruthy is a small town in Ernakulam district. It is about 21 *km* south-east of Ernakulam and 8 *km* east of Thrippunithura.

The suggestions for improvement of Mulamthuruthy zone is given below:
1. Provide sufficient roadway width.
2. Acquire minimum of 15 *m* land for widen the pavement.
3. Change the alignment of road on horizontal curves to enhance adequate sight distance.
4. Remove the illegal constructions from the road.
5. Provide necessary road signs and markings.

VI. CONCLUSIONS

The study was an attempt to find out the most vulnerable accident locations or the black spots in Alappuzha and Ernakulam districts making use of GIS. The WSI method was used to rank the accident locations, and top ranked six spots in Alappuzha and ten spots in Ernakulam were selected as per the WSI value for the data
collection and analysis in GIS platform. Based on the analysis, Kalavoor in Alappuzha and two spots Kalamassery and Mulamthuruthy in Ernakulam were identified as most vulnerable accident locations and suggested some possible alternative or corrective measures to improve the transportation system in these locations, from which the decision maker can select suitable measure for the location. The method is found to be effective in identifying the black spots, provided sufficient secondary data is available.

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