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Accident Analysis and Identification of Black Spot Locations Using Qgis on NH-24 (Moradabad to Bareilly Section)

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Abstract: A road traffic accident is becoming a prime complication in any transportation network. With the increase in vehicle population, the increase in the number of accidents is also increasing twice a fold. Road accidents are now anticipated to be the seventh principal cause of death by the year 2030. Analysis of the accidents on the roadways and spotting the accident-prone locations is necessary to provide relevant safety improvement measures. Recent research shows an increase in the integration of geographical information systems (GIS) for analyzing accidents, road design, and safety management considerably. This study focuses on the accident analysis and acknowledges the accident blackspot location on National Highway-24(Moradabad to Bareilly section) from chainage 148.000 KM TO 269.000 KM in the state of Uttar pradesh.The data were first analyzed on Ms-Excel and then the data was inputted in QGIS to identify the blackspot locations based on the latitude and longitude of the accident locations.

The conclusions it is recommended to implement strict driving policies to reduce the number of accidents.it was found that the animals coming on the road has a greater share in accidents. It is suggested to implement strict driving policies and roadside patrolling vehicles to put a check on the overspeeding vehicles.

Keywords: Accidents, Blackspot, Geographic Information System, QGIS

INTRODUCTION

The road network in India is 2nd largest in the world having 6.21 million kilometers of road length with 1,26,350 km(2.03%) of National Highway, 1,86,908 km(3.01%) of State Highway, and other roads of 59,00,858 km(94.96%) (MoRTH, 2019). Hence, roads are an important mode of transport in India.The main aim of all transportation networks is to provide good mobility, where accidents results are inextraneous by-products of the system, which is required to berestrained to achieve the objective. Accounts for nearly 11% of deaths due to accidents in the world and thus INDIA ranks 1st among the 199 countries for the highest number of road accident deaths(Saufi, 2018).

Road traffic accidents, specifically highway-vehicle collisions, cause huge damage to the lives of nearly 1.25 million people worldwide every year (Iqbal et al., 2020).As the movements of vehicle increases, the likelihood of accidents also increases (Fayaz et al., 2018).

Study Area

This study was carried out on the Moradabad - Bareilly section of National Highway-24 from

chainage 148.000 KM TO 269.000 KM in the state of Uttar Pradesh.National Highway 24 (NH 24) is a leading national highway in India which connects Delhi to Lucknow in Uttar Pradesh.

Problem Statement

Statistics from the Ministry of Road Transport and highwayin India acknowledged that, in the year 2019, nearly 449,002 accidents took place in the country which leads to the death of 151,113 personscausing 451,361 injuries. Of which 35.7% of deaths took place on National highways which comprise2.03% of the road network only. A total of 1055 accidents took place on NH-24(Moradabad to Bareilly section) from the year 2016 to 2020. Out of which there were a total of 257 Fatal injuries, 599 Grevious,1265 Minor injuries, and 57 cases of property damage from the year 2016 to 2020.

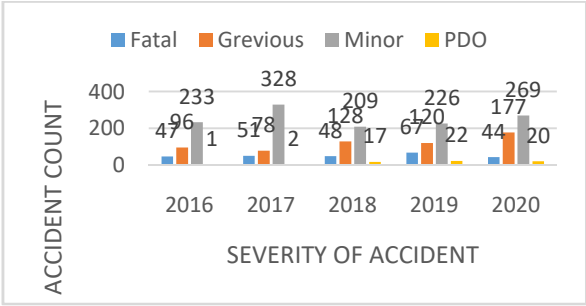

Figure: Severity of accidents

Research Background-GIS and Road Accident analysis

As per ESRI, a geographic information system (GIS) is a structure for collecting, administering, and evaluating data having a broad range of geographical coordinates. GIS combines distinct types of data, works out the spatial location, monitors layers of information,and converts this information into visualizations using maps and 3D scenes. Hence with this specific potential, GIS reveals deeper insights into data, such as situations, patterns, and relationships, and thus helps to improve in deciding the best use of the available limited funds and thus it is now largely used in transportation planning agencies, especially among metropolitan transportation organizations.

GIS technology in road safety analysis helps in anticipating the locations and cause of accidents by storing the attributes of accidents like the location of the accident(chainage, latitude, longitude), the number of accidents, type of vehicle involved, the components of the roads, weather conditions where accidents occur(Kazmi et al., 2020). GIS is believed tobe a good tool for working on the various nature of accidents(Ghosh et al., 2004). GIS functions include multidimensional features like thematic mapping, statistics of different data, charting of the data, matrix manipulation, modeling and algorithms, decision support system, and concurrent access to several databases.

Statistical analysis is also an important method, used traditionally for such analyses. Integrating both, spatial analysis with statistical methods can be believed to give better results in accident analysis.

OBJECTIVE OF THE STUDY

GIS allows the experts of road safety to correlate accidents with different attributes like land use and zoning data along with other demographic data to achieve an enhanced understanding of the interrelationship between different attributes of occurrence of the accidents. The visual competence of GIS enables the mapping of FIR

data, Geometric data, and Inventory data(Ghosh et al., 2004).

The detection of crash blackspots is the elementary step to implement road safety measures. The adoption of geographic information systems (GIS) in transportation safety applications, has increased expeditiously in the past years(Maistros & Schneider, 2018).

This research thus focuses on the use of the Geographic Information System (GIS) technology to gain a better understanding of the relationships between traffic accidents and road design. The planned approach will help in increasing the efficiency of analysis of road traffic accidents and execution of a safety action plan in the future.

1. To identify the accident blackspot by employing GIS technology and locating the blackspot location using QGIS.
2. To analyze the different factors contributing to road traffic accidents.
3. To suggest the corrective measures for the blackspot locations.

LITERATURE REVIEW

Choirul Umam et al., (2021) research was focused on road traffic accidents and their analysis by taking some road stretches in the Gresik district usingthe Geographic Information System (GIS). The author used the EAN(Equivalent accident number), UCL(upper control limit) using QGIS software to display the accident-prone area in detail.

Srikanth & Srikanth, (2020) research was focused on the identification and ranking of the accident blackspots using Kernel Density Estimation (KDE) and analysis of Blackspotusing Getis-Ord Gi* method. The author obtained the visuals of the blackspots from KDE, and then performed the Blackspot Analysis using Getis-Ord Gi* method to check the statistical significance ofthe blackspots location identified using KDE andranked the statistically significant blackspots based on the density estimate.

Watrianthos et al., (2020) studied the locations of accidents having a high frequency of occurrence and represented them in the form of spatial data and used the accident data to generate a density map for calculatingand analyzing the critical locations using Quantum GIS. The author used the Kernel Density Estimation (KDE) method with a search bandwidth in an area of 300 meters and obtained the accident heat maps of the study area.

Kazmi et al., (2020) used the KDE tool and GIS technology to identify the accident blackspots of the stretches of the UK. The result showed that the maximum number of accidents occurred during a weekend, mostly in the evening time, more frequently in October and November,when the speed is restricted up to 30 Kmph, on ‘A’ class road and at the locations having “T” or staggered junction and concluded that the environmental factors.

Bolla & Djahi, (2018) research was focused on developing and analyzing the database of road traffic accidents by using QGIS. The author used thefield calculator features for accident weighing and UCL calculations and can be helpful to accommodate and check the needs of the decision-makers to make faster and more accurate decisions for reducing the number of accidents.

Severity Index

Le et al., (2020) research was focused on investigating the effect of severity index on temporal and spatial patterns of accidents black spots locations relating it with the day and seasons using GIS-based statistical analytic techniques. The author found thatboth analyses gave nearly the sameblackspot locations, but the rankings of some blackspots were found to be different due to the use of the Severity index and concluded that includingSeverity Index in determining road traffic accidentsblackspots gives better results.

Iqbal et al., (2020) focused on the analysis and identification of the blackspots ofa road traffic accident on the Lahore-Islamabad Highway. The author used MS Excel and Origin Pro software to digitized the data and find out the collision analysis and employed the collision point weightage method for the identification of the blackspots. The author concluded that human behavioris the primary contributor responsible for collisions among vehicles in road traffic accidents while the other contributors were environment and vehicle.

Identifying the Black Spot Location Using Weighted Severity Index

The increasing number of casualties and frequency of road traffic accidents (RTAs) is resulting in severe socioeconomic loss to the nation.Accident leads to serious injuries, damage to health and property, social misery, general degradation of the environment and in an extreme case, death(Parmar et al., 2018). Thus it becomes the utmost task of priority to safety engineers to reduce the number of casualties by knowing the exact causes of the accident. The cause of the accident could be the poor geometry of the road, frequent intersection, the sudden curve, fault of the driver, etc.

Methodology-

1. Obtaining accident data for the chosen study area.
2. Preprocessing of the data.
3. Giving weighted severity index to each accident id.
4. Obtaining black spot location using the QGIS.

Data Collection

Accident data were collected from the Niyamatpur Ekrotiya toll plaza(Moradabad) which has the collective data of the police station and theNHAI report.

Accident Black spot

The Ministry of Road Transport & Highways - India, (2015) defined the accident blackspot as the stretch of the national highway of the length of about 500m in which either 5 road accidents occurred during the last three calendar years or the 10 fatalities(in all three years put together) took place in the last three calendar year.

Weighted Severity Index (WSI)

Several studies were performed to see the effect by both considering and ignoring the severity of the collision for the determination of the high impact locations in the accident analysis. For the analysis by not considering the severity of the accident, theaccident rank is taken as “1”. This givesan equal weightage to each accident irrespective of the severity. Some researchers concluded that, by not considering the weighted

data, it is hard to detect whether the observed impact location is right or wrong.

It is assumed that the more serious collisions should be given higher weights. There is no globally defined weighing system for the accident severity. Though under the weighted severity index, casualties are divided into three groups i.e (i) Fatal, (ii) Grevious, (iii) Minor. Based on the damage by the accidents, fatalities were given the weight of 10 points, grievous injuries were given the weight of 5 points and the minor injuries were given the weight of 1 point. Hence, the Severity index(SI) for each collision location can be calculated as per the given Equation:

$SI = 10\times F+ 5\times G + M(1)$

where:

F= total number of fatal accidents

G= total number of grievous accidents

M= total number of minor and property damage only accidents.

Weighted severity index was obtained showing the total number of accidents in that particular range.

Table: Weighted Severity Index range of accident data

WSI range	Accident count
0-9	758
10-19	232
20-29	45
30-39	11
40-49	5
70-79	2
80-90	2

Steps For Locating Accident Spots Using QGIS

The most vulnerable accidents spots having a high severity index were identified using the WSI method and the process of locating such a black spot is done using QGIS processing the following steps-

1) Converting the Excel Data containing the attributes of an accident like Chainage, Latitude, Longitude, etc into '.csv' format.
2) Adding a new layer in QGIS as a delimited text layer and then insert the file saved in step 1 into it. The digitized map of the Old NH-24 was imported in QGIS from the Open street map (present in the Browser panel of the QGIS).
3) Then the attribute table containing all the attributes of the accident is processed and the field containing the weighted severity index column was given the operator value to obtain the required black spots having severity index value >=40. '9' black spots having a severity index >=40 were identified

Table: Location and Rank of black spots having WSI value Greater than 40

Chainage	Latitude	Longitude	Weighted Severity Index	The rank of Blackspot
166.330	26.91062055	76.40645092	90	1
181.580	26.86851871	75.96024028	84	2
259.850	26.92194545	76.49385492	70	3
236.000	26.96998871	76.78641257	70	4
189.400	26.97206543	76.7977391	45	5
217.480	26.91125875	76.33297353	45	6

169.320	26.87737933	76.21429376	42	7
197.450	26.86096429	75.98700153	40	8
222.700	26.87625935	75.93525401	40	9

4) Similarly, 58 black spots having a WSI value between 20 and 40 are identified

5) Using the pivot table of the Ms-Excel the data for the accidents counts of the last three year(2018,2019,2020) for the 500m distance(as per section 3.4) was arranged and plotted in the QGIS to compare the hotspot locations as obtained above using the WSI and as per the definition of the MoRTH. Accidents blackspots as obtained by Using the WSI having a value Greater than 40 and by the MoRTH definition as mentioned in section 3.4 and the ranking of the blackspots obtained by using the MoRTH definition.

Table: Location and Rank of black spots having accident count greater than 5 under the 500m location.

Chainage	Latitude	Longitude	Accident Count	Fatal Injuries	Rank of hotspot
166.2 – 166.7	26.94984917	76.60170115	13	4	1
181.3 – 181.8	26.91155788	76.41307239	11	0	2
259.5 – 260.0	26.94458781	76.5584406	10	2	3
235.7 – 236.2	26.91808566	76.47260332	9	2	4
189.2 – 189.7	26.93113249	76.51898914	9	0	5
217.3-217.8	26.93835392	76.5384125	9	1	6
169.1 - 169.6	26.87341154	76.20368577	8	0	7
197.2 – 197.7	26.86724735	76.1869618	8	1	8
222.4 - 222.9	26.87170284	76.19902657	7	0	9
198.3 – 198.8	26.87706009	76.21344159	7	2	10
155.6 - 156.1	26.91421092	76.45272955	7	1	11
171.8 – 172.3	26.9475942	76.57781563	7	4	12
256.1 – 256.6	26.9504576	76.60748047	7	5	13
233.5 – 234.0	26.97706682	76.80951107	7	4	14
175.3 – 175.8	26.99431477	76.83344417	7	2	15
162.8-163.3	26.9225017	76.49683476	7	0	16
182.3-182.8	26.92335636	76.5012845	7	2	17
196.8-197.3	26.94334503	76.55406369	7	1	18
205.3-205.8	26.89620209	76.28549978	6	0	19
267.8-268.3	26.91390135	76.44860683	6	0	20
246.3-246.8	26.87758194	75.93002542	6	3	21
214.3-214.8	26.85658698	76.00362254	6	0	22
202.8-203.3	26.85618151	76.0205503	6	0	23
205.3-205.8	26.85802146	76.09432444	6	0	24
152.3-152.8	26.94932754	76.59641013	6	2	25
193.3-193.8	26.96999868	76.78649631	6	5	26
192.8-193.3	26.91478874	76.4589111	6	1	27
251.8-252.3	26.93696473	76.53432902	6	2	28

6) Of the above 28 black spots location obtained using the MoRTH definition the top 10 blackspots location is selected and the location, cause, and remedial measures for these top 10 blackspots are provided in chapter 6.

Patterns and Trends of Road Traffic Accidents From 2016-2020

Road traffic accidents are the mixed results of human behavior, road, and vehicular characteristics.Vehicle-pedestrian involvement in accident analysis is the prime factor to determine the vulnerability of mode of vehicles involved in an accident and to improve the safety measures

(John, 2019). Knowing the characteristics of the attributes of the collision locations will help the transport planners to take the safety measures and ultimately the goal to reduce the number of collisions can be achieved.Hence, this study aimed to analyze the patterns and the trends of road traffic accidents at a local level for the period 2016-2020. The results presented in this chapter willhelp the transport planner in determining the corrective measures which can be implemented by the road authorities at the local level.

Road Traffic Accident by Year From 2016-2020

Road traffic accidents on the NH-24 Moradabad to Bareilly section from the year 2016 to 2020, which shows that a total of 1056 accidents was responsible for the 257 fatal injuries. An average of 51 fatal injuries recorded annually while there is an increase in the total number of accidents fromthe year 2016 to 2020. The year 2019 recorded the highest number of fatal injuries while the next year the fatal injuries were found to be minimum.

Road Traffic Accident By Month From 2016-2020

The pattern of road accidents by month was reviewed and the results show that the total number of accidents was found to occur highest in October(10.1%) followed by June(10.0%). February experienced the lowest (6.1%) record of the total number of accidents from 2016-2020. Fatal injuries were found to be maximum in October(11.7%) followed by December(11.3%) and found to be lowest in February(4.3%).On average, 87(8.2%) accidents causing an average of 21(8.2%) fatal injuries were recorded per month from 2016-2020. These results confirm the assumption that the most fatal accidents occur during the festive seasons and holidays.

Road Traffic Accident By Day From 2016-2020

Accident was high from Monday to Friday(69.7%), followed by the weekend(30.3%), while the highest number of the accidents occurred on Wednesday (16.7%) and the lowest number of the accident occurred on Friday (12.7%). The total number of fatal injuries was found to be the maximum on Saturday, while the lowest fatal injuries were observed on Friday.

Road Traffic Accident By Time (3-Hr Interval) From 2016-2020

Road traffic accidents by time was observed from 2016-2020. The time interval was categorized into 8 blocks of 3-hours intervals each. The result shows that there was an increasing trend of the occurrence of the accident from 6 AM to 9 PM. The highest number of accidents was observed during the 6-9 PM (16.3%), followed by 3-6 PM(15.9%), 12-3 PM(13.6%), 9-12 AM(13.3%),9-12 PM(11.7%), 3-6 PM(10.3%), 6-9AM(10.2%),while the lowest(8.6%) accidents occurred in 0-3 AM block. The findings here validate the findings of the research by MoRTH, (2019) who found that the maximum number of accidents(19.3%) was recorded during the 6-9 PM interval in the country followed by the 3-6 PM constituting 17.5% of road accidents and concluded that the evening and the afternoon times are the most dangerous times to be on the road. The maximum number of fatal injuries was

observed during 3-6 PM(19.1%), followed by 9-12 PM(15.2%), 6-9 PM(14.4%), 3-6 AM(12.8%),12-3 PM(10.9%),9-12 PM(9.7%), 6-9 AM(9.7%), 0-3 AM(8.2%).

Road Traffic Accident By Lighting Condition From 2016-2020

Accidents as per the lighting conditions categorized into daylight, twilight, and nightlight where the twilight is defined as the time of the day between daylight and darkness, whether that's after sunset(considered the time between 17.00 to 19.00), or before sunrise(considered the time between 4.00 AM to 6.00 AM). The data shows that the total number of accidents(47.5%), as well as the total number of injuries(51.6%), are both found to be highest during the daylight, also the highest fatal injuries(42.4%) occurred during the daylight, followed by the 35.4% during the nightlight and the lowest record of 22.2% occurred during the twilight.

Road Traffic Accident By Weather Condition From 2016-2020

Weather conditions on road traffic accidents were reviewed. Results show that the highest (95.5%) accidents were occurred in sunny and clear weather conditions, followed by 2.0% in Mist/fog conditions,0.9% in cloudy and other weather conditions,0.7% in rainy conditions. Results match the research by MoRTH, (2019) which shows that maximum accidents occurred in Sunny/clear(73.6%) weather conditions at all Indian levels for 2018-2019.

Road Traffic Accident By Cause Of Accidents From 2016-2020

Road traffic accidents was broadly categorized into three categories as Human factors, Road environment factors, and Vehicular condition. The results revealed that out of 1055 accidents recorded on NH-24 (Moradabad to Bareilly section), the highest number of accidents occurred because of the human factors(82%), followed by Road environment factors(11.5%), and the Vehicular conditions accounted for 6.5%.

Human Factors

Out of this 82.5% of the road accidents on NH-24 from2016-2020, some high potential risk behaviors were identified. These include, Over speeding (72%), wrong side driving (7.1%), dozing at wheel (6.9%), drunken driving (6%), careless driving (4.3%), overtaking (3.7%).

Road Environment Factors

Road environment factors include (i) type of road features, (ii) weather condition, (iii) type of junction, (iv) geographical area (residential, institutional, commercial, etc) where the accident can happen. Accident considering road environment factor occurred due to animal came in the front of the vehicle(57%), followed by unusual median crossing(19%), a pedestrian suddenly came up(6.5%), bad weather condition(7.4%), etc.

Vehicular Conditions

Vehicular conditions involves cases of accidents related to the mechanical condition,age of the vehicle,overloading, etc (MoRTH, 2019). The analysis of the data of the NH-24 from 2016-2020 shows that the maximum number of accidents considering the vehicular condition occurred due to Tyre burst (55.1%), followed by the mechanical fault (44.9%) which includes the cases of the short-circuiting in the vehicle.

Road Traffic Accident by Type of Vehicle Involvedfrom 2016-2020

Vehicle involved in the crime vehicle (Primary vehicle) and the victim vehicle (Secondary Vehicle) involved in the road traffic accidents. This includes the Vehicle categorized into Ambulance, Bus, Car, HMV (includes truck, container, tanker, trailer), LMV (includes Tempo), Tractor Trolley, Two-wheelers, and Unknown vehicle(which fled away after the accident and could not be noted). The highest number of accidents occurred by Car (31.8%), followed by Two-wheelers (23.9%), HMV (21.8%), Unknown vehicles (13.5%), Bus (5.2%), Tractor trolley (1.8%), LMV (1.1%), Ambulance(0.9%). Victim vehicle which was found to be at high risk is Two-wheelers (31.9%), followed by HMV (15.3%), Car (13.8%), Animal (10.3%), Pedestrian (9.5%), Unknown vehicle (8.5%), Tractor Trolley (6.3%), Bus (3.2%), LMV (0.9%), Ambulance (0.5%).

It occupies a large space on the road and hence gives less space for other vehicles to overtake. The data reveals that HMV is the second most hitting primary vehicle on the road which was responsible for hitting 199 vehicles on the road during 2016-2020 of which the collision of the HMV with HMV is the most occurring, which may be due to the overspeeding and the highest occupancy of the HMV's during the night. The data shows the correlation with research done by the MoRTH, (2019) whose research also shows that the collision of trucks with trucks is maximum (45.1%).

Table: Cause of the accident for the type of vehicle involved

Cause of Accidents	Number of Collisions
The animal came in front of a vehicle	
Ambulance	2
Bus	1
Car	25
HMV	3
LMV	2
Two-wheeler	36
Bad weather	
Bus	4
Car	3
HMV	1
Two-wheeler	1
Careless driving	
Bus	3
Car	8
HMV	13
Tractor Trolley	3
Two-wheeler	6
Unknown vehicle	4
Dozing at wheel	
Ambulance	1
Bus	3
Car	15
HMV	37
LMV	1
Two-wheeler	3
Drunken	
Bus	1
Car	12
HMV	4
Two-wheeler	31
Unknown vehicle	4
Mechanical Fault	
Bus	6
Car	14
HMV	7
LMV	1
Tractor Trolley	1

Two-wheeler	1
Unknown vehicle	1
Over speeding	
Ambulance	5
Bus	25
Car	197
HMV	122
LMV	6
Tractor Trolley	9
Two-wheeler	142
Unknown vehicle	117
Overtaking	
Ambulance	1
Bus	3
Car	12
HMV	11
Tractor Trolley	1
Two-wheeler	2
Unknown vehicle	2
Pedestrian	
Bus	1
Car	4
HMV	2
Two-wheeler	3
Unknown vehicle	10
Tyre burst	
Bus	2
Car	22
HMV	10
LMV	2
Two-wheeler	2

CONCLUSION

1. Arise of 6.2% in the number of accidents from the year 2019 to 2020,but during the same year the cases of fatal injuries decreased by10.3%. The rise in the total number of accidents may be due to an increase in the traffic flow whereas the decrease in the total number of fatal injuries is a result of the effective implementation of the traffic policies.
2. October month was found to have the maximum number of accidents as well as fatal injuries, this is due to the occurrence of a large number of festivals in October.
3. The total number of injuries was found to be maximum on the weekends(Saturday followed by Sunday), this may be due to the return of working people to their homes from an urban area to their village and the other reason is due to the more consumption of the alcohol on Saturday.
4. The total number of fatal injuries was found to be maximum from 6PM to 6AM, while the total number of accidents was found to be more during daylight.
5. 95.5% of accidents occurred during the clear weather condition
6. Rear-end collision is the major type of collision found on the stretch due to the over speeding of the vehicles.
7. Human factors were responsible for the maximum number of accidents,followed by the road environment factors which were found to maximum due to stray animals coming in the front of vehicles on the road.
8. Whereas the accidents which occurred due to vehicular condition were found to contain the maximum due to the bursting of the tyres.
9. Cars were found to be the major crime vehicles hitting the Two-wheelers the most.
10. HMV vehicle drivers were found to be dozed at the vehicles the most and thedozing was found to be maximum during the early morning hours when the intensity of the sleep is most.

FUTURE SCOPE

1 QGIS is also use in other applications. Advance version of GIS is also help to find out more data regarding accidents.

2 QGIS technology is used to create and manage digital maps, and to visualize spatial data in a variety of formats, inliuding maps,charts, graphs, and other visualizations.This allows users to understand spatial patterns and trends, and to make informed decisions based on the data.

3 QGIS technology should be used to identify black spots on other highways of country.

4 Analyze the more factors contributing to road traffic accidents.

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