Identifying Black Spot: A GIS Approach to Road Safety and Accident Severity Patterns

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Abstract **- Road safety is a dynamic element of sustainable urban growth especially in rapidly expanding cities like Pune. This research aims to identify and examine accident-prone zones which are known as "black spots" along the Yerwada to Alandi road, which faces increasing traffic congestion and frequent accidents. Utilizing five years of detailed accident records from 2020 to 2024, the study employs Geographic Information System (GIS) technology for spatial analysis supplemented by Severity Index (SI) and Accident Severity Index (ASI) methods to identify and prioritize dangerous segments.**

The approach combines accident reports, traffic volume data and field case studies to design the spatial distribution of minor, major and fatal crashes. Key findings of the study specify that locations like Yerwada and Vishrantwadi consistently record high accident rates and severity which are mainly due to poor road design, missing pedestrian facilities and weak traffic control. Rear-end and head-on collisions are the most frequent types of accidents. Further, the study highlights the crucial role of merging GIS models with traffic engineering insights to effectively detect, visualize and address black spots. Also, it provides recommendations for targeted safety measures such as dedicated lanes, enhanced signage and stricter enforcement to reduce risks and improve road safety. This methodology offers a replicable framework for urban traffic safety planning in other large cities.

Keywords **- Geographic Information Systems, Road Safety, Spatial Analysis, Accident Severity Index, Black Spot**

INTRODUCTION

With each passing day, the need for road safety continued to grow as it is an essential component of sustainable urban development particularly in a rapidly expanding metropolitan city like Pune, India. Urban expansion is accompanied by the increasing complexity of transportation networks which often results in keen vehicular congestion, infrastructure strain and a corresponding rise in road accidents. A crucial component of effective road safety management is the identification and assessment of "black spots" in specific areas that exhibit a significantly higher frequency of traffic accidents. As per [1] a road accident black spot is a road stretch on NH of about 500 m in length, in which either five road accidents took place during the last three years or ten fatalities took place during the last three years. The road accident includes fatal as well as injury accidents. Further, the identified black spots on NHs are ranked based on average severity index (ASI)[2,3].

Understanding the spatial and temporal distribution patterns of these black spots is essential for planning focused intrusions aimed at minimizing accident-related injuries and fatalities. The Yerwada to Alandi corridor in Pune has been selected as the study area representing a typical example of the challenges associated with urban transportation and road safety. This corridor is marked by high traffic density, diverse vehicle types and inadequate pedestrian infrastructure. This stretch has witnessed a steady rise in road accidents over recent years. This study aims to assess accident patterns along this corridor over five years from 2020 to 2024 using Geographic Information System (GIS) tools combined with the Severity Index (SI) and ASI to locate, classify and prioritize high-risk zones.

Further, GIS-based spatial analysis enables researchers and planners to visualize accident patterns, identify clusters and understand the interplay between

roadway design, traffic volume, and accident types [4,5]. By integrating secondary accident data with spatial mapping and traffic engineering principles, this study seeks to deliver actionable insights into road safety risks and propose appropriate countermeasures. Also, research gives traffic management strategies, policy decisions and infrastructure improvements. The findings not only address local safety concerns but also offer a replicable methodology for other urban regions facing similar challenges.

METHODOLOGY

1. Study Area
2. Data Collection
3. Data Analysis
4. Identification of Black Spot
5. Spatial Mapping of the Accidental Area
6. Results and Conclusions

STUDY AREA

This research focuses on a key urban corridor in northeast Pune, Maharashtra from Yerwada to Alandi, a location which is known for its heavy traffic flow mixed vehicle types and increasing congestion due to rapid urban development. The corridor includes critical junctions such as Yerwada Junction, Vishrantwadi Chowk and Alandi Phata and it also serves as a significant religious destination. Dighi area which is situated along this route is main study location due to its very high frequency of accident occurrences and infrastructural issues.

To enable precise identification of accident-prone zones, the entire corridor has been divided into segments of 500 meters to 1 kilometer. This segmentation facilitates a detailed spatial analysis of accident patterns and helps pinpoint high-risk locations based on accident frequency and severity. The overall study area spans roughly 15–20 kilometers, covering both densely populated city zones and emerging peripheral regions. This structured approach enhances the reliability of the black spot assessment and supports the development of focused road safety solutions tailored to specific segments.

DATA COLLECTION

The data for this research study focused on the Yerwada to Alandi corridor in Pune, was collected for the period from 2020 to 2024. Data were obtained through physical site observations along the selected road stretch. Significantly, accident records for the years 2020–2024 were collected from nearby police stations in Pune, specifically for the Yerwada to Alandi corridor, in the form of First Information Reports (FIRs). The analysis employed both qualitative and quantitative methods: descriptive analysis of accident trends, causes, and characteristics was performed using Microsoft Excel, while spatial analyses including density, cluster and hotspot identification, were conducted using QGIS.

To evaluate accident severity, the Severity Index (SI) was calculated based on a weighted ($SI=(K\times W_f)+(S\times W_s)+(L\times W_l)$) Where, K = Number of fatal accidents, S = Number of serious injury accidents, L = Number of minor/slight injury accidents, W_f, W_s, W_l = Weights (e.g., 5, 3, 1 like in Belgian method)

Table 1 Accidents data is collected from commissioner's office traffic Pune

Location ID	Location	Lat	Lon	Major Accidents (M)	Minor Accidents (I)	Fatal Accidents (F)	Total Accidents (T)
PT 2608001	Yerwada	18.55262	73.87971	513	200	88	801
PT 2668019	Vishrantwadi	18.57027	73.87889	488	302	54	844
PT 2642900	Kalas	18.59142	73.87374	181	328	5	514
PT 2648010	Dighi	18.6115	73.8732	201	316	7	524
PT 2650011	Laxmi Narayan Nagar	18.62828	73.87466	247	388	7	642
PT	Kate Colony Alandi	18.6452	73.88119	218	340	6	564

2616012							
PT 2988021	Wagheshwar Temple	18.66796	73.89012	165	443	7	615
PT 2988051	Alandi	18.6773	73.89464	220	342	6	568

RESULTS

Dark Blue – Hight Fatal Accident
Dark green- Slightly High Fatal Accident
Green- Moderate Fatal Accident
Light Orange- Slightly less Fatal Accident
Orange - Less Fatal Accident

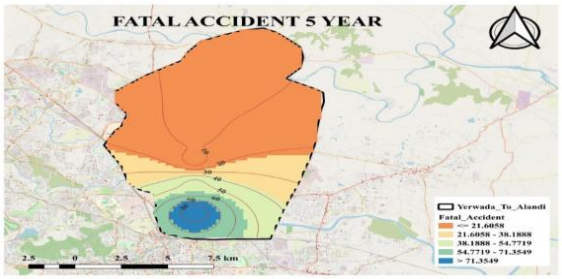

Figure 1. Graph of the fatal accidents in the last 5 years

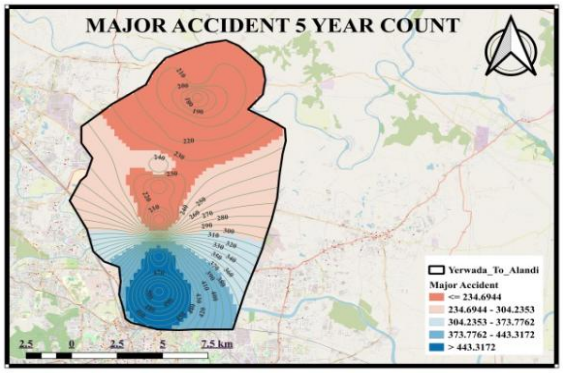

Figure 2. Graph of the major accidents in the last 5 years

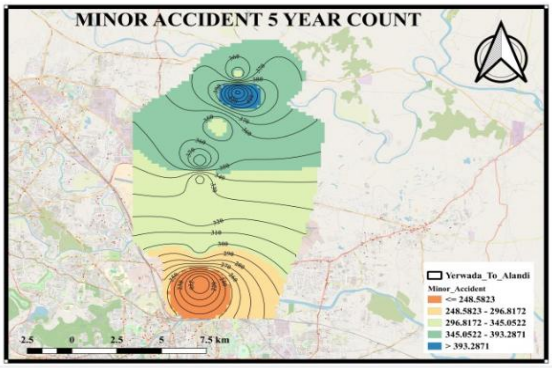

Figure 3. Graph of the minor accidents in the last 5 years

From Figures 1 and 2, based on the data and GIS analysis, it was observed that accidents in Yerwada are predominantly concerning. Specifically, 12.5% of the reported accidents are categorized as very severe, while 25% are classified as severe. Additionally, about 33.33% of the accidents are considered moderately severe, indicating significant risk to road users. Only 8.33% of the accidents are categorized as minor and considered less critical. Meanwhile, 20.83% of the accidents fall under the very minor category but still necessitate routine monitoring and preventive measures to ensure continued safety.

Figure 3 shows that the southern region near Yerwada shows the highest density of minor accidents due to heavy traffic and complex intersections, as indicated by deep orange and red contours. In contrast, the northern area near Alandi records fewer minor accidents, shown by blue and green contours, likely due to lower traffic and better road conditions. This gradient highlights the need for targeted road safety measures in the southern zone.

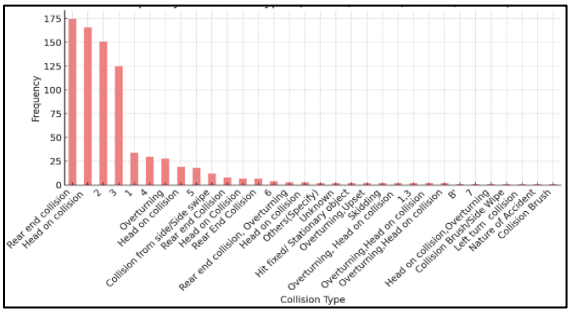

Figure 5. Frequency of accidents based on the collision type

Figure 5 breaks down accidents by collision type, with rear-end and side-impact collisions being the most prevalent. This suggests that traffic management strategies, such as improved signage and lane discipline, could mitigate these incidents.

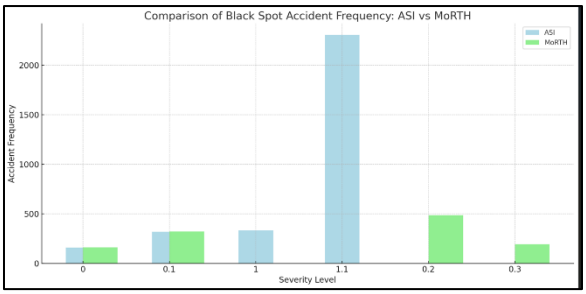

Figure 6. Comparison of black spot accident frequency ASI Vs MoRTH

Finally, Figure 6 compares the frequency of accidents at black spots as identified by the Accident Severity Index (ASI) and the Ministry of Road Transport and Highways (MoRTH). The graph highlights discrepancies in reporting or methodology between the two systems, indicating a need for standardized criteria to accurately identify high-risk zones. Collectively, these findings underscore the multifaceted nature of road accidents and the importance of data-driven strategies to enhance safety measures.

CONCLUSIONS

The study revealed alarming trends in both the frequency and severity of road accidents along the Yerwada–Alandi corridor over a five-year period. By integrating accident data with QGIS spatial analysis, the research successfully identified key accident hotspots, revealed temporal variations in crash occurrences, and mapped high-risk zones characterized by poor infrastructure, over-speeding, and lack of pedestrian safety provisions. A clear year-on-year increase in the total number of accidents was observed, with fatal and grievous injury cases consistently forming a significant portion of the total incidents.

Analysis of seasonal patterns showed that the months of March, November, and December recorded the highest Severity Index values across multiple years, indicating a recurring trend of severe accidents during these periods. Critical accident-prone locations such as Vishrantwadi Chowk and Alandi Phata emerged as key black spots in the corridor, warranting immediate attention.

The application of advanced GIS techniques, including precise blackspot identification and layer-based temporal mapping, proved highly effective in analyzing spatial and temporal accident trends. The findings of the study underscore the urgent need for targeted road safety interventions, improved traffic management systems, and comprehensive infrastructure upgrades. Additionally, there is a pressing requirement to promote pedestrian-friendly road designs and implement widespread public awareness campaigns to enhance overall road safety and reduce accident rates in this rapidly urbanizing region.

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