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DEVELOPING INFORMATION SYSTEM ON BLACKSPOT SEVERITY FOR TRAVELLERS BY USING PYTHON AND GIS TECHNIQUES

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SUMMARY

To reduce road traffic accidents, it is mandatory to identify and analyze road network blackspots with a high accident rate. This analysis aims to develop a framework to analyze the severity of blackspots for travelers using the Python programming language. The proposed study uses accident data to identify the black spots.

Python programming language helps us perform geospatial-based analysis and data processing. It performs clustering of data spatially to identify the blackspots and statistics to calculate the severity and cause of accidents at these blackspot locations. The severity of each accident blackspot is calculated based on the frequency of accidents, injury severity, and volume of traffic at these locations.

The analysis is performed using maps and provides information about the blackspots for the stretches of road networks i.e. Balampur Ghati to Chanchal Square, Golkhedhi Square to Chanchal Square, and Balampur Ghati to Police Control Room of Bhopal, Madhya Pradesh, India. By providing this information to the travelers this study ensures that the travelers choose the safest route possible.

Key words: *blackspot severity, GIS, alternate routes, python.*

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INTRODUCTION

The severity of blackspots is measured according to the number of accidents in that section of roads which causes imperilment for the travellers. Black spots are formed due to poor geometry of roads, very high volumes of traffic, improper drainage, and deficient lighting. If users are unaware of these blackspots, their life is in danger [1]. This study uses Python to develop a framework that provides information about each black spot. So, it can be used to provide travelers with information so they can choose a safer travel route [2]. This study uses each location's traffic accident data and the related casualties. This data can be collected through the Traffic Police Department or some other techniques [3].

Once we have the data, we can analyze it and plot it on the maps. This will provide us with the trends in the data. Then we can calculate the severity using Python [4, 5, 6]. Once we calculate the severity, we can assign a ranking to the blackspots according to the casualties or minor injuries that have occurred on these blackspots [7]. Then develop a system that gives information to the travelers about the threat level at these locations. So, to sum up, the development of this system will help reduce the number of accidents and fatalities at these Blackspots.

For the assessment of the severity of the accident sites, the Weighted Severity Index method is the most popular criterion. This method is used to give the weightage or rank to blackspots based on the number of accidents and the number of deaths on the road [8, 9]. Once we have calculated the severity scores for each blackspot, Python programming is used to create a rating system that provides pieces of information to travelers about the risks associated with each location. This might be a simple scale, with higher ratings indicating higher levels of prons of accidents or other problems [10, 11]. Alternatively, we could use a more complex system that considers several constituents, such as the type of road, the time of day, or the weather conditions.

Finally, Python was used to develop a technique that allows travelers to easily access this information. In summary, by using Python for the interpretation of blackspot data on traffic accidents, developed information on blackspot severity that aids travelers and making more informed decisions about their routes. This can be applicable in decreasing the risk of accidents and injuries on the roads and making travel safer for everyone [33].

LITERATURE REVIEW

For the mitigation of safety on roads, the enlargement of information systems to appraise and convey the severity of traffic blackspots to travelers has flatter increasingly prime. The locations on highways or roads with a high occurrence of traffic accidents are defined as blackspots, and understanding their severity is helpful for travelers to mitigate risks [12, 13]. With the help of the following literature review, we explored existing research and methodologies in the field and focused on the implementation of Python programs for the processing, interpretation, and visualization of data.

Importance of Blackspot Analysis

Assessment of blackspots is key for road safety enhancement and its identification and severity analysis are critical for developing selected interventions to decrease accidents and improve road safety [14, 15, 16]. For resource allocation, it is necessary to evaluate the blackspots and authorities can allocate resources more effectively by understanding the severity of different blackspots [17, 18]. Blackspot analysis also promotes traveler awareness and provides travelers an information about blackspot severity helping them to make informed decisions and adopt safer travel routes [19, 20].

The multiple components that contribute to traffic accidents within the Lagos Metropolitan Area were evaluated for the research. The likelihood of an incident happening on Lagos roadways was displayed to be influenced by fourteen different elements or individuals. Several distinct geographical and non-spatial information were obtained, analyzed, and evaluated to research the accident incidence in the Metropolis. Depending on such variables or causes, the Weighted Severity Index (WSI) was developed.

Application of Python in Blackspot Analysis

Python has emerged as a powerful tool for data science and analysis, offering numerous libraries for data processing, statistical analysis, and visualization.

- For data processing, libraries such as Pandas and NumPy are applicable for its manipulation and analysis [21, 22].
- For the visualization of data, Matplotlib and Seaborn provide robust tools for creating detailed visualizations of Blackspot [23].

- Software like Folium and GeoPandas are used for creating interactive maps and conducting spatial analysis of blackspots [24, 25].

- Machine Learning such as Scikit-learn and TensorFlow are popular libraries for applying machine learning models to predict blackspot severity [26].

Case Studies and Applications

Several studies have demonstrated the use of Python in blackspot analysis:

- Elvik in 2008 applied statistical methods using Python to analyze accident data and identify high-risk locations [27].

- In 2009, Anderson utilized GIS and Python to visualize accident hotspots and recommend safety improvements [19].

- In 2020, machine learning models were implemented in Python to predict and assess blackspot severity based on historical accident data [28].

- Kidando in 2019 examined how Travel Time Reliability (TTR) and other factors affect the likelihood that a severe collision will occur on an arterial road. Two random-effect logistic regressions were used to address the unobserved heterogeneity issue: the Dirichlet random-effect (DRE) and the traditional random-effect (TRE) logistic regression [29].

- In 2017 the automated extraction on highways was focussed, which are dotted with a variety of man-made and natural objects, including cars, trees, and the shadows cast by either trees or buildings. This method used three stages to achieve a precise road extraction: first, it classifies images into interested classes using a maximum likelihood algorithm; second, it modifies the classified images using connected components and morphological operators to extract desired object pixels by removing unwanted pixels from each class; and third, it extracts lines using the RANSAC algorithm [30].

MATERIALS AND METHODS

Study Area

Bhopal, the capital city of Madhya Pradesh, India, is located in the central part of the country. The city is situated at approximately 23.2599° N latitude and 77.4126° E longitude Figure 1. It is nestled on the Malwa plateau, which provides a unique topography with a mix of hilly terrain and flat plains. As of the 2011 Census of India Approximately 1.8 million people, making it one of the most populous cities in Madhya Pradesh. The city has a population density of around 3,000 individuals per square kilometer. Bhopal has seen significant population growth due to urbanization and industrialization. Bhopal boasts a well-developed infrastructure, with A comprehensive network of roads, a functional public transport system including buses and a recently developed BRTS (Bus Rapid Transit System), and a railway junction connecting it to major cities.

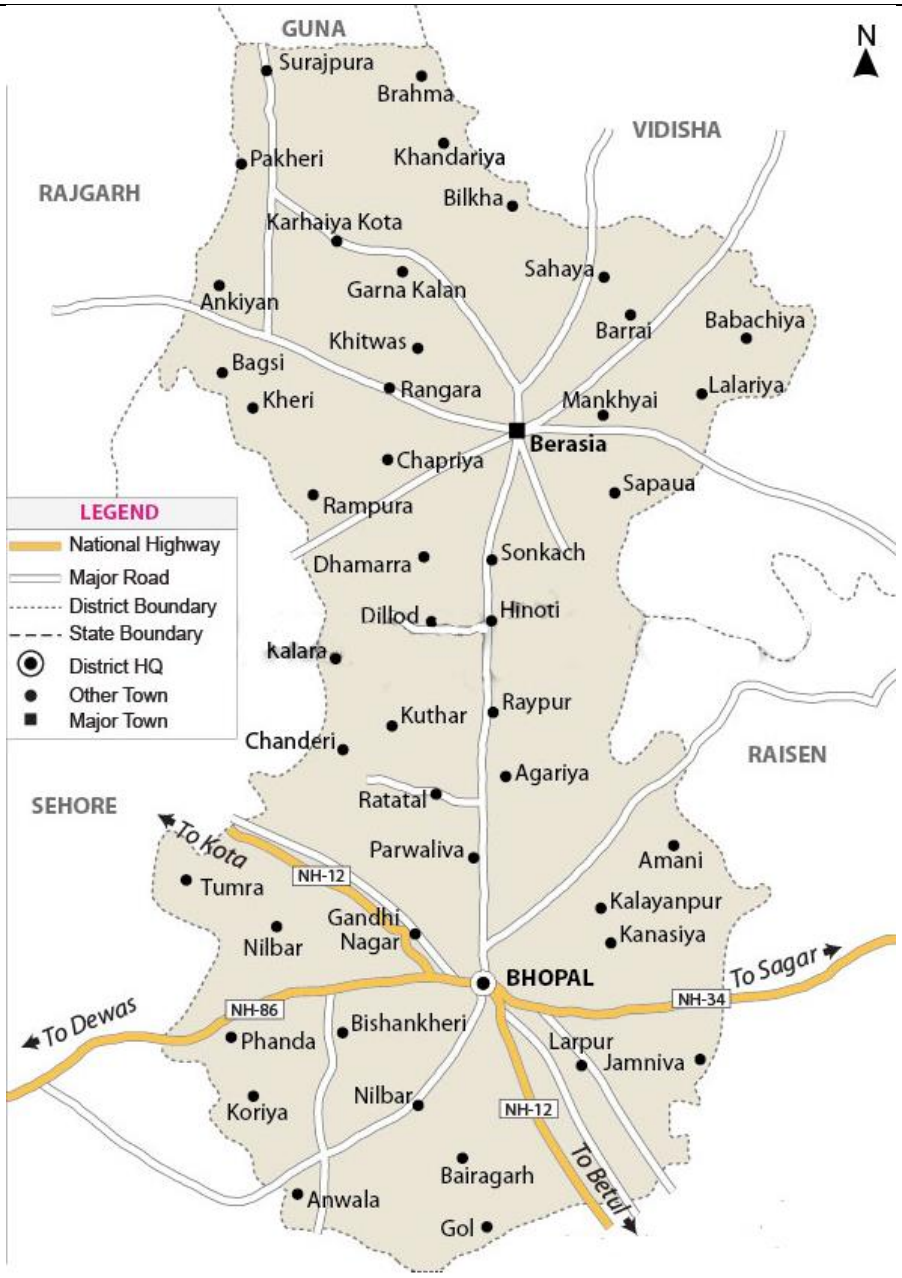


Figure 1. The study area map of the bhopal district

Bhopal has a well-developed road network that includes national highways, state highways, and arterial roads, connecting various parts of the city and neighbouring regions. Bhopal's traffic conditions vary significantly across different parts of the city, influenced by factors such as road infrastructure, population density, and commercial activity. Rapid urbanization has outpaced the development of road infrastructure, leading to bottlenecks and congestion. Inadequate parking facilities in commercial areas contribute to on-road parking and traffic jams. The presence of a diverse range of vehicles, from two-wheelers to heavy trucks, creates challenges for smooth traffic flow.

Bhopal's road network and traffic conditions reflect the city's rapid growth and urbanization. The infrastructure growth and traffic issues generate major barriers, and the existing projects and cogent plans for traffic management develop future improvements based on expectations in mobility which also reduce traffic-related problems. To assess these issues and assurance of sustainable urban development, it is necessary to plan and execute systematic transportation-based policy.

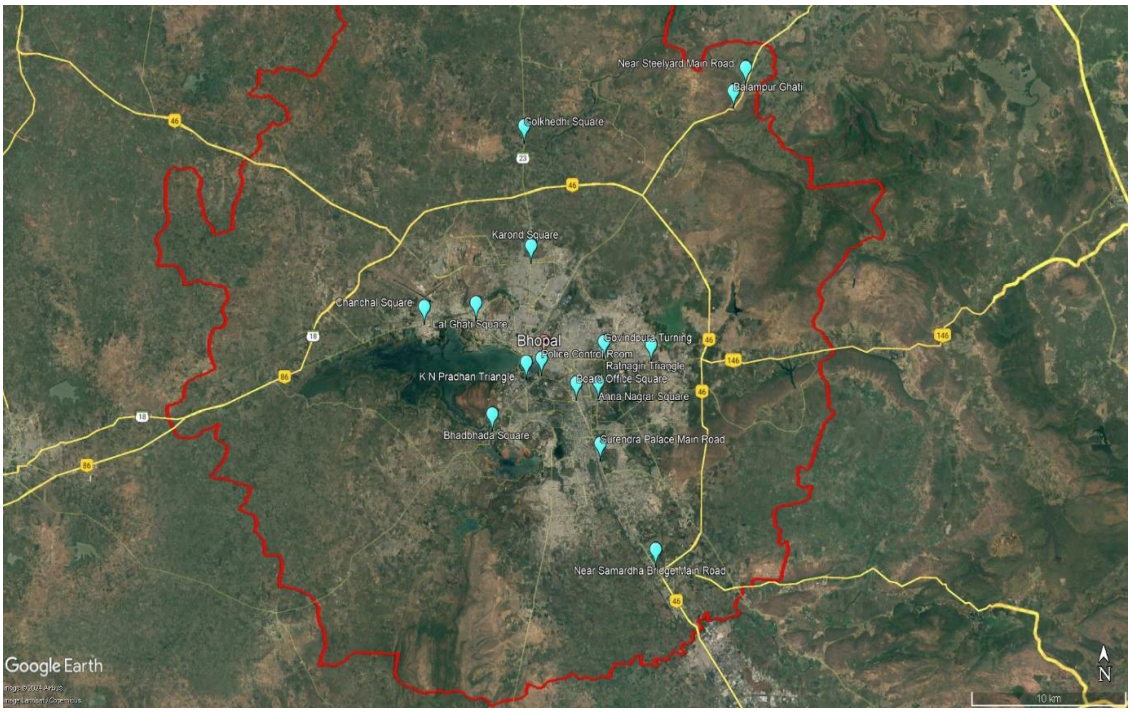


Figure 2. Location map of the accident site in urban bhopal

Input Data

Weighted Severity Index (WSI)

For the spatial analysis of road accidents, the Weighted Severity Index (WSI) technique is used. The WSI technique is employed in this study to differentiate and rank the locations of Road Traffic Accidents (RTAs). The WSI is estimated by using accident types like death, major injuries, and minor injuries. In this work, the WSI analysis is performed manually [21].

$$\text{WSI} = M_x U_x + M_y U_y$$

Where,

M_x = Number of accidents,

U_x = for accidents weight assigned = 6,

M_y = Number of deaths,

U_y = for deaths weight assigned = 4.

Information on Blackspot Severity for Travellers by Using Python

The map with the blackspot location is created with the help of Google Earth Pro and Arc GIS Figure 2 which is then used as an input for Python software. One can use Google Earth Pro and Arc GIS to know the coordinates of the Blackspot locations [31, 32]. With the help of this one can determine the different routes between these coordinates. With the use of some algorithms that consider the Blackspots severity, one can decide the safest possible route between the origin and destination [40], [34, 35]. One can also use the number of accidents data and number of deaths occurred on the possible routes to decide the safest possible route between the origin and destination [38, 39]. To do this one can use the road traffic accident records and can depict that information on the maps.

An individual can use different techniques such as, one can create an image that gives information about the Blackspots fatalities and the number of accidents that have occurred at such locations that are present along the different routes between the origin and destination points [27, 36, 37]. One can also create a graph to show the number of accidents and their patterns. The aim is to provide safer traveling to the users and to provide some information to the Traffic Police Department. So that they can take some prevention measures to reduce the number of accidents and casualties. The Blackspot locations which are prone to accidents as compared to other Blackspots should be taken care of on a priority basis.

- **Input:** Map in digital form, origin, destination, number of accidents, number of deaths, WSI.
- **Step 1:** Find the coordinates of each hotspot by using the "find_cor" module, using "CV2.EVENT-LBUTTO-NDOWN" function.
- **Step 2:** Find possible paths between the start point and the destination using the function "find_route" which uses data from path table input data.
- **Step 3:** Using the output data from Step 2 and input data from ArcGIS (Weight Severity Index, Rank, Number of accidents, Number of deaths) plot the path in the map image.
- **Output:** Map images marked with possible paths with Weight Severity Index, Rank, Number of accidents, and Number of deaths on the map.

RESULT AND DISCUSSION

Weighted Severity Index

The WSI method was applied to every location which after interpretation was classified between the range of 0 to 100. The highest range showed the extreme severity class and the lower value showed the least severity class which is considered a safer route as compared to more accident-prone areas. After the analysis using the severity index, it was found that Balampur Ghati and Golkhedhi Square had the highest rank concerning blackspot severity followed by the Police Control Room which showed the need for nearest routes assessment. Evaluation of possible routes through the selected locations is described below.

Start Point: Balampur Ghati; Destination: Chanchal Square

From Balampur Ghati to Chanchal Square, there are a few alternative routes that may be followed, and each has advantages and disadvantages of its own. It will be required to consider variables like distance, journey time, and the availability of transit choices to choose the optimal route. Taking the main road out of Balampur Ghati and heading toward the city center is one way to get from Balampur Ghati to Chanchal Square Figure 3. The main road would probably be signposted and easy to follow, making this approach quite simple.

Longer travel times could result from increased traffic congestion on this route, especially during rush hours. For those who prefer nature or rural settings, there is always the choice to take a more picturesque route through the countryside.

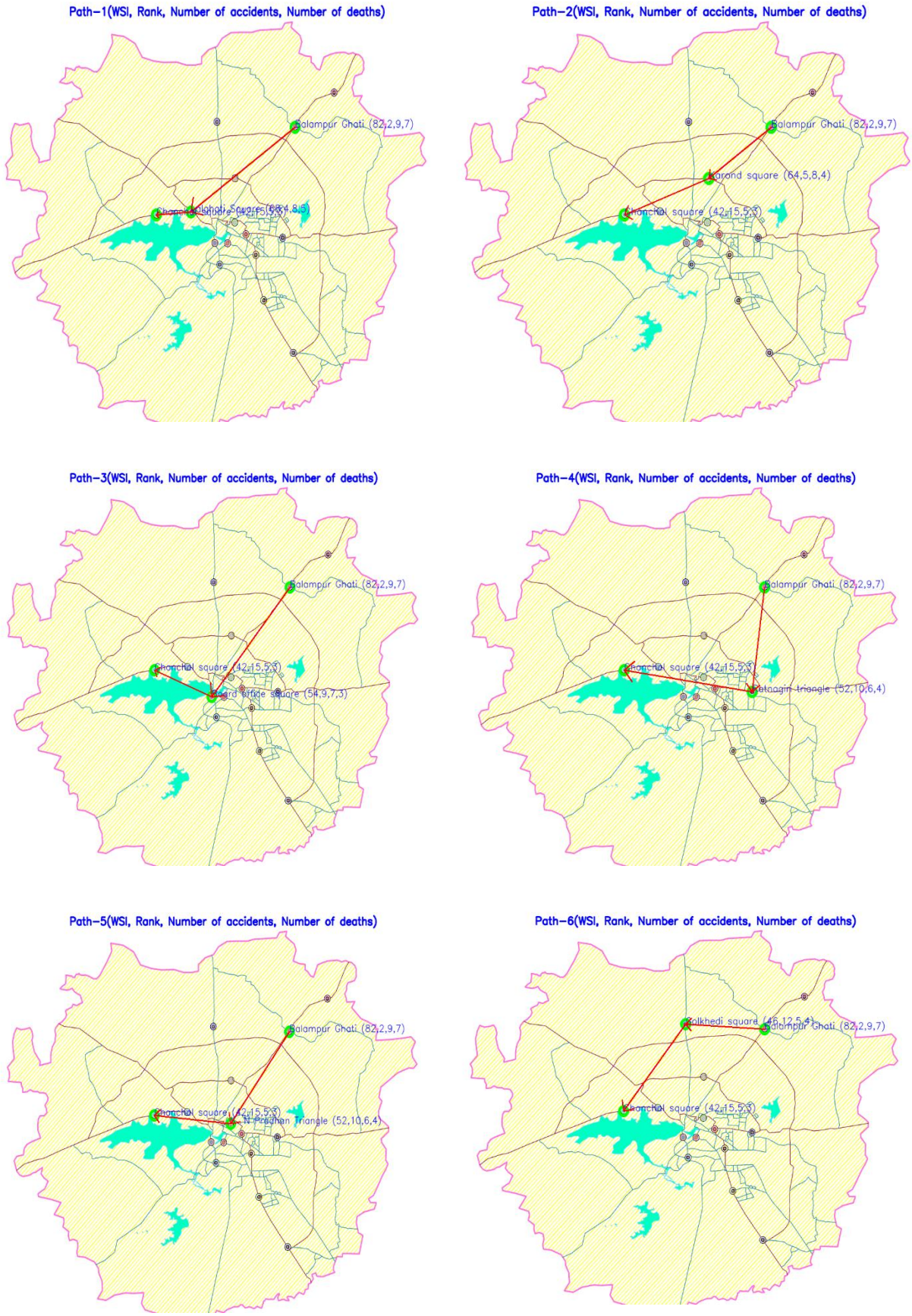


Figure 3. Analysis of possible path from balampur ghati to chanchal square

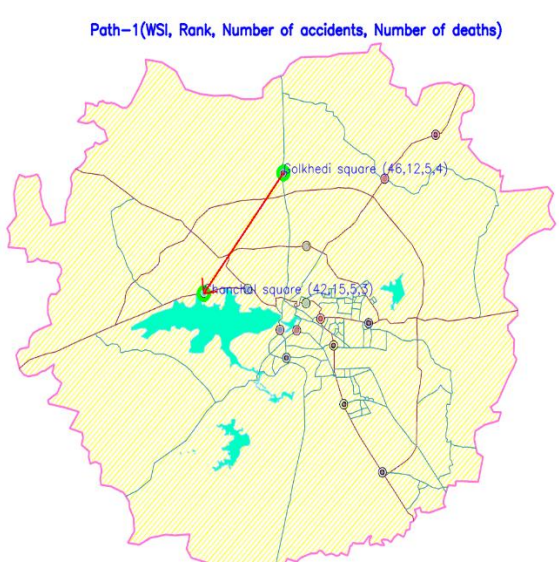
Selecting shorter routes passing through some rural areas having more aesthetic views in comparison to other routes could be more time-consuming. Also, these routes may have less traffic volume as compared to other possible routes. Prioritising public transportation is also a good option especially if the destination is in more crowded locations such as commercial or industrial areas. Public transport is inexpensive compared to other available modes of transport but has limitations too. The public transportation system will be less preferred when travel time becomes a predominant factor of consideration.

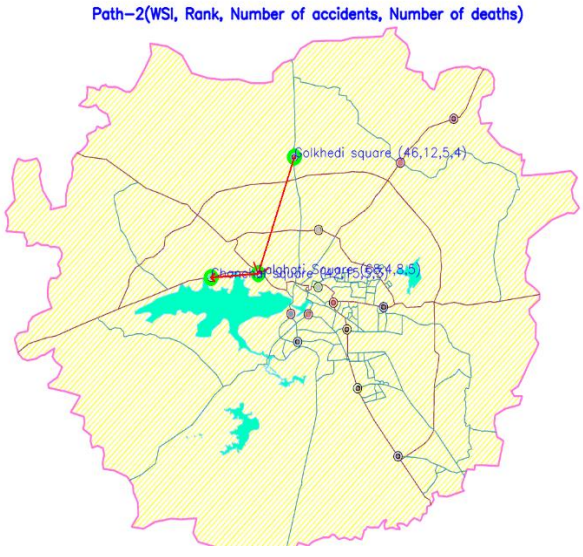
Also, the selection of routes from Balampur Ghati to Chanchal Square will depend on the user considering factors like Blackspot location and severity, conditions of the road, traffic volume on the routes, travel time, etc.

Start Point: Golkhedi Square; Destination: Chanchal Square

Here there are many potential routes to follow to reach the destination of Chanchal Square with individual pros and cons. Thus, to opt for the best possible route of approach certain factors such as estimated distance, traffic congestion, route accessibility, and safety parameters should be considered. Taking Golkhedi Road intersecting with National Highway 47 to reach the Chanchal square is one of many possible routes Figure 4. It is the most feasible approach as the distance to be followed is around 10 kilometers. Despite being the shortest route, travelers could experience heavy traffic congestion during office hours on this route so it is not most suitable for bike riders and pedestrians.

Another alternative approach could be Golkhedi Road to State Highway 17 to Chanchal Square. This route is slightly longer as compared to the previous route because Chanchal Square from this route ranges about 12 kilometers. However, it will be less congested than National Highway 47 but still, it is not suited for bikers and pedestrians. The third route is through State Highway 18 from where travelers could turn left and follow the highway until it reaches Chanchal square. This is the longest route among all the other mentioned approaches as it measures 15 kilometres to reach Chanchal Square, but is the most scenic option of all. This route is best suited for bikers and pedestrians as it is the fastest route among all three options because it is the least traveled approach. This also acts as a con for this route as during night time the safety of pedestrians and bike riders could be compromised.





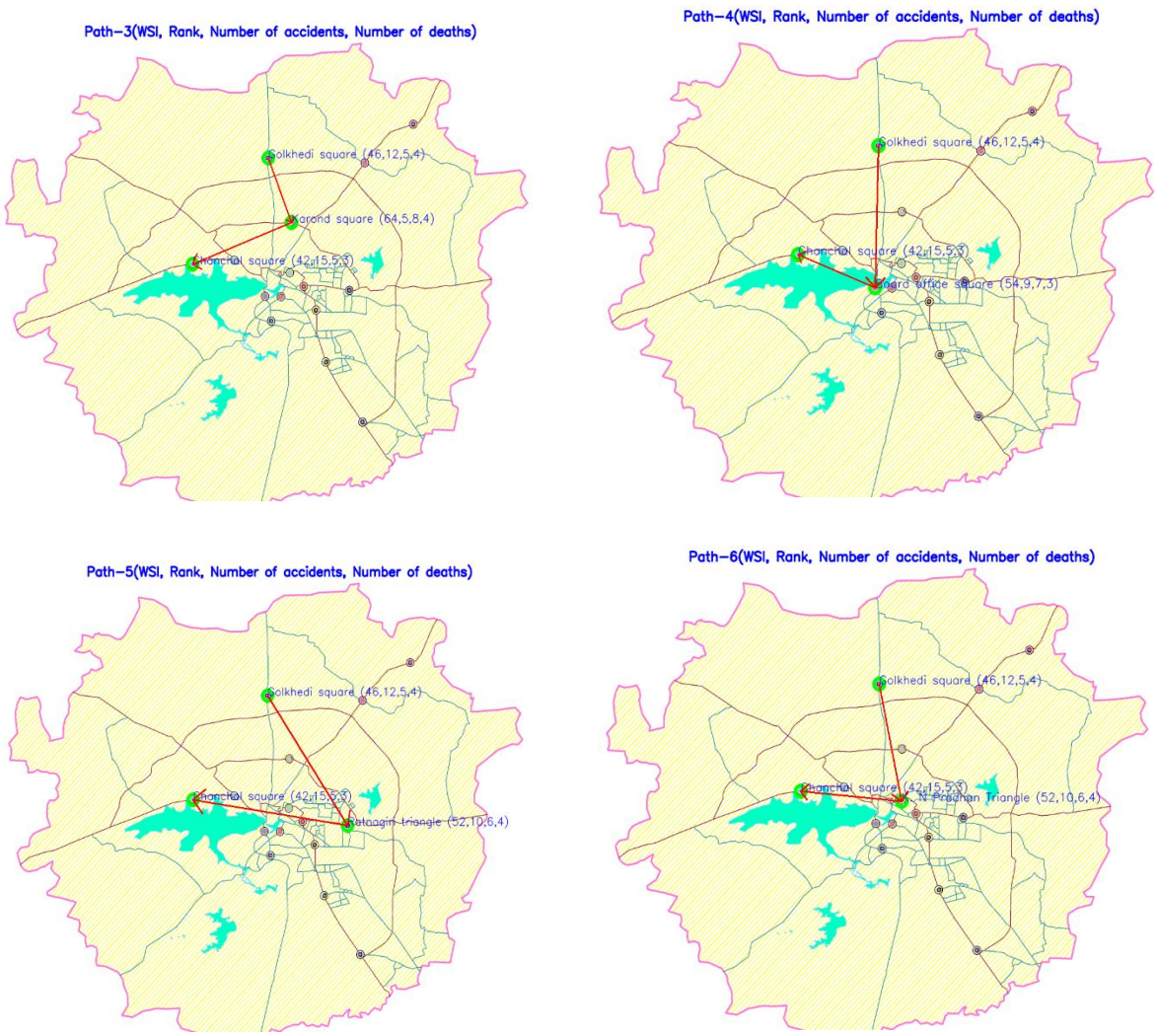


Figure 4. Potential routes analysis from golkhedi square to chanchal square

Therefore, the best possible approach to Chanchal Square relies on traveler's priorities and personal preferences. Those who prefer to drive in less traffic conditions along with scenic landscapes and do not mind going the extra mile for it would prefer State Highway 18. However, those who prioritize direct and simple routes and are used to driving in heavy traffic would take National Highway 47 as it is the shortest route possible. Furthermore, people favoring a balance of both safety and shorter traveling time would prefer State Highway 17 to reach their destination.

Start Point: Balampur Ghati; Destination: Police Control Room

Assessment of the best possible routes from Balampur Ghati to the Police Control Room should consider certain variables, such as calculated approximate distance, traffic congestion conditions at peak hours, transport mode, and the availability of transit choices. Travelling by personal car is one of the ways to cover approximately 25 kilometers from Balampur Ghati to the Police control room. Depending on the traffic congestion at that specific hour of the day, this route could result in a traveling duration of around 40 minutes to an hour. Other modes of transport are Train or Bus to complete this trip Figure 5. These options of train or bus would result in going to a railway station or bus stop and reaching the closest point of the police control room and completing the trip either on foot, through taxi, or pooled cab. Although these modes of transport would take longer traveling time they are cost-effective. The most basic mode of transport to reach the destination is by either walking or riding a bike. However, the option of walking is not practical given the distance is around 25 kilometres and a bike ride of such a distance compromises the safety of the travellers though it is the most inexpensive way to reach Police Control Room.

Thus, the choice of optimal mode of transport depends on the traveller's priority and personal requirements. For example, if cost is the primary factor of consideration bike or pooled cab will be the preferred mode of transport. Car driving could be the choice if speed and shorter travelling time is the priority. Although, the ride quality and duration of the trip could be heavily hampered if the availability of mode of transport and traffic congestion is not as per the expectation of the traveller.

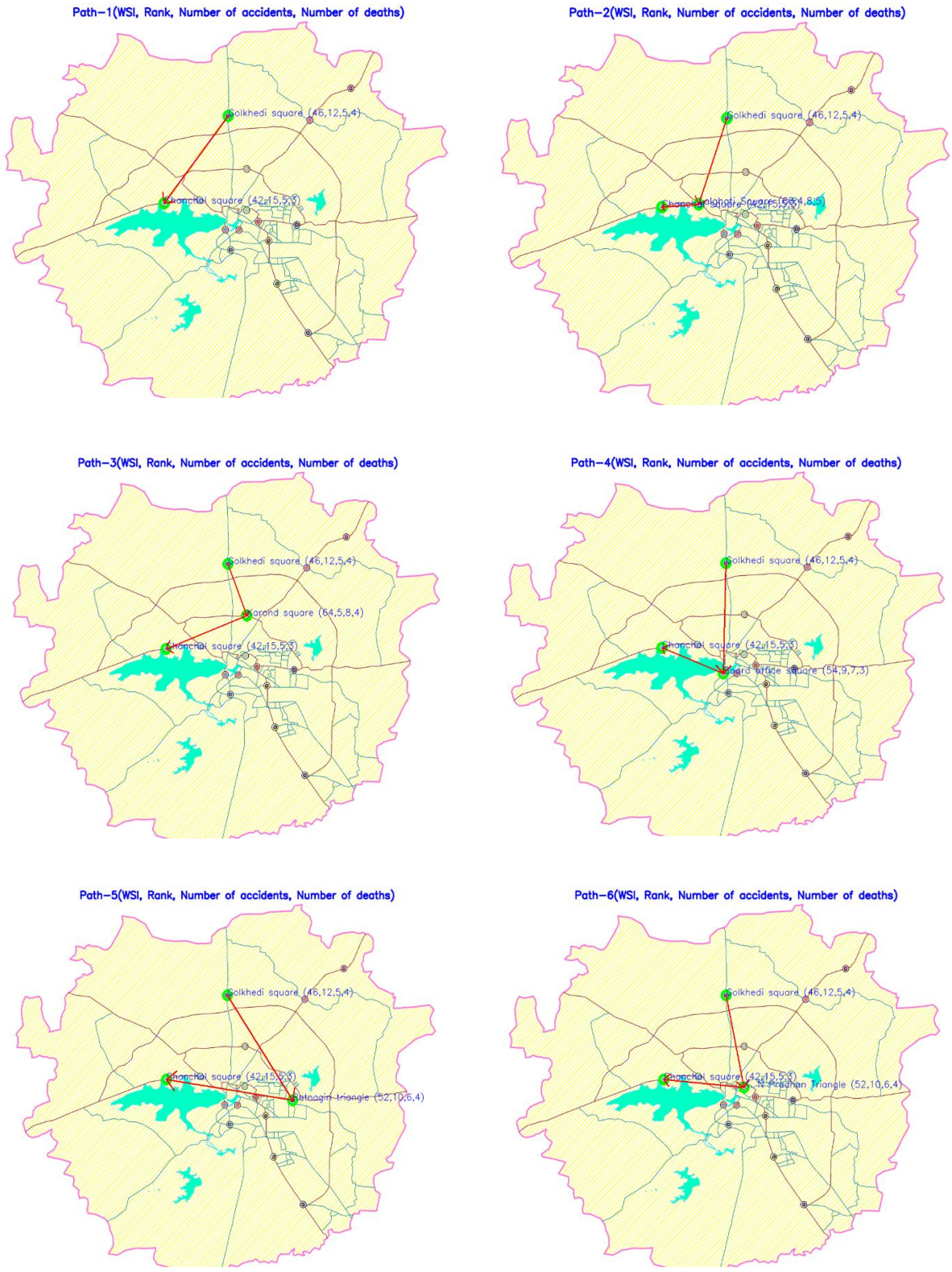


Figure 5: Possible routes analysis from balampur ghati to police control room

CONCLUSION

The information system in the study was framed to reach the specified necessity of the region it serves which makes transportation easier for travelers. With the application of Python programming language, which is admired for its flexibility and reliability of use, the data were developed. The maps that were developed using this application are practical and intuitive to use, preferable for people to navigate and find the information according to their requirements. One of the key features of the information system is that it includes information about the blackspot region of Bhopal which causes a significant risk to travelers.

By developing information about these interest areas, the information system aids to aware travelers to the potential hazards and prepares them to take appropriate precautions. The existing literature supports the use of Python in developing information systems for blackspot severity analysis, and its robust data processing, analysis, and visualization capabilities are absolute in this application. Future research and development should aim to overcome current challenges and raise the effectiveness of systems for the improvement and management of road safety.

Overall, the use of a GIS system and the implementation of various strategies can help the Madhya Pradesh transportation department to know the factors responsible for traffic accidents in the state and take appropriate action to decrease the risk of future incidents. By adopting a comprehensive approach to accident prevention, the department can work towards improving road safety and ensuring the smooth flow of transportation for all commuters and travelers in the state.

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