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Impact of Polymer Chemistry on Population and Land Use Pattern to Identify Black Spot

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Abstract

The incorporation of polymer chemistry has become more essential in the design and upkeep of roadways, greatly improving their strength, adaptability, and overall effectiveness. The use of polymers in road building mainly focuses on the alteration of bitumen (asphalt) and the creation of novel pavement materials. The roads are one of the best and most suitable modes of transport for every person in India, but in this highly populated country, there are several chances of road accidents that cause fatalities, injuries and property damage. To minimise the risk of road accidents, it is important to know the reasons, and road factors of the stretch where accidents are frequently happened and set the priority list to take the necessary actions in highly risky locations. In this paper, a detailed analysis of road accident data has been carried out for Panipat and Rohtak City, Haryana (India). The accident data accessed from the Haryana Police website have been analysed for the 5-year period spanning 2018-2022, and then based on this data identification & representation by Arcmap10.8 of accident-prone locations, blackspots and predict the impact of Population & Land use pattern by using neural network approach has been done for the selected study area.

Keywords: Road accidents; polymer modified asphalt; full-depth reclamation; geosynthetics; land use pattern

INTRODUCTION

Conventional bitumen often falls short in delivering the required performance attributes, particularly in severe weather conditions and under large traffic loads. The addition of polymers, such as styrene-butadiene-styrene (SBS), ethylene-vinyl acetate (EVA), and crumb rubber, enhances the elasticity, temperature sensitivity, and resistance to deformation of the resultant PMB. Polymers improve the durability of bitumen by enhancing its binding capabilities, resulting in roadways that are more resistant to cracking, rutting, and other types of damage. As a result, this leads to the creation of roadways that have a longer lifespan and need less money to maintain [1,2]. PMB has superior temperature resistance, effectively reducing softening and deformation in hot weather conditions. On the other hand, it also retains its elasticity at low temperatures, which decreases the likelihood of breaking in cold climes. Polymer-Modified Asphalt (PMA) refers to asphalt that has been enhanced using polymers. The addition of polymers to asphalt mixes improves their ability to bend without breaking, making them more resistant to the pressure of high loads and dynamic stresses. This is especially advantageous for routes that experience significant traffic volumes and frequent use by large vehicles. Polymers enhance the water resistance of asphalt, reducing the penetration of water and consequent harm such potholes and

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erosion. Ensuring road integrity in regions susceptible to high rains is of utmost importance. Certain polymer-modified asphalts are specifically engineered to diminish road noise, resulting in a more serene driving experience. This is accomplished by using the material's improved elastic characteristics, which aid in reducing sound vibrations. Cold mix asphalt is a versatile and easy-to-use material that does not need heating. It is often blended with polymers to enhance its performance [3,4]. This kind of asphalt is very advantageous for promptly and effectively patching and mending roads, particularly in distant or metropolitan regions where hot mix facilities are not readily available. The use of polymers in cold mix asphalt diminishes the need for heating, thereby decreasing energy consumption and emissions throughout the building process. This makes it a more ecologically sustainable alternative in contrast to conventional hot mix asphalt. Full-Depth Reclamation (FDR) using polymers is a method that involves recycling and promoting sustainability. Polymers are essential in full-depth reclamation, which involves recycling old road materials on-site to form a new and stable foundation layer [5,6]. Incorporating polymers into the recycled material improves its characteristics, resulting in more robust and long-lasting roadways, while reducing the need for fresh raw materials. Polymers are used in the manufacturing of geosynthetics and geogrids, which are integrated into road substructures to enhance load distribution and stabilisation. These materials serve to mitigate subgrade displacement and enhance the overall durability of the pavement. Ongoing research is being conducted on the advancement of polymer-based smart road technologies, including the creation of self-healing asphalts capable of autonomously repairing minor fractures. These advanced materials include microcapsules packed with healing chemicals that are triggered when the pavement cracks, therefore prolonging its lifespan [7,8]. The use of polymer chemistry in road building and maintenance provides a multitude of advantages, such as improved longevity, adaptability, resistance to temperature, and ecological sustainability. The use of polymers in road infrastructure is anticipated to expand as technology progresses, resulting in the development of safer and more dependable transportation networks in the future. The global transportation network is supported by roads. The nation's economy and population movement depend heavily on its road network. A good transport system may connect markets and provide significant economic benefits to the populace. However, out of all modes of transportation, highways are the most prone to accidents, placing the public at risk of fatalities, serious injuries, and damaging vehicles [9,10].

In 2021, the state reported 9,933 accidents that left 4,706 people dead and 8,121 people injured. In contrast, 9,431 accidents resulted in the death of 4,507 people in 2020. Gurugram is in first place with 871 accident. These accidents left 379 people dead and 695 people injured. Motorcyclists, pedestrians, and cyclists make up the majority of the vulnerable road users who die on the nation's roads—about half of all fatalities. Day by day accidents are increasing due to so many reasons and sometimes they are very unpredictable levels of seriousness. A stretch of road that is known to have a high accident risk is commonly known as a ‘black spot’ or ‘black zone’. The first stage in creating a safer road network is identifying the sections of highways where accidents happen often, commonly referred to as ‘accident black spots.’ Numerous analytical tools and methodologies have been used throughout the years to pinpoint accident ‘black spots.’ It might happen for a variety of reasons, such as a concealed junction on a busy route, misplaced warning signs, a sudden bend on an otherwise straight road, etc. Road engineers and highway planners have found accident prediction models to be a valuable tool for identifying causes and, as a result, suggesting solutions to increase road safety.

The researcher talks about how to identify the black spots on the road stretch of NH-47 (Godhra - Gujarat MP Border) by the analysis of the FIR data of the year 2012 to 2017 provided by the Police Station record which was written manually in the local language - Gujarati. The collected FIR data of stretch was analysed year- wise to know the accident hotspots in MS Excel [11].

The identification and analysis of the accident data for the NH-44 between Kundli and Panipat, Haryana. In this study, a total of 10 black spots have been identified during the 3 years i.e. 2019 to 2021 in the research area and rank them according to WSI (weighted Severity Index) and also investigate the cause and suggest countermeasures for each blackspot location [12].

The methodology of trying to identify high-density accident hotspots using the spatial tool KDE (Kernel Density Estimation), which allows for the overall visualization and manipulation of the accident based on density and was used to create the fundamental spatial unit for the hotspot clustering method. The study serves as a broad- scale representation of the clustering of traffic accidents [13].

Using demographic and transportation statistics utilizing ANN and non-linear regression approaches, Scientist has made an effort to forecast the incidence of deaths, injuries, and accidents in Turkey. The ANN model was determined to be the one that performed the best overall and had the fewest errors. A fifteen-year timeframe from 2006 to 2020 was used to examine the effectiveness of the ANN model for future estimates. In view of Turkey's anticipated entrance to the EU in 2020, road safety regulations were evaluated using two different scenarios. Indicators of a significant safety issue for the nation's road traffic include the rising number of accidents and injuries caused by vehicles [14].

The process of appropriately digitizing the necessary road network and using prioritization based on predetermined road quality standards. Analysis of the supplied road network then reveals potential accident hotspots. To pinpoint potential accident hotspots, we consider the following factors: Factors such as roadway width, lane count, daily traffic volume, roadway type, drainage infrastructure, and pavement quality all contribute to the overall travel experience. The most common vehicles, the presence of shoulders, the location of obstacles at the edges and the median, the rate of expansion of the ribbon, and the radius of horizontal curves. The prioritising of accident incidence along routes is facilitated by using GIS to blend attribute data with geographical data. This data may be visually represented and used to guide further steps [15].

The investigation and analysis of accidents at various intersections aid in pinpointing the areas where accidents are more common and lower road safety. Ranking the accident location involved using the Weighted Severity Index (WSI) Method. The black area was chosen based on the WSI having a value greater than 40 in the data obtained, and we offered relevant alternate strategies to lower accident rates at such a black spot [16].

The author employ an artificial neural network methodology to determine whether human behavioral features, environmental factors, and road conditions are significant predictors of injury severity. Several neural networks are used to examine the study's hypothesized non-linear relationship between injury severity and crash- related parameters. Find out what led to the different degrees of harm and what circumstances contributed to the crashes Delen et al., 2006) [17].

The number of people killed or injured in car crashes has increased by around 8 percent over the previous decade, and there are no indications that this trend is abating. This study examined the factors contributing to the rising annual toll of traffic fatalities and proposed strategies for analysing and mitigating them, such as the creation of road safety research centers [18].

This article demonstrates how to apply geospatial analysis to line or point datasets with spatially wide properties using Kernel Density Estimation (KDE) and Percent volume contours. KDE is commonly distance represented as a raster dataset, where the density value of each cell is scaled according to its from the initial features. The search's bandwidth or range, the units of measurement, and the attribute field to be used in computations can all be customized by the user [19].

The article is based on research into the many factors that contribute to traffic mishaps in the Lagos Metropolitan Area. To comprehend the Metropolis's accident pattern, numerous geographical and non-spatial datasets were collected, processed, and analysed. The Weighted Severty Index was developed with these factors in mind (WSI). In addition, density-based clustesring was used to figure out how severe accidents occurred in Black Spots. Results include shortest-path analysis, service-area analysis, accident-location severity, and vulnerability level across the Metropolis, all calculated using the

Weighted Severity Index (WSI) [20]. Kernel density algorithms were used to calculate and generate a density surface from point features. Here, density is measured in terms of the overall number of mishaps per unit area [21]The reason for developing this is to identify an appropriate method for prioritizing accident blackspots. The methodology used involves locating the blackspots using the weighted severity index (WSI), accident density, and severity index and ranking methods. The severity index, which reflects an area's susceptibility to accidents, was taken into consideration when creating Kerla's accident blackspots priority list.

A model to identify blackspots on the road stretch. For conducting the model analysis certain factors are considered. These factors are based on Road Geometry such as the number of lanes in each direction, Type of road, Width of formation, Surface condition of the road pavement, Presence of median etc. By taking into account various weights for various parameters, the total weight is calculated and the route is ranked according to its likelihood of accidents [22].

The author describes how the point pattern data have been represented on the map with the help of the spatstat. The multiple points are shown on a single map without any congestion and handling the real data set is to be very easy [23].

The application of the artificial neural network to predict the increment in the accidents occurring in the coming months by using the recent month's data in Turkey Compare the 6 models in ANN. (Mohan and Landge 2017) describes the WSI (Weighted Severity Index) method used to rank the accident blackspot locations which is one of the Quantum of Accident Methods invented by Srinivasan in the year 1987 Weight Severity Index, $(WSI)=(41\times K) + (4\times GI) + (1\times MI)$ Where K is the number of persons killed GI is the number of grievous injuries MI is the number of minor injuries Locations having WSI above 40 are termed accident black spots [24].

The accident-prone zones of the Hyderabad district, Telangana, have been identified using a Geographic Information System (GIS). The 2016 data for traffic accidents in the Cyberabad area have been used for this purpose. Various police departments' accident records will be collected for this investigation. Details about the mishap itself. Date, location, vehicle type, and casualty count are only some of the details stored in the GIS database. Accident analysis research aims to identify high-accident locations and low-safety zones. The ‘IBM SPSS’ program is used to examine accident records [25].

The spatial autocorrelation of pedestrian-vehicle collision data to rate dangerous bus stops using a geographic information system (GIS) technique. After identification developed the maps of the study area in which unsafe bus stands were shown by the point according to their rank and sensitive buffer sizes [26].

The author discussed the traffic accident scenario in India and why they happened in Dehradun city, the capital of Uttaranchal state. The researcher analysis the FIR of the Dehradun police station to identify the main cause of the accident from the year 1998 to 2002, the satellite location of the accident points is plotted in the ESRI ARC GIS. The query modules were created with the availability of a structured output from a collection of input data in mind. Through this analysis, the result comes that the peak hour of the accident was 2 PM and 10 PM. The city of Dehradun is used as a case study to illustrate how a GIS- based database on traffic accidents may be valuable [27].

In the research, as part of our study, we created a base map of Bluefields, Nicaragua, using Google Earth satellite imagery. Using optical imaging, specialists in dengue management chose certain neighborhood’s for focused control measures. These neighborhood’s were based on the distribution of dengue cases, the prevalence of larval infestation, and the potential development sites for larvae. The Google satellite images are used for the representation of dengue-affected patients through ARC GIS 9 for a better understanding of the locations [28].

It shows how to use the open-source GIS program Q GIS to carry out blackspot identification for metropolitan regions of developing countries (Quantum GIS). Blackspots had been identified on the Sardar Patel Ring Road, Ahmedabad city, Gujrat. The creation of maps and geospatial analysis had been done in the Q GIS and gave suggestions to rectify the problems [29].

The analysis of the accident was recorded by the police. This paper deals with the identification of road blackspots on the basis of the FIR data and prioritizes the blackspots according to the WSI method. created the KDE map in ArcGIS to better know the severity of the stretch [30].

It describes Why it's crucial to have up-to-date land use/land cover patterns and how they're affected by human requirements, land abuse, and land exploitation. The authors of this study explain how to utilize supervised classification to determine land use and land cover from satellite images. The use of satellite remote sensing technology enables the collection of current, reliable data on land use and cover, as well as periodic change monitoring [31].

The severity of car crashes was studied in connection to factors like driver, vehicle, road, and environmental conditions using an artificial neural network. Two well-known ANN paradigms, the multilayer perceptron (MLP) and the fuzzy ARTMAP neural network, were investigated [32).33]describes the causes of the accidents and methodology of the identification of the blackspots on a stretch of NH-52 in Aurangabad city, where the research did a detailed study for each location and observed the maximum accidents had occurred during the night due to heavy road traffic as compare to day time. describes how the usage of GIS tools is very helpful in identifying and plotting the accident-prone area. GIS has capabilities will store, query, capture, analyse, and display data and decide to improve road features, assess traffic safety, and improve [34].

Methodology & Study Area

Figure 1. shows the schematic diagram of the methodology for the study is indicated in given chart.

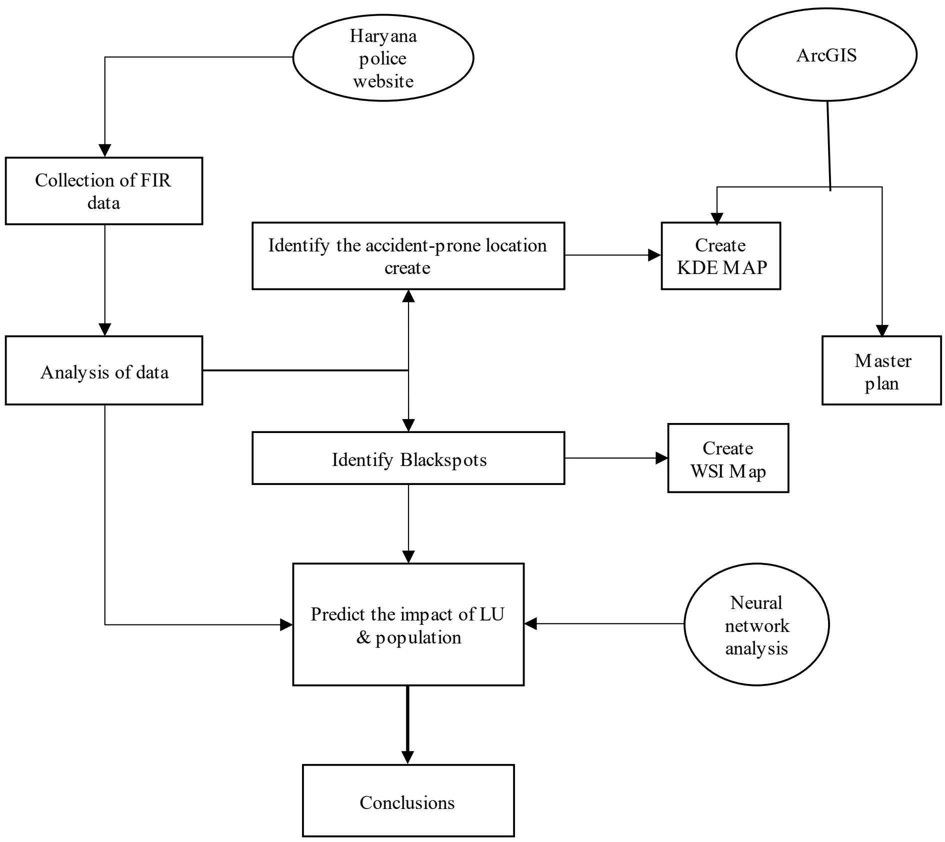

Figure 1. Schematic diagram of the methodology.

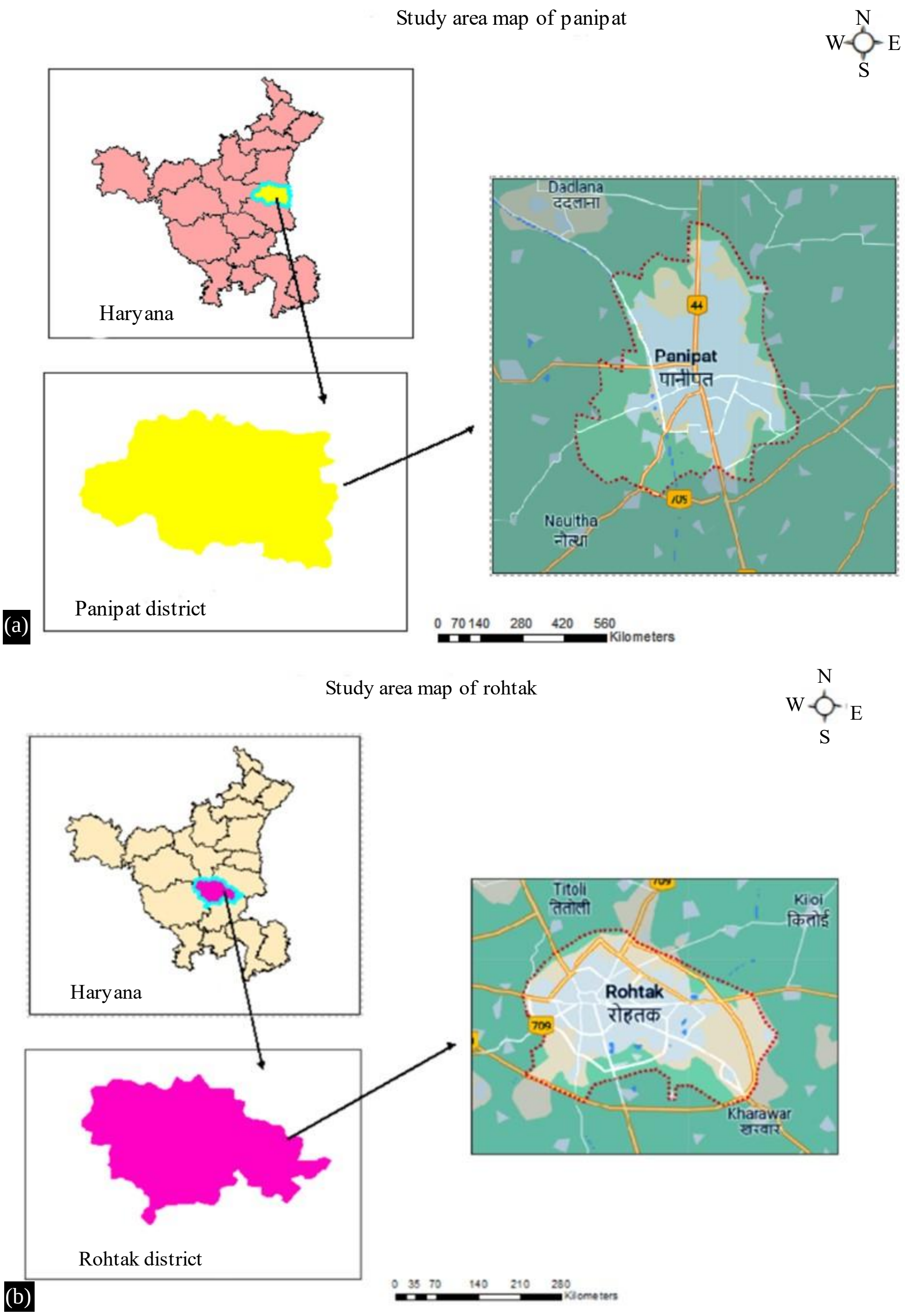

Figure 2. a) The study area map for Panipat City; b) The study area map for Rohtak City.

The city of Rohtak serves as the district's administrative centre of Rohtak district. It is situated on NH 9 (formerly NH 10), some 250 kilometres south of Chandigarh and 70 km northwest of New Delhi. The coordinates of Rohtak are 28.8955° N, 76.6066° E.

DATA ANALYSIS

Identification of Accident-Prone Locations

From the FIR data from 2018 to 2022, the accident-prone locations where 2 or more accidents had occurred, were analysed by applying the spatial tool Kernel Density Estimation (KDE) approach in the ArcMap10.8

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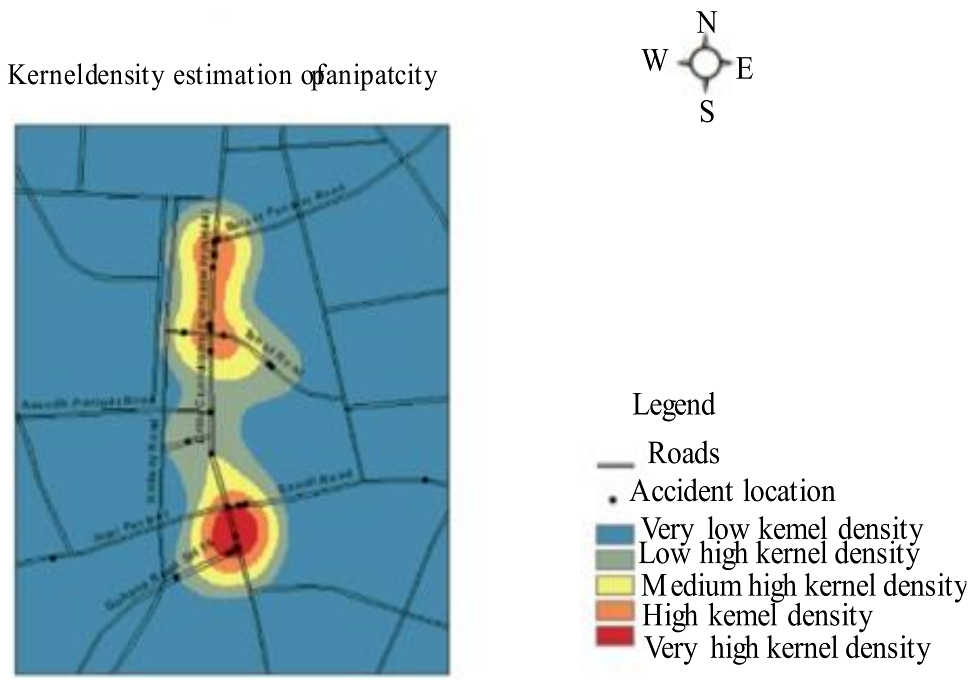
For determining hazardous locations while taking accident severity and spatial interactions into account, Kernel density Estimation (KDE) is highly suggested. (30) had been applied to this approach. The bandwidth and the function K, often known as a ‘Kernel,’ are the two parameters that affect the form of the kernel density when using this method. When referring to risk, the terms "kernel and bandwidth" both refer to a horizontal range of accident likelihood. Consequently, bandwidth and kernel can be viewed as horizontal and vertical elements. The kernel function conceptually divides the studied area into small, user-defined cells, then calculates cell values that are highest at the locations of the points, reduce away from the points, and ultimately reach zero at the radius.

The following steps are followed for making the map of the risky locations of the study areas:

- Initially, using the Digitization tool of ArcMap 10.8, create the master plans with reference from the Google Earth image for both cities (Panipat and Rohtak City).
- Digitize all the necessary features such as road network, buildings, drains, etc.
- Assign the attributes for every feature of the map by adding multiple fields such as Latitude & Longitude, names, land use, population, etc.
- Add the placemarks of the identified accident-prone locations in Google Earth Pro.
- Now, georeferenced the satellite imagery obtained from the Google Earth Pro of accident-prone locations with the master plans of the study areas by georeferencing using the four known coordinates point in the Arc GIS.
- Plotting the accident-prone locations on the master plans, the KDE tool is applied to know the accident severity in both cities, which is also represented in the given below Figure 3.

Both of the aforementioned figures illustrate a map of the Kernel Density Estimation that depicts the road network of the study areas' cities and lists the sites where two or more accidents occurred between the years of 2018 to 2022, the double-lined symbol which is mentioned in the legends of the maps also the black dots are representing the accident-prone locations. The five colour bandwidths represent the accident severity rate of the road stretch of Panipat and Rohtak city such as with red being the very high kernel density which means that the zone is highly risky, lighten the colour up to sky blue representing the very low kernel density which means that zones are low risk.



(a)

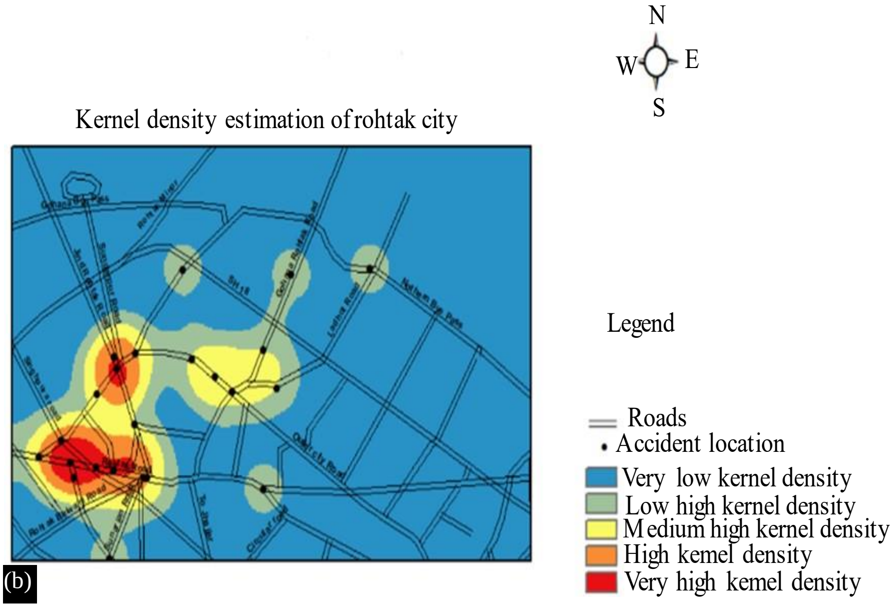


Figure 3. The map showing the Kernel Density Estimation (KDE) of the accident stretches in Panipat and Rohtak city.

Identification & Ranking of Blackspot

High-risk road stretches that have experienced a relatively large number of accidents compared to the rest throughout a given time period are known as accident blackspots. In this study, the locations showing 5 or more accidents during the 3 – year period i.e. 2020-2022 have been treated as blackspots. Accordingly, 5 blackspots have been identified in Panipat & 9 blackspots in Rohtak city.

Table 1. Panipat city.

S.N.	Blackspot location	Road Stretch	Number of accidents	Number of accidental deaths	Number of persons injured	Rank
1	Red Light	Delhi Chandigarh Highway NH-44	10	4	8	1
2	Bus stand	Delhi Chandigarh Highway NH-44	9	4	4	2
3	Sanjay Chowk	Delhi Chandigarh Highway NH-44	5	3	2	3
4	Platinum Textile World	Barast Road	5	2	3	4
5	Sky lark	Delhi Chandigarh Highway NH-44	5	2	3	5

Table 2. Rohtak city.

S.N.	Blackspot location	Road stretch	Number of accidents	Number of accidental deaths	Number of persons injured	Rank
1	Gohana bypass	Rohtak – Sonipat Road	20	12	7	1
2	Hisar by pass chowk	Hisar Road	18	3	15	2
3	Hisar by pass chowk	Hisar Road	18	6	13	2
4	Sukhpura Chowk	Outer City Road	15	4	15	3
5	IDC Chowk	Circular Road	9	6	3	4
6	Valmiki Chowk	Hisar - Rohtak - Sonipat Road	7	1	6	5
7	Drain no.8	Hisar Road	6	5	4	6
8	KVM School	Ladhot Road	5	1	4	7
9	Shyam Colony	Hisar Road	5	1	4	7

Based on the above tables i.e. Table 1 & Table 2 the maps are generated with the help of ArcMap 10.8 of the value of the WSI (Weighted Severity Index) score of the Panipat city in which only five blackspots locations are identified during the period of the year 2020 to 2022 and Similarly, nine blackspots are identified in Rohtak city which are showing with the dots on the master plans of the study areas as per increase in WSI score the size of the dot are increasing respectively. These maps help set the priority of taking necessary steps to rectify the most hazardous location first. Figure 4 shows the map of the WSI accident venerability map of Panipat city & Rohtak city.

The above two Figure 4 are the weighted severity index accident venerability maps of the research areas in which only those locations are considered from the master plans where the blackspots occurred. These black spots are presented by the dot density or size increase according to their WSI value. These maps help set the priority of taking necessary steps to rectify the most hazardous location first.

Implementation of Neural Network

Neural Networks can be defined as a system designed to establish a standard for the brain's functions and features. (24)used this approach, Neural networks are produced by connecting artificial neural cells in different configurations. After passing a learning algorithm and learning process, a Neural network has the potential to gather information, keep it safe, and generalize it using weights between the cells. “Network outputs are determined by subtracting an activation function from the input data. Fig. 5 shows the network architecture of the neural network.

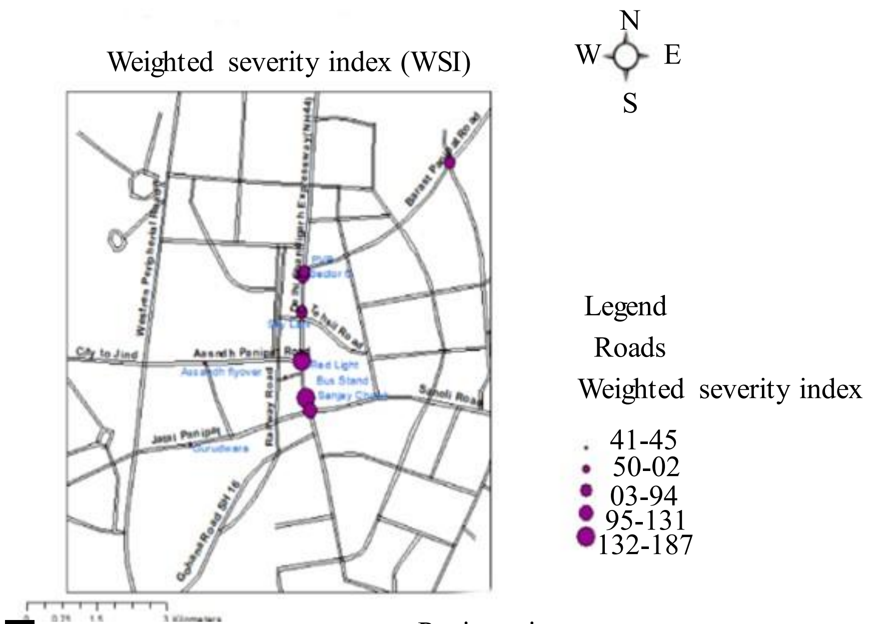
$V=\sum x_i w_i + \theta, \quad y= F(v)$

Where,

W = Weight matrices of cell X= Input vector cell V= Net input cell Y= Output cell

For carrying out the prediction, the neural network method is followed. In this method, tables of the many weighted elements that are likely to affect the frequency of accidents on the roads must be created. These criteria are given weights on a scale from 1-10, with higher weights going to those that reduce the likelihood of accidents. Using the MS Excel spreadsheet, the total weights are determined. The many considerations are taken into account, and each is given the appropriate amount of weight. These include the causes of accidents on the road.

Weighted severity index (WSI)



(a) Panipat city

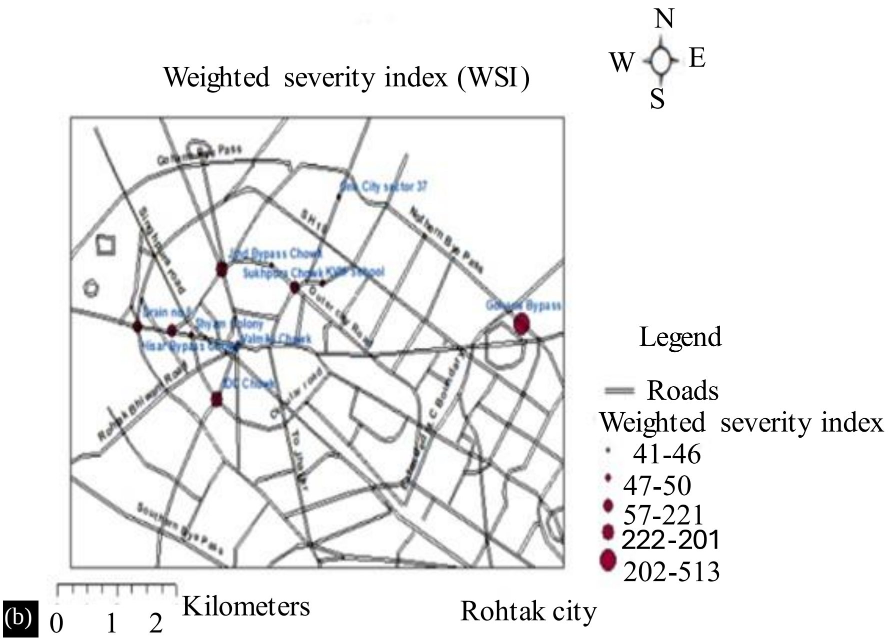


Figure 4. Weighted severity index (WSI) accident venerability Map of Panipat City and Rohtak city.

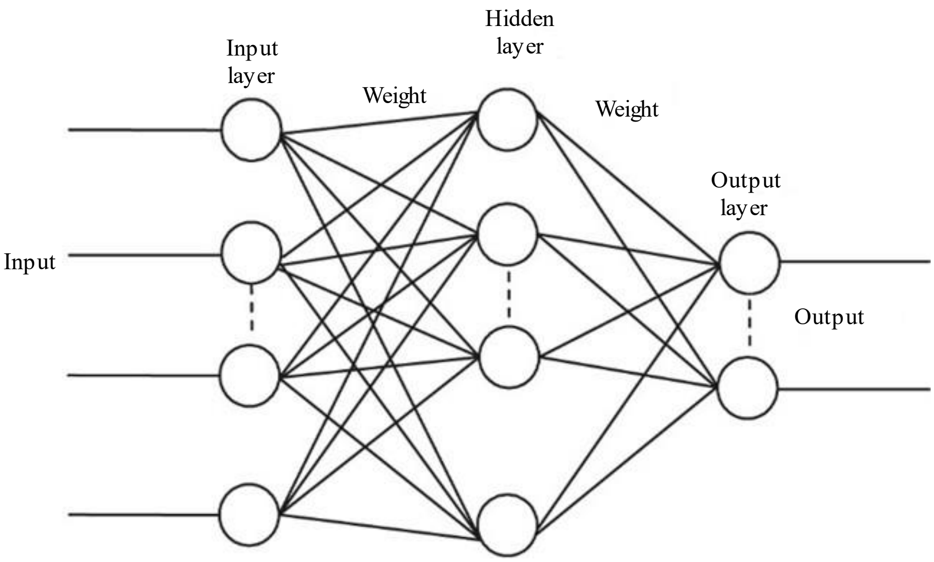


Figure 5. Network architecture for ANN.

The following ten parameters are considered;

1. Number of lanes in each direction
2. Width of formation
3. Class of road
4. Surface Type
5. Surface condition
6. Drainage facility
7. Shoulders
8. Median
9. Land Use
10. Population

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The total weight allocated for each road segment is found by adding the weights together, finding the mean, and then normalizing the result using the maximum weight (in this example, 90).

Hence,
Total Weight = (∑ Individual Weights) /90 × 100

On the bases of the final weight percent which have been calculated by the above criteria, the accident-prone level i.e. low, medium& high have been given to every location. The following Table 4 represents the three accident-prone levels as per final normalized weights.

Table 4. Prioritization Table.

Final normalized weights	Accident prone level
75-100	Low
40-75	Medium
0-40	High

Table 3 & Table 4 represent the actual road prioritization factors of the selected stretches as per the KDE (Kernel Density estimation) for both research cities. In these tables, all the necessary data have been allotted which were either collected by Google Earth Pro, site visits, or by internet-like population data for the year 2022.

The following Figures 6,7,8 & 9 generated by the neural network shows the network architecture for both the research cities by including and excluding population and land use pattern (9,10,35–40).

Table 3. Factors used in prioritization with their weights.

S.N.	Factor affecting occurrence of accidents	Possible variation	Weightages assigned
1	No. of lanes in each direction	1	2
		2	4
		3	6
		4	10
2	Width of formation	>6m	1
		6m-8m	3
		8m-10m	5
		10m-12m	7
		>12m	10
3	Class of road	NH	1
		SH	4
		MDR	8
		other roads	10
4	Surface Type	Bituminous	4
		Concrete	10
5	Surface condition	Poor	1
		Fair	6
		Good	10
6	Drainage facility	Absent	2
		poor	4
		Satisfactory	6
		Good	10
7	Shoulders	Absent	4
		Unpaved	6
		Paved	10

8	Median	No	4
		Yes	10
9	Land use	Industrial	2
		Commercial/ Public use	4
		Residential / Town	8
		Open Space	10
10	Population	<5000	10
		5000-10,000	7
		10,000-15,000	4
		>15,000	1

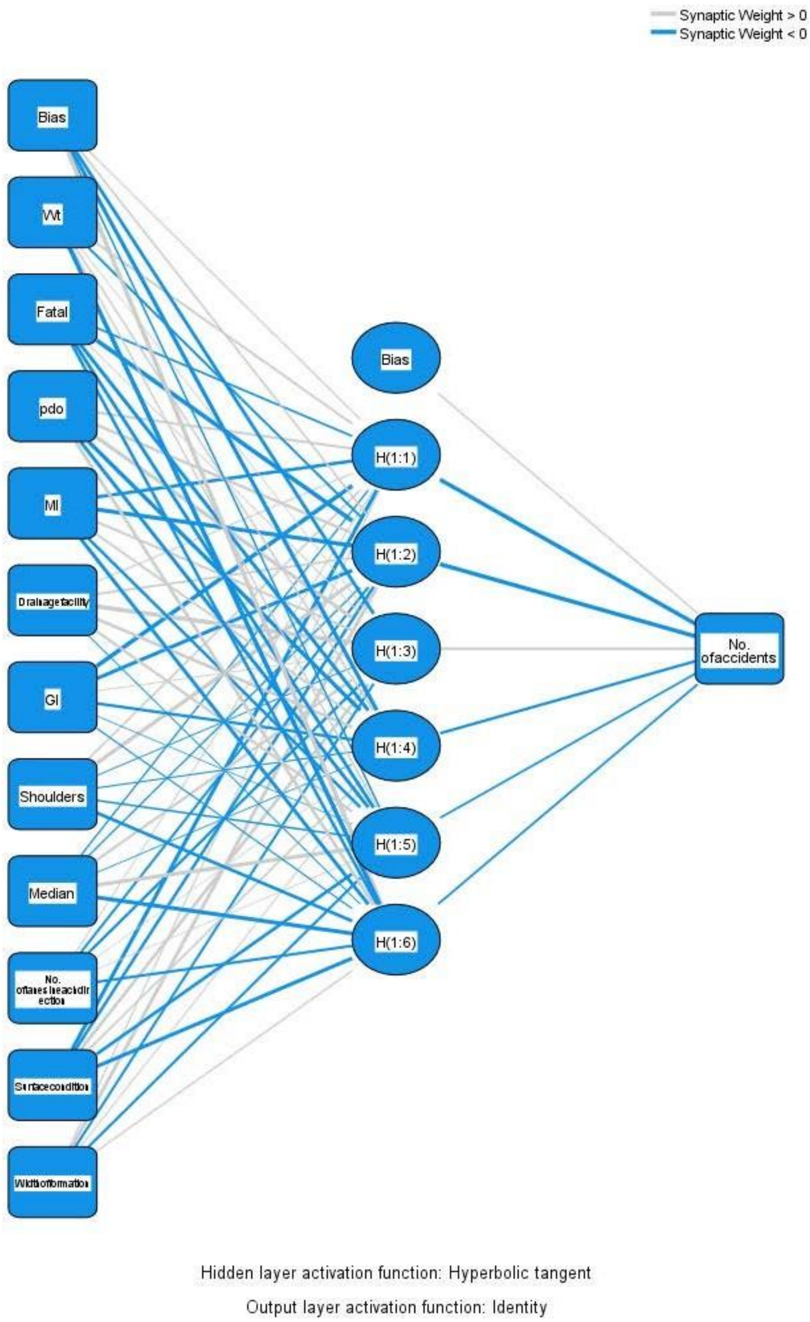

Figure 6. Network architecture for panipat city by considering road factors excludingpopulation and land use pattern.

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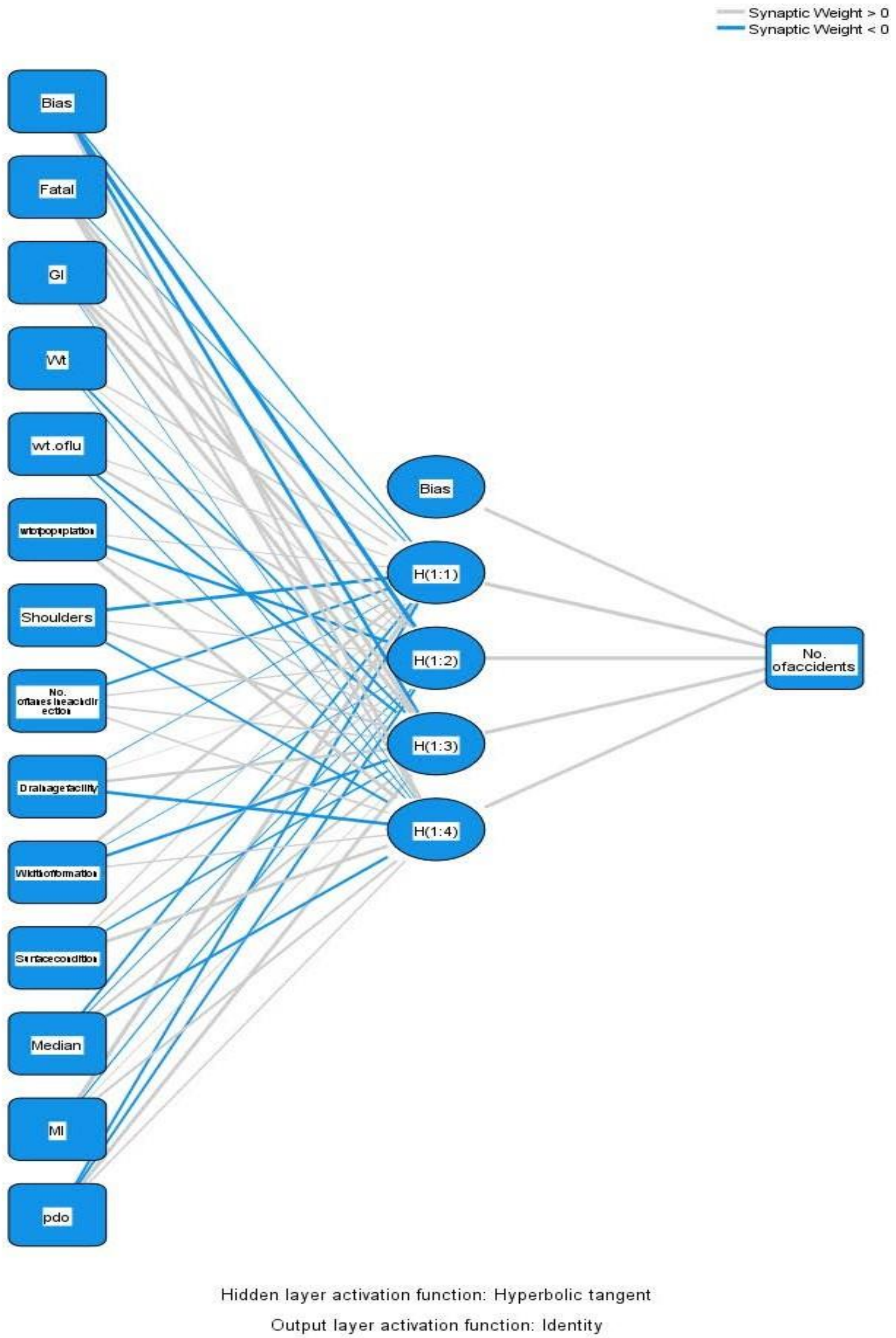

Figure 7. Network Architecture for Panipat city by considering all road factors including population and land use pattern.

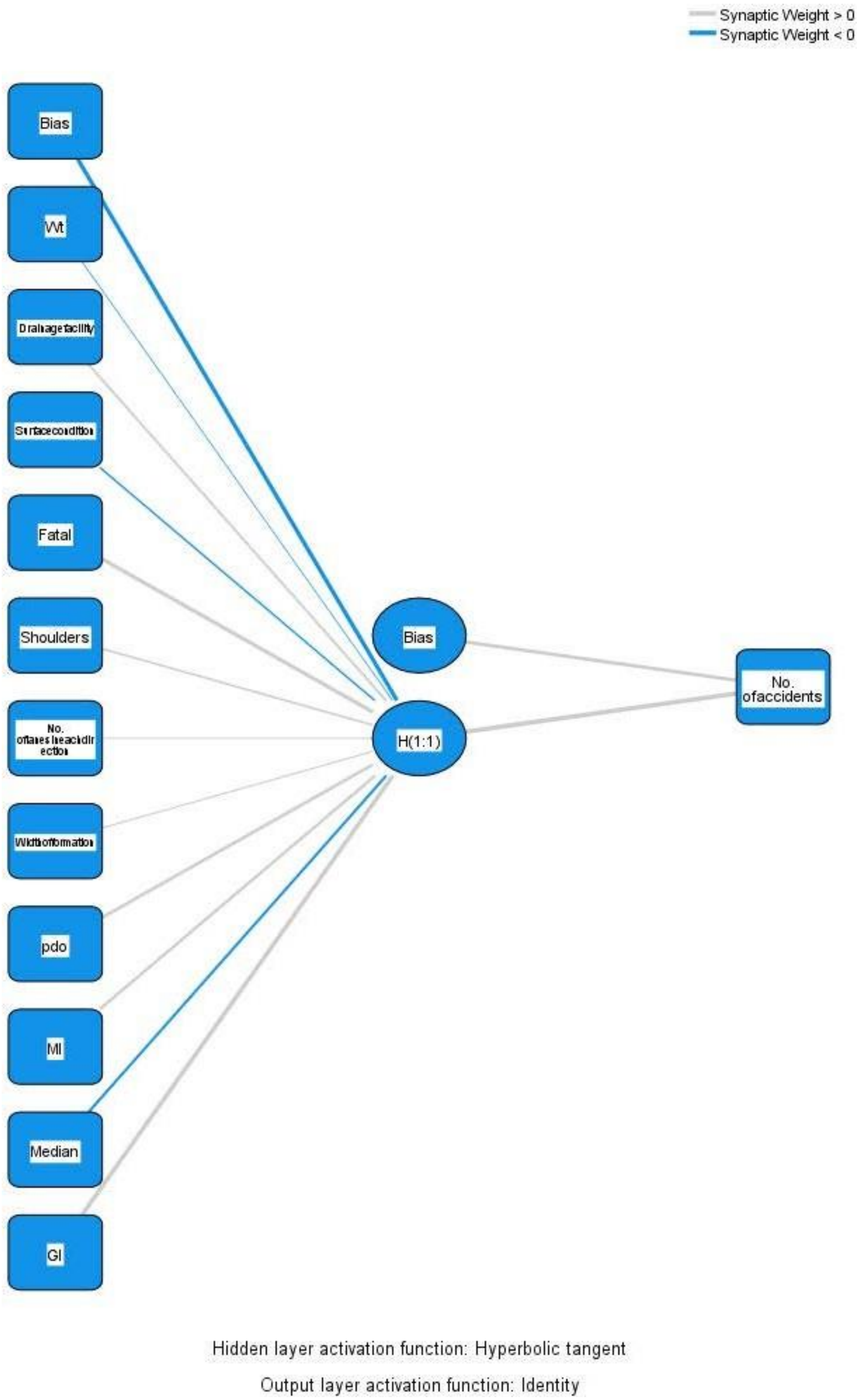

Figure 8. Network Architecture for Rohtak city by considering road factors excluding population and land use pattern.

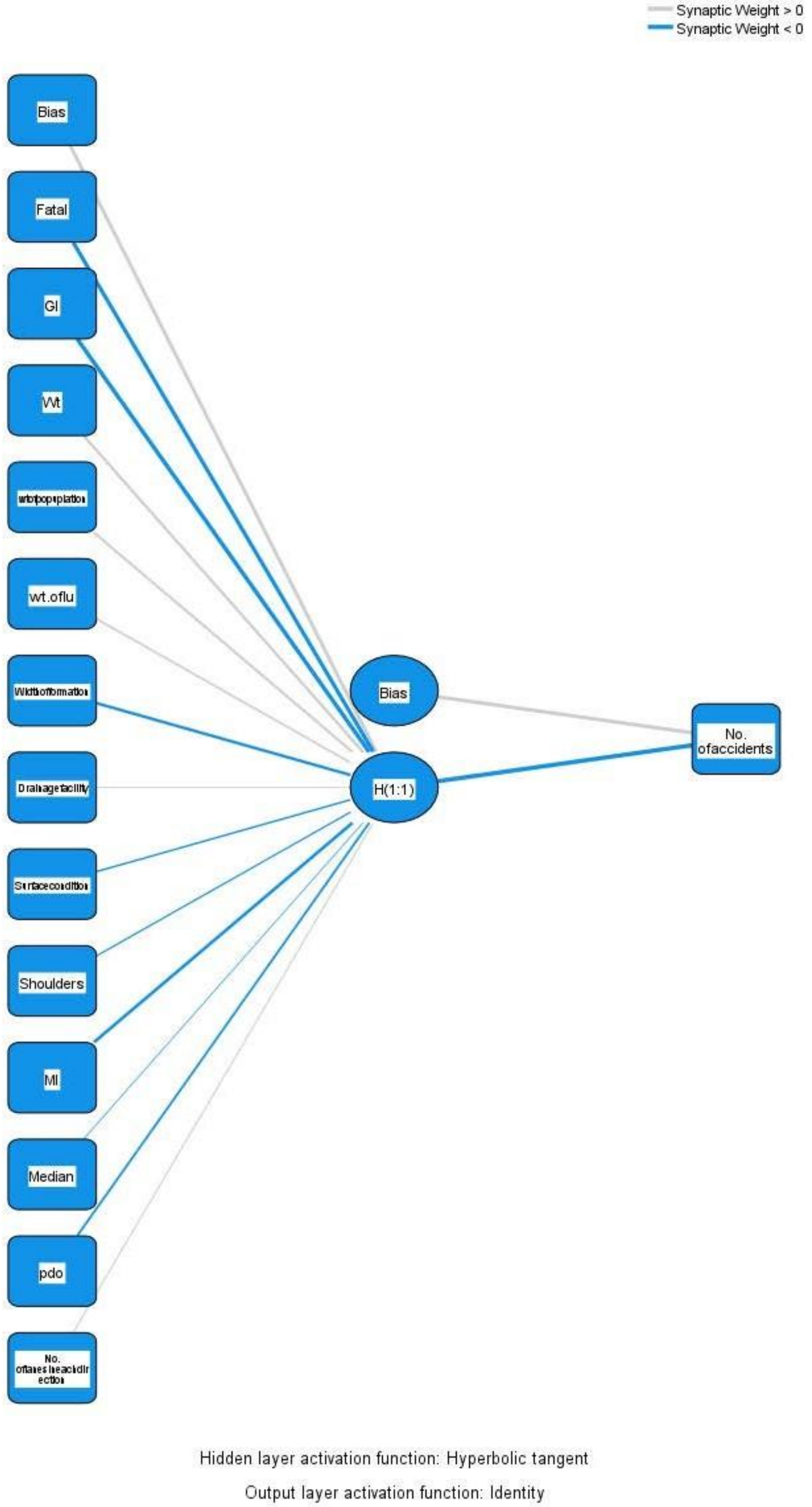

Figure 9. Network architecture for Rohtak city by considering all road factors including population and land use pattern.

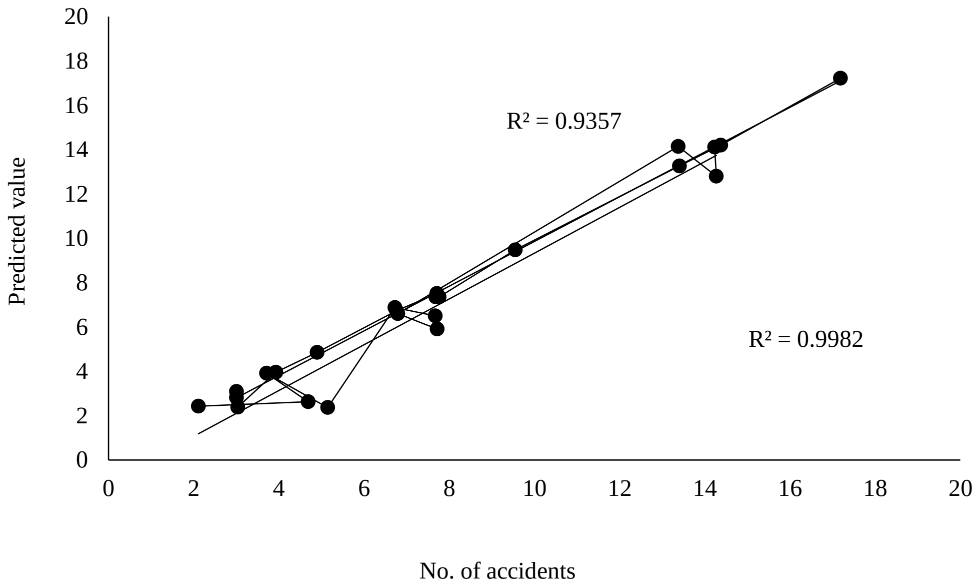

Figure 10. Predicted value No. of accidents relationship for panipat city.

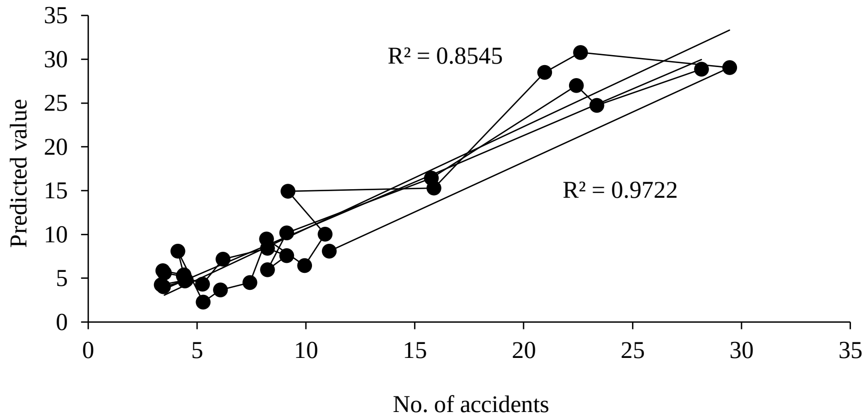

Figure 11. Predicted value – No. of accidents relationship for Rohtak city.

The above Figure 10 & 11 shows the comparison of regression value, R^2 between the excluding and including land use & population factors for Panipat and Rohtak city. Table 5 describes the predicted values and number of accident equations.

Table 5. Predicted value – No. of accidents Equations

Sr. N.	City	Road factor	Equation
1	Panipat	Excluding LU & Population	Y = 1.0325x - 0.9948
		Including LU & Population	Y = 1.0082x - 0.2236
2	Rohtak	Excluding LU & Population	Y = 1.1655x - 1.0007
		Including LU & Population	Y = 1.0621x + 0.0538

RESULTS AND DISCUSSION

From the detailed analysis of 5 – year accident data of both research area i.e Panipat and Rohtak city total impact on the blackspots of population and land use. The following observation can be drawn from the study:

- During 2018 – 2022, a total of 189 road accidents took place in the study areas i.e. Panipat City, and 253 road accidents happened in Rohtak city
- In Panipat city, 62 people were killed &153 people were injured in 189 accidents, which include 92 grievously injured, 48 minor injuries, and 13 Property damage only. Similarly, in Rohtak city ,82 people killed & 179 people were injured in 253 accidents, which include 115 grievously injured, 50 minor injuries, and 14 were Property damage only.
- A total of 21 accident-prone locations were found in Panipat City and 29 accident-prone locations were found in Rohtak City from 2018 to 2022.
- In terms of the KDE (Kernel Density Estimation), the Sanjay Chowk on the stretch of Delhi Chandigarh highway NH-44 was identified as in the red zone (very high kernel density) which means the frequency of accidents was higher than the order locations, Sky lark to PVR stretch comes under the orange zone (High kernel density).
- In Rohtak City, the Hisar bypass chowk & Jind bypass chowk have come under in red zone, where the bandwidth of the red zone in Hisar bypass chowk have higher than the Jind bypass chowk.
- As per the MoRTH guidelines, a total of 5 blackspots have been identified in Panipat city and 9 blackspots in Rohtak city.
- In Panipat city, Sky lark blackspot on the NH-44 stretch, and in Rohtak city Gohana bypass Chowk has been identified as rank 1 as per the Weighted Severity Index.
- As per the table 4 of the accident prone level all the selected blackspots in Rohtak lies in the medium level except Shukhpura chowk which has been in low accident prone level. Similarly , in Panipat Platinum Textile World, Assandh flyover have lies under the low accident prone level and rest eleven locations have in medium level.
- It is observed from the relationships between predicted value – no. of accidents for Panipat, the regression value R^2=0.93, by adding Population & Land use pattern the regression value R^2=0.99 has increased up to 0.6 or 6 % and for Rohtak the regression value R^2=0.85, by adding Population & Land use pattern the regression value R^2=0.97 has increased up to 0.12 or 12%. The impact of adding two new factors i.e. Population & Land use pattern in the road prioritization weights in Rohtak almost double than the Panipat city.
- The reason of the greater impact of LU & population has be the segregation of the data, the location of the blackspots have been distributed within the whole city, where the variation can be seen in the LU& population data, but in Panipat city, the maximum number of accidents occurred on the same stretch and lesser location of the blackspots compare as Rohtak i.e. on Delhi Chandigarh highway (NH-44) , so that the data of LU & Population could not change.

CONCLUSIONS

The study presented in the dissertation is conducted to predict the impact of the LU& Population on the blackspot locations. The following main conclusions are drawn from this work:

- The identification and analysis of accident black spots help in identifying the stretches were accidents are more and these spots reduce the road safety in general. The spot on the road were traffic accidents frequently occur is termed as black spot.
- Using GIS generated maps seems to be convenient for the identify the location of the accidents and also understood the land use / land lover pattern of the area.
- The WSI (weighted severity index) method was used to rank the accident locations. The top ranked spot was selected and it will help in prioritize to rectify the cause of accident at the top ranked location.
- The predicted impact of the population and land use pattern on the blackspots have been increased for Rohtak city.
- Information derived from land use& land cover change and population can be helpful in reduce the chances of occurring the blackspots at planning stage.

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