Black Spot Location Identification for National Highway: A Case Study of Mugling – Kotre Section of Prithivi Highway of Nepal

Rajan Gurung[1], Rajendra Aryal[2], Narayan KC[3], Buddhi Raj Joshi[4*]
[1, 2, 4] School of Engineering, Faculty of Science and Technology, Pokhara University, Pokhara-30, Kaski, Nepal
[3] Kathmandu Metropolitan City-16, Kathmandu, Bagmati, Nepal
[*]Corresponding Author: buddhirojana2@gmail.com

Abstract

The rapid development of road infrastructure enhances connectivity and at the same time increases road crashes. A road traffic accident is one of the leading causes of injury and death in Nepal that has a great impact on the country's economy. The identification of frequent road traffic crash spots and their causes are essential for the implementation of the most efficient countermeasures. Accident black spots are high-risk spots where numbers of accidents take place frequently and repeatedly. The study focused on the identification of black spots on the Mugling-Kotre section of the Prithivi highway of Nepal to provide knowledge for possible preventive measures for the improvement of road safety. The weighted severity index (WSI), prioritization index (PI), and focus group discussion have been performed to evaluate the safety status in the proposed area. The accident data were analyzed based on the weighted severity index (WSI), and the prioritization index (PI) was estimated by assigning a suitable weight to the factors contributing to an accident. Based on these results, six accident spots have been found critical regarding traffic safety. The result obtained from WSI and PI was further evaluated based on the focus group discussion so that essential safety measures could be implemented to enhance road safety.

Keywords: *Black spots, Prioritization index, Road traffic accidents, Road Safety, Weighted severity index*

Introduction

Nepal's national highway network consists of 11178.92 kilometer (km) which influenced 2370.04 persons per km based on the Population Census 2011 and density of 7.58 km/100 square km (DoR, 2021). A road traffic accident is a global tragedy with an ever-rising trend that is considered a brutal anthropogenic disaster and have a disproportionate impact on residents of low-and middle-income countries including Nepal where around 90% of fatality occur (Mowafi et al., 2021). Globally, around 1.3 million people die each year because of road traffic crashes among which children and adult of age 5 to 29 years seem critical and half of the death belongs to pedestrians, cyclists, and motorcyclists (Ahmed et al., 2023; Angın et al., 2021; Babaie et al., 2022). The effects of injuries and fatalities due to road traffic accidents (RTAs) have a tremendous impact on the socioeconomic development of a country (Elmrghni, 2022). According to WHO-2021, Road Traffic Accidents Deaths in Nepal reached 4,654 or 2.90% of total deaths in the year 2020. The fatalities and injuries occurred not only due to RTA but also due to vehicle falling, overtopping, flood sweeping, and landslide burial in Nepal. Such traffic accidents not only cause personal losses but also a significant burden to the gross domestic product of any country. Analysis of road accident scenarios at the state and city levels shows that there is a huge variation in fatality risk across states and cities (Singh, 2017). In response, the United Nations released the Global Plan for the Decade of Action for Road Safety 2011-2020 in 20112 and included road traffic injury prevention as Target 3.6 of the Sustainable Development Goals (SDG) in 2015. Despite overwhelming concerns and investment from national and international agencies regarding road safety in Nepal, the total costs of Road Traffic Injuries (RTI) in 2017 were estimated at USD 122.88 million which is 1.52% of the gross national product (GDP) (Banstola et al., 2020).

The growth in the number of motor vehicles is a direct result of the rapid growth of the population and increased economic and technological development. Road transport has been a very easy and popular service in Nepal, despite the poor and vulnerable condition of roads, with over 90% of the goods being transported by roads (Khadka et al., 2021). There are various contributing factors including vehicular characteristics, road user characteristics, and the condition of road infrastructure resulting in fatalities (Mohanty et al., 2022). The main causes of road traffic accidents are multifactorial, arising from four sources: driver-related, vehicle-related, road-related, and environment-related (Deme, 2019; Hadaye et

al., 2020; Molla, 2023). The Ministry of Physical Infrastructure and Transport (MoPIT) is the central authority of the Government of Nepal charged with the responsibility to enhance the economic and social development of the country by linking various geographical and economic regions through the national strategic transport network. MoPIT is responsible for linking rural areas of the country with markets to support economic activities and projects related to tourism, agricultural, electrical, industrial, and other sectors of Nepal.

Nepal suffers a heavy burden of RTI, with fatalities occurring mainly on highways caused by bus crashes in hilly districts out of Kathmandu Valley. Traffic police data and hospital medical records provide the sources for RTI information. Most published studies on road traffic injuries (RTI) in Nepal are descriptive and hospital-based, suggesting that persons in the age group 20–40 years, males, pedestrians, and motorcyclists are commonly injured (Huang et al., 2017). The major reasons for accidents were high speed of vehicles, steering or brake failure, untrained and intoxicated drivers, driving by cleaner/conductor, continuous long duty hours of drivers, poor condition of the vehicle, muddy and slippery roads, haphazard overtaking practice on single lane roads, lack of concentration of drivers on driving, non-observance of safety measures, traffic rules and signs, drive a vehicle without wearing seat belt/helmet, kept more passengers than allowed/ available seats, hung passengers on gate, backside and roof, loaded cargo beyond the limited weight and height (Kumar Bhagat, 2017; Pradhan et al., 2023).

Nepal has a National Road Safety Strategy and Road Safety Action Plan based on the five pillars of the United Nations Global Plan for the Decade of Action for Road Safety 2011– 2020: road safety management; safer roads and mobility; safer vehicles; safer road users; and post-crash response. However, limited progress has been made in addressing these pillars and consequently, Nepal is facing serious road safety challenges despite significant budget allocation in collaboration with national and international institutions. Road safety initiatives must be inclusive of all road users and roadside communities and places, especially of those users that are most vulnerable and least protected in their road environments (C. M. Chang et al., 2022). Inclusive road user policies and integrated land use/transport planning and place-making are necessary to ensure urban and rural roads are safe and accessible for all road users in Nepal. Nepal must work on upgrading the legislation and policy by considering the financial implications, adequate funding to employ staff to implement and enforce laws, and financial investment for the infrastructure and human resources to support the monitoring of injury prevention efforts (Pant et al., 2021).

The identification of black spots is the most important aspect of road traffic accident management and top priority must be given to correcting black spots on highways (Bisht & Tiwari, 2020). The traffic accident data and accessing road attributes are helpful for the identification of black spots. Geometrical and physical conditions, traffic volumes, average speeds and average accident rates at around black spots are considered effective factors in the occurrence of accidents (Murat, 2011). The WSI, PI, and Analytical Hierarchy Process (AHP) for the identification of black spots are equally important for the identification of blackspots for highways in Nepal. The Prithivi highway between Mugling and Pokhara is one of the major gateways for economic and tourism activities in the region. It is essential to improve capacity, reliability, and safety for long-term sustainability. The road, which currently does not segregate slow-moving vehicles and pedestrians, needs to be upgraded with service lanes in urban areas to improve safety, particularly for women and children, who are more likely to walk, ride a bicycle, or use public transport which requires capacity augmentation and pavement reconstruction to maintain acceptable levels of services. The fifth plan (FY: 2019/2020-2023/2024) of the Government of Nepal has included the improvement (Phase 1) of the Mugling-Pokhara road section which is under construction. The project is assumed to be finished in the year 2025 with the total estimated cost of the project being $254 million. The Asian Development Bank (ADB) has approved a $195 million loan to improve the highway section between Pokhara and Mugling in Nepal and the Government of Nepal will provide $59 million which was stated in the loan agreement document. The design standards are supposed to feature enhanced geometry, pavement, structure, drainage, and safety; and an intelligent traffic system to improve sustainability, safety awareness, and safety compliance. So, the study has ample opportunity to enhance the safety status during re-construction which may lead towards safer

travel in the days to come. In conclusion, as part of the project, 81 km of road will be widened to four lanes from Pokhara to Abukhaireni and improvements will be made to the surfacing, structure and drainage including installation of safety features such as crash barriers, traffic signals, and other warning light systems. Despite the road improvements, it is essential to work on traffic safety by considering the perception of the road users.

A multi-disciplinary approach is always needed in understanding and solve the problem of road traffic accidents (Gopalakrishnan, 2012). The study considers road traffic crashes that involve fatalities, minor injuries, and major injuries to identify black spots section of the highway. The other types of road accidents were not included in the study. The analysis of the study is based on the WSI and PI estimation for black spot identification. For black spot identification, a detailed investigation of the causes of the crashes, understanding the impact of road crashes, and sustainable preventive measures including systematic recording of road crashes are the essential area of improvement for Nepal. This study has only utilized the traffic crash data which is registered in the database of the traffic police office at Tanahun District. This study focuses on the analysis of road crashes, analysis of prioritization of critical locations for road crashes so that respective authorities may plan and design preventative measures to improve RTA in Nepal, especially in the Mugling-Kotre road section of Prithivi Highway.

Materials and Methods

Study Zone

The study area consists of the Mugling-Kotre road section of Prithivi highway 71 km in length which mainly passes through the Tanahun District of Nepal. The road section touches Anbukhaireni Gaupalika, Bandipur Gaupalika, Byas Nagarpalika, and Shuklagandaki Nagarpalika.

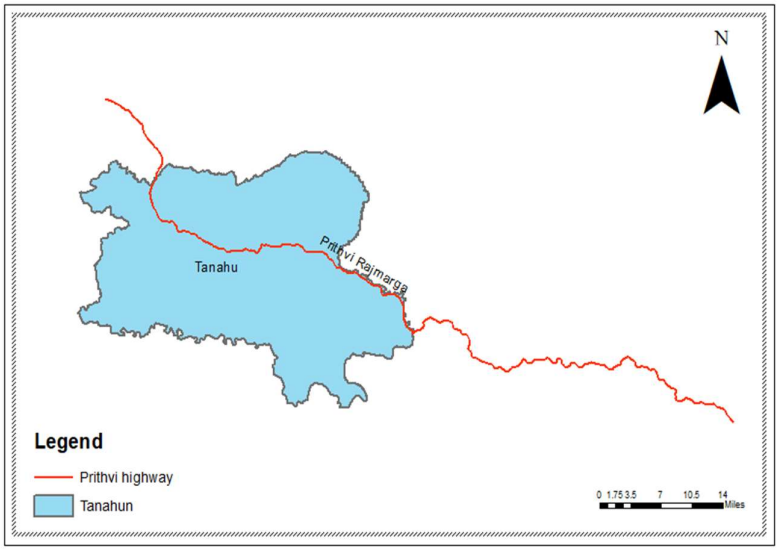

Figure 1: GIS map of the study area

Data Collection

Primary Data

Road inventory survey and road attributes survey has been conducted at various sections of the highway. A focus group discussion was also carried out at various places to ascertain the safety condition of the road sections.

Secondary Data

Accident data for three fiscal years (FY:2075/66, 2076/77, 2077/78) were collected from the traffic police office of Tanahun District. The accident data contains the information regarding date, time and location of the accidents including major and minor injuries, number of fatalities, vehicles involved and probable cause of an accident. In addition to this, literature, reports, and information from the website of the Department of Roads (DoR) were considered secondary data for the analysis.

Data Analysis

The quantitative data analysis was done for the identification of black spots based on WSI, and PI and each attribute has been statically analyzed for significance. The qualitative data analysis was done based on the respondent's perception regarding the safety condition of the road section. The weighted severity index is calculated based on the classification of accidents as fatal (K), grievous injuries (GI) and minor injuries (MI). High-quality data are the foundation to identify black spots and evaluate the effects of road traffic injury prevention measures (F. R. Chang et al., 2020). The location having the highest severity index value is ranked first followed by the rest. The concept of this method is that fatality or injury crashes are given greater weight than property damage-only crashes. The weights are given based on socio-economic values and is a dimensionless value indicating the hazardousness of a spot (Ramos et al., 2015; Vyas et al., 2015). The WSI value can be estimated by using (Equation 1) listed below.

WSI = 41K + 4GI + MI……. (Equation 1)

Where WSI – Weighted Severity index

K - Number of fatalities

GI - Number of grievous injuries

MI -Number of minor injuries.

Similarly, black spot locations can also be identified without the use of traffic accident data which utilizes the road attributes and geometric parameters (Keymanesh et al., 2017) that provides the safety status regarding geometrical features of the road. The information regarding the number of lanes, the width of the road, drainage condition, visibility, frequent vehicle types, presence of shoulder, edge obstruction, median barrier, and International Roughness Index (IRI) value has been collected at various critical road sections. The IRI value has been assigned from the DoR guidelines. The assigned weightage for each parameter has been presented in the following table (Table 1).

Table 1: Assigned weightage of road geometry parameters.

Factors occurrence of accidents	**Possible variations**	**Weight Assigned**
Number of lanes in each direction	1	4
	2	6
	3	8
	4	10
Width of the road	Single lane 3.75 m	2
	Two lanes without raised kerbs, 7.0 m.	4
	Two lanes with raised kerbs, 7.5m	6
	Intermediate carriageway	8
	Multi-lane pavements	10
Drainage facilities provided	Good	10

Factors occurrence of accidents	**Possible variations**	**Weight Assigned**
	Satisfactory	7
	Poor	4
	No Drainage	1
Visibility	Very poor	2
	Poor	4
	Average	6
	Good	10
Frequent vehicle type on the road	Bus / Truck	2
	Car	4
	Two Wheelers	6
	Bicycles	8
	Cart	10
Presence of shoulders	Yes	10
	No	4
Presence of edge obstructions like advertising hoardings, trees etc. very close to the road	Yes	4
	No	10
Provision of median barriers to channelize the traffic	Yes	10
	No	4
International roughness index (IRI) value	>3.5	1
	3-3.5	2
	2.5-3	4
	2 - 2.5	6
	1.5-2	8
	1 - 1.5	10

The PI of each road section can be estimated by adding all the individual weights and normalizing the value using the maximum weight as below (Equation 2).

$$\text{PI} = \frac{\Sigma \text{ Individual weight } \times 100}{\text{Total weight assigned}} \ldots\ldots\ldots \text{(Equation 2)}$$

Based on the GSI and PI, the most critical section of the road regarding traffic safety concerns can be categorized and finally compared with the perception of road uses.

Research Framework

The conceptual framework functions as a road map for the study, offering an organized and methodical strategy to direct data collection, analysis, and interpretation. It aids in the development of a clear understanding of the research topic, the formulation of research questions, the creation of suitable methodologies, and the interpretation of the results. In the realm of research, the term "solution" typically pertains to the proposed approach or intervention derived from the theoretical understanding

provided by the conceptual framework. This approach often strives to address a problem or improve a particular situation which has been presented in the following figure (Figure 2).

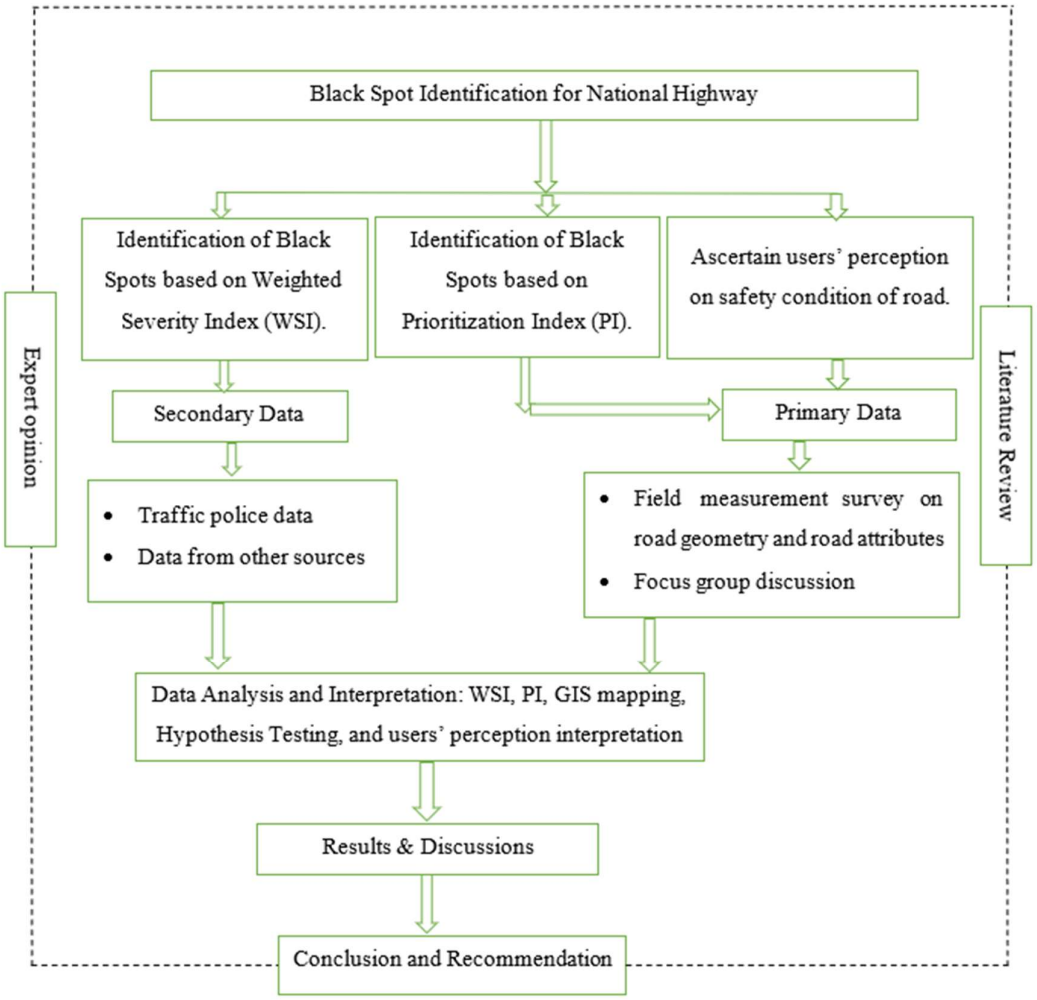

Figure 2: Methodological Framework

Results and Discussion

Weighted Severity Index

The weighted severity index is calculated based on the classification of accidents as fatal (K), grievous injuries (GI) and minor injuries (MI) using (Equation 1) and using data from (Table 2).

Table 2: Secondary data of road crashes collected from Traffic Police office Tanahun District

Fiscal Year	Number of Fatality	Major Injury	Minor Injury	Number of Accident
2075/76	60	118	70	108
2076/77	44	63	85	68
2077/78	48	76	51	90
Total	**152**	**257**	**206**	**266**

The calculated WSI of each the road section has been presented in the following graphs (Figure 3).

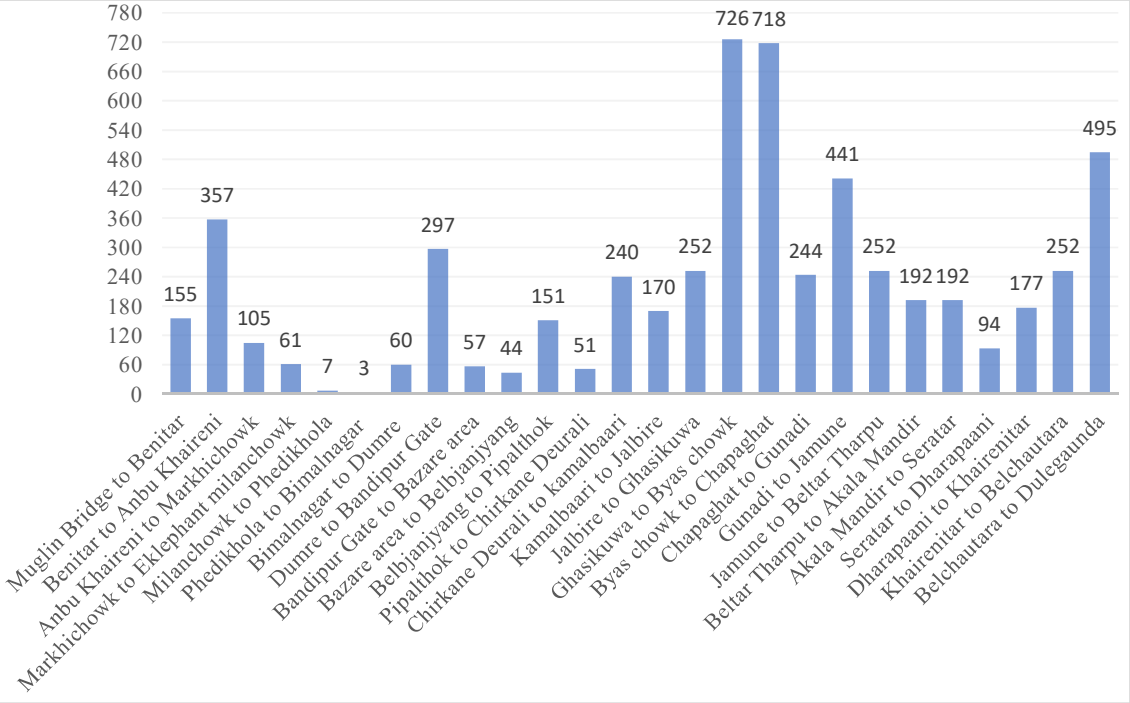

Figure 3: Calculated WSI value for different road section

The BSL was identified by using WSI. The WSI value of different locations has been calculated and it shows that the Ghasikuwa to Byas Chowk section of the Prithvi highway has the highest WSI value indicating the most hazardous location and accident risk-prone zone. Similarly, the Byas Chowk to Chapaghat area has the second largest WSI, Belchautara to Dulegaunda area has the third largest WSI, Gunadi to Jamune area has the fourth highest WSI, Benitar to Anbu Khaireni has the fifth highest WSI, and Dumre to Bandipur Gate has sixth highest WSI value respectively. The major causes of the accident are due to the driver's fault, the types of vehicles, the condition of the road. The main cause of the RTA is due to carelessness, use of alcohol, over speeding, and overtaking in the critical sections of the road. Similarly, pedestrians are equally responsible for road crashes. The poor pavement conditions are also responsible for the RTA which causes the impact on the vehicle that causes RTA in the highway. The maximum number of motorcycles are being involved in RTA in the critical section of road.

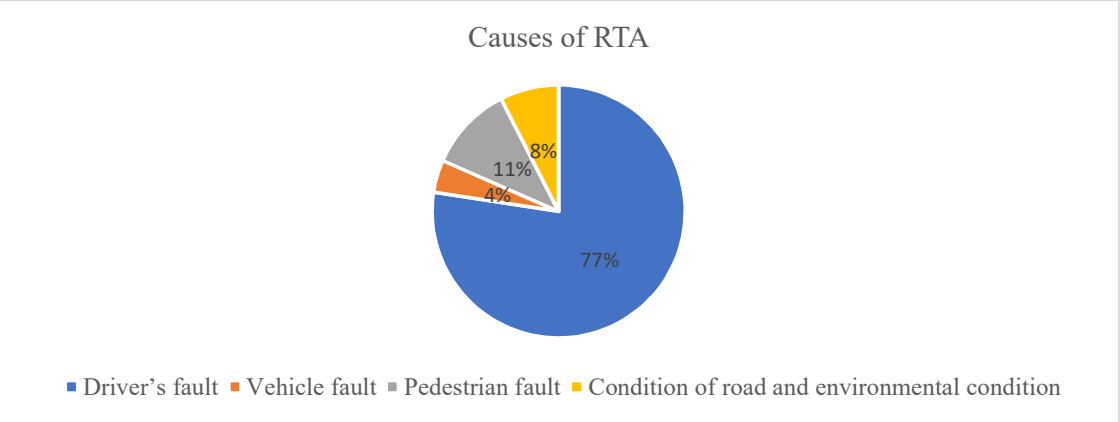

Figure 4: Causes of RTA in the section of road

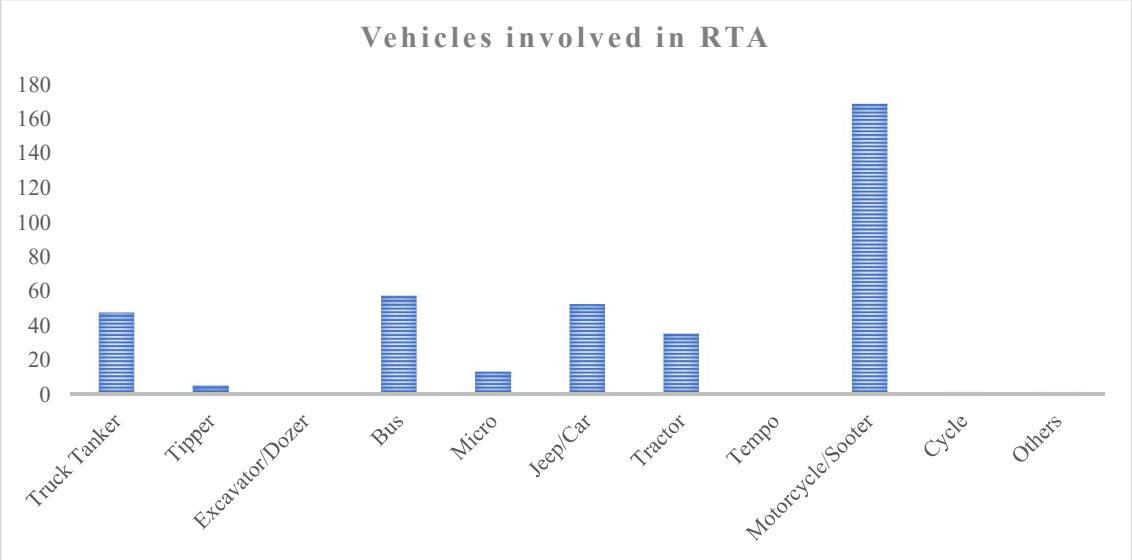

Figure 5: Vehicle type involved in RTA

Prioritization and mapping in geographic information system

The field survey was done to evaluate the road geometry which includes the number of lanes, width of the road, drainage condition, visibility, frequent vehicle type, shoulder condition, edge obstruction, and median barrier, and IRI has been measured at various road sections.

Table 3: Condition of road geometry parameters for PI

Name of Section	No. of lanes in each direction	Width of road (m)	Drainage Facility	Visibility	Frequent vehicle types	Presence of shoulder	Edge obstruction	Median Barriers	DoR Average IRI Value
1	2	7.8	Poor	Very poor	2 wheelers	<half	Yes	No	6.66
2	2	11	Poor	Poor	2 wheelers	<half	Yes	No	7.49
3	2	11	Satisfactory	Average	2 wheelers	Yes	Yes	No	9.61
4	2	9	Satisfactory	Average	2 wheelers	Yes	No	No	6.66
5	2	11	Good	Average	2 wheelers	Yes	No	No	4.8
6	2	11	Good	Average	2 wheelers	Yes	Yes	No	6.14

Table 4: Assigned value for PI calculation.

Name of Section	No. of lanes in each direction	Width of road (m)	Drainage Facility	Visibility	Frequent vehicle types	Presence of shoulder	Edge obstruction	Median Barriers	DoR IRI Value	Total (=Σall×100/90)	Accident prone level	Rank
1	4	4	4	2	6	4	4	4	1	37	High	1
2	4	8	4	4	6	4	4	4	1	43	High	2
3	4	8	7	6	6	7	4	4	1	52	Medium	3
4	4	6	7	6	6	10	10	4	1	60	Low	5
5	4	8	10	6	6	10	10	4	1	66	Low	6
6	4	8	10	6	6	7	4	4	1	56	Medium	4

Name of the road sections: 1= Ghasikuwa to Byas Chowk, 2=Byas Chowk to Chapaghat, 3= Belchautara to Dulegaunda, 4= Gunadi to Jamune, 5= Benitar to Anbu Khaireni, and 6= Dumre to Bandipur Gate.

After analyzing all road parameters by calculating weight, Ghasikuwa to Byas Chowk got the lowest prioritization value and ranked highest accident-prone area. Byas Chowk to Chapaghat section got the second lowest prioritization value and ranked as the second highest accident-prone area. The site-specific observation indicates that patches and potholes developed in the road, unnecessary edge obstructions like electric posts, bushes, trees shrubs, lack of sign board and marking provisions, insufficient paved shoulders, and insufficient sight distance leading to the lowest prioritization value making the accident-prone level high at Ghasikuwa to Byas Chowk and Byas Chowk to Chapaghat section. Similarly, Belchautara to Dulegaunda and Dumre to Bandipur Gate has the third and fourth-ranked highest prioritization value with medium accident areas. The roadside parking, pavement failure, poor visibility, insufficient road shoulder, insufficient width of road, and absence of zebra crossing make the accident-prone level medium at these sections. Further, Gunadi to Jamune, and Benitar to Anbu Khaireni have the highest prioritization value among all having low accident-prone areas with fifth and sixth rank respectively. Poor safety barriers, poor lighting and visibility, insufficient shoulders, edge obstructions, driving while drinking and not wearing helmets make the accident-prone level low at Gunadi to Jamune and Benitar to Anbu Khaireni section of road. The coordinate of the top six black spots was taken from GPS and plotted in GIS to rank and map the location.

Table 5: Coordinate of Black spots

S/N	Road section	Latitude	Longitude
1	Ghasikuwa to Byas howk	27° 59' 15"N	84° 16' 49.08"E
2	Byas chowk to Chapaghat	27° 58' 48"N	84° 14' 2.04"E
3	Belchautara to Dulegaunda	28° 4' 32.16"N	84° 4' 17.04"E

4	Gunadi to Jamune	27° 59' 17.16"N	84° 11' 9.96"E
5	Benitar to Anbu Khaireni	27° 51' 45"N	84° 32' 49.92"E
6	Dumre to Bandipur Gate	27° 57' 50.04"N	84° 24' 33.12"E

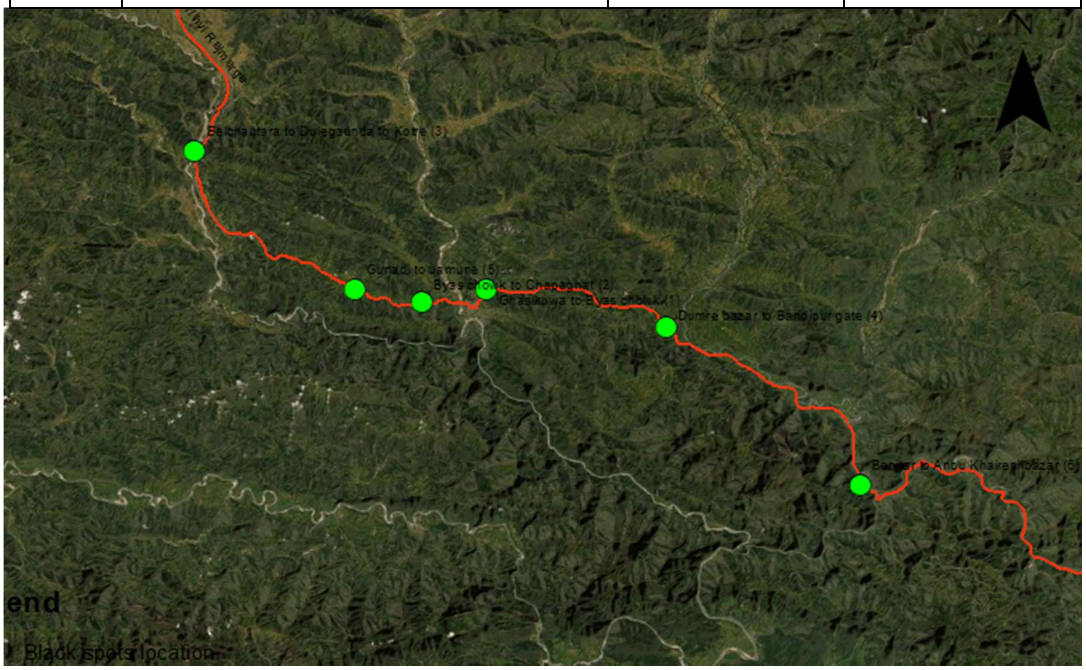

Figure 6: Black spot location on PI.

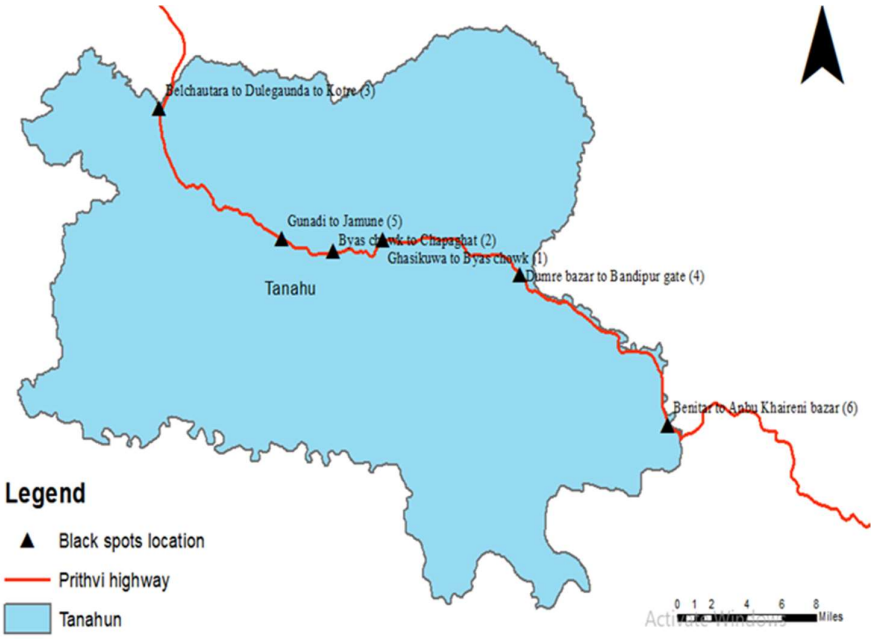

Figure 7: GIS map of black spots based on PI.

Focus group discussion

A multi-disciplinary approach is always needed in understanding and problem-solving of road traffic accidents (Azami-Aghdash, 2020; Huth et al., 2014). Focus group discussion was carried out at four different places including Anbukhaireni, Dumre, Damauli and Dulegaunda. The stakeholders involved in the focus group discussion were traffic police, motorcyclists, car drivers, truck drivers and local road users. Respondents' views about the overall situation of road traffic accidents in the study area, causes and contributing factors to road accidents and their trends were accessed. Participants felt that driver ignorance, pedestrian ignorance, and existing road conditions are the major contributors to road traffic accidents. The results presented below summarize the responses of different stakeholders.

1. According to the traffic data, most of the road traffic accidents are caused by drivers' errors and faults. The main errors were driving too fast, wrong overtaking, drunk and negligence. But drivers insisted that accidents are caused not only because of their faults but also a pedestrian fault, vehicles faults and the condition of the road. Potholes developed in the road, pedestrians not following the traffic rules, and braking problems of the vehicle were the cause major causes mentioned by drivers. Local people insisted all the factors are equally responsible for the cause of an accident.
2. According to qualitative informants, considering the types of vehicles involved in RTA, two-wheelers are more involved in an accident. Most of the traffic police and drivers insisted that road traffic accidents mostly occur during the month of festival, ceremony, and rainy season. The data shows that accidents occur mostly during November-December and July-August.
3. The data from the traffic police office insisted that most of the accidents take place on Friday and Saturday. Friday and Saturday are the last days for the office during the week. People celebrate Friday as the weekend and have fun on Saturday which reduces the concentration of driving which was accepted by the respondent.
4. Local people insisted that most accidents take place at offices and school time in the morning and in the evening time whereas traffic police believed that the youngsters are creating problems for road safety.
5. All respondents agreed that the provision of safety barriers and the repair and maintenance of roads is essential to reduce accidents.
6. The Black spots identified are the critical section for driving and major accidents have taken place at these locations.

Conclusion

RTA accident constitutes a huge social and public health problem that constitutes a loss of life and economy. The study was an attempt to identify the hazardous location and most vulnerable accident black spots in the Mugling-Kotre road section of Prithvi Highway. The geographic information system was utilized for the analysis, prioritization, and locating of black spots. The accident record and database from the district traffic police station for the last three years were collected. The weighted severity index (WSI) method was used to identify the critical accident black spots. Based on the WSI value of different road sections Ghasikuwa to Byas Chowk has the highest WSI value indicating the most hazardous location and accident risk-prone zone. Similarly, the Byas Chowk to Chapaghat area has the second largest WSI, Belchautara to Dulegaunda area has the third largest WSI, Gunadi to Jamune area has the fourth highest WSI, Benitar to Anbu Khaireni has the fifth highest WSI, and Dumre to Bandipur Gate has the sixth highest WSI value respectively represents the hazardousness of the spot. The required road characteristics and traffic parameters of the selected spots were assigned, measured, and given the weight of 0-10 range. Based on the prioritization index (PI), Ghasikuwa to Byas Chowk got the lowest prioritization value and ranked highest accident-prone area. Byas Chowk to Chapaghat section got the second lowest prioritization value and ranked as the second highest accident-prone area. Similarly, Belchautara to Dulegaunda, and Dumre to Bandipur Gate have the third, and the fourth-ranked highest prioritization value with medium accident areas. Further, Gunadi to Jamune, and Benitar to Anbu Khaireni have the highest prioritization value among all having low accident-prone areas with the fifth and the sixth rank respectively. The location of the black spots is

plotted using a GIS mapping tool. The identified black spots were then assessed, and the accident scenarios were further analyzed. Finally, a focus group discussion was conducted with stakeholders at different locations and the result of the respondents' perceptions was drawn. The focus group discussion concluded that the identified black spots are the most critical section for road safety concerns which is currently undergoing expansion with the road being widened. The project has been funded by the Asian Development Bank (ADB) and the Government of Nepal, Department of Roads (DoR) is the implementing agency for the improvement of the roads to strengthen disaster risk reduction, landslide management and road safety.

Recommendation

It is essential to conduct the International Road Access Programme (iRAP) star rating analysis for each black spot and immediate preventive measures should be adopted to save life and the economy. The detailed study of each intersection and critical locations should be further developed so that safety for each road user (Vehicle, Motorcycle, Bicycle, and Pedestrian) could be assured at the maximum level of services.

Competing Interests Disclaimer

The authors have declared that no competing interests exist. The data used for this research are commonly and predominantly used data in our area of research and country. There is no conflict of interest between the authors and other stakeholders because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by any authorities rather it was funded by the personal efforts of the authors.

Data Availability Statement

The data that support the findings of this study are available to the main author, upon reasonable request.

References

Ahmed, S. K., Mohammed, M. G., Abdulqadir, S. O., El-Kader, R. G. A., El-Shall, N. A., Chandran, D., Rehman, M. E. U., & Dhama, K. (2023). Road traffic accidental injuries and deaths: A neglected global health issue. *Health* Science *Reports*, *6*(5). https://doi.org/10.1002/hsr2.1240

Angın, M., Ismael, S., & Ali, A. (2021). Analysis of Factors Affecting Road Traffic Accidents in North Cyprus. In Technology *& Applied Science Research* (Vol. 11, Issue 6). www.etasr.com

Babaie, M., Joulani, M., Ranjbar Hameghavandi, M. H., Asgardoon, M. H., Nojomi, M., O'Reilly, G. M., Gholami, M., Ghodsi, Z., & Rahimi-Movaghar, V. (2022). Risk of permanent medical impairment after road traffic crashes: A systematic review. In *Chinese Journal of Traumatology - English Edition*. Elsevier B.V. https://doi.org/10.1016/j.cjtee.2022.11.002

Banstola, A., Kigozi, J., Barton, P., & Mytton, J. (2020). Economic burden of road traffic injuries in Nepal. *International Journal of Environmental Research and Public Health*, *17*(12), 1–13. https://doi.org/10.3390/ijerph17124571

Bisht, L. S., & Tiwari, G. (2020). Assessing the Black Spots Focused Policies for Indian National Highways. Transportation *Research Procedia*, *48*, 2537–2549. https://doi.org/10.1016/j.trpro.2020.08.256

Chang, C. M., Vavrova, M., & Mahnaz, S. L. (2022). Integrating Vulnerable Road User Safety Criteria into Transportation Asset Management to Prioritize Budget Allocation at the Network Level. *Sustainability (*Switzerland*)*, *14*(14). https://doi.org/10.3390/su14148317

Chang, F. R., Huang, H. L., Schwebel, D. C., Chan, A. H. S., & Hu, G. Q. (2020). Global road traffic injury statistics: Challenges, mechanisms and solutions. In *Chinese Journal of Traumatology - English Edition* (Vol. 23, Issue 4, pp. 216–218). Elsevier B.V. https://doi.org/10.1016/j.cjtee.2020.06.001

Deme, D. (2019). Review on Factors Causes Road Traffic Accident In Africa. | *1 of Journal of Civil Engineering* Research *& Technology J Civ Eng Res Technol*, *1*. https://doi.org/10.47363/JCERT/2019(1)101

DoR. (2021). *Statistics of National Highway [SNH 2020-21]*. https://dor.gov.np/home/page/statistics-of-national-highway-snh-2020-21-home

Elmrghni, S. (2022). Trends of Road Traffic Accident, Fatalities in Benghazi City from 2011- 2015. *International* Journal *of Forensic Sciences*, *7*(2). https://doi.org/10.23880/ijfsc-16000263

Gopalakrishnan, S. (2012). A Public Health Perspective of Road Traffic Accidents. *Journal of Family Medicine* and *Primary Care*, *1*(2), 144. https://doi.org/10.4103/2249-4863.104987

Hadaye, R., Rathod, S., & Shastri, S. (2020). A cross-sectional study of epidemiological factors related to road traffic accidents in a metropolitan city. *Journal of Family Medicine and Primary Care*, *9*(1), 168. https://doi.org/10.4103/jfmpc.jfmpc_904_19

Huang, L., Poudyal, A. K., Wang, N., Maharjan, R. K., Adhikary, K. P., & Onta, S. R. (2017). Burden of road traffic accidents in Nepal by calculating disability- adjusted life years. *Family Medicine and Community Health*, *5*(3), 179–187. https://doi.org/10.15212/FMCH.2017.0111

Keymanesh, M., Ziari, H., Roudini, S., & Ahangar, A. N. (2017). Identification and Prioritization of "Black Spots" without Using Accident Information. *Modelling and Simulation in Engineering*, *2017*. https://doi.org/10.1155/2017/1832654

Khadka, A., Gautam, P., Joshi, E., Pilkington, P., Parkin, J., Joshi, S. K., & Mytton, J. (2021). Road safety and heavy goods vehicle driving in LMICs: Qualitative evidence from Nepal. *Journal of Transport and Health*, *23*. https://doi.org/10.1016/j.jth.2021.101247

Kumar Bhagat, S. (n.d.). *SITUATION OF LAND TRANSPORTATION IN NEPAL* (Vol. 31, Issue 2).

Mohanty, M., Panda, R., Gandupalli, S. R., Arya, R. R., & Lenka, S. K. (2022). Factors propelling fatalities during road crashes: A detailed investigation and modelling of historical crash data with field studies. *Heliyon*, *8*(11). https://doi.org/10.1016/j.heliyon.2022.e11531

Molla, A. S. (2023). Magnitude and determinants of road traffic accidents in North Gondar Zone; Amhara Region, Ethiopia. *F1000Research*, *12*, 367. https://doi.org/10.12688/f1000research.123111.1

Mowafi, H., Rice, B., Nambaziira, R., Nirere, G., Wongoda, R., James, M., Group, G. W., Bisanzo, M., & Post, L. (2021). Household economic impact of road traffic injury versus routine emergencies in a low-income country. Injury, *52*(9), 2657–2664. https://doi.org/10.1016/j.injury.2021.06.007

Murat, Y. S. (2011). An entropy (Shannon) based traffic safety level determination approach for black spots. Procedia - *Social and Behavioral Sciences*, *20*, 786–795. https://doi.org/10.1016/j.sbspro.2011.08.087

Pant, P. R., Mytton, J., Dharel, M. R., Dangi, A., Rai, W. B., & Joshi, S. K. (2021). The prevention of – and first response to – injuries in Nepal: a review of policies and legislation. *Health Research Policy and Systems*, *19*(1). https://doi.org/10.1186/s12961-021-00686-1

Pradhan, M., Upadhyay, H. P., Shrestha, A., & Pradhan, A. (2023). Road Traffic Accident among Patients Presenting to the Emergency Department of a Tertiary Care Centre: A Descriptive Cross-sectional Study. *Journal of the Nepal Medical Association*, *61*(258), 127–131. https://doi.org/10.31729/jnma.8032

Ramos, L., Silva, L., Santos, M. Y., & Pires, J. M. (2015). Detection of Road Accident Accumulation Zones with a Visual Analytics Approach. *Procedia Computer Science*, *64*, 969–976. https://doi.org/10.1016/j.procs.2015.08.615

Singh, S. K. (2017). Road Traffic Accidents in India: Issues and Challenges. *Transportation Research Procedia*, *25*, 4708–4719. https://doi.org/10.1016/j.trpro.2017.05.484

Vyas, P. R., Honnappanavar, M. L., & Balakrishna, H. B. (2015). Identification of black spots for safe commuting using weighted severity index and GIS. In *International Journal of Advanced Structures and* Geotechnical *Engineering* (Vol. 04, Issue 01). https://www.researchgate.net/publication/311594009