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An Analysis of Road Crash Black Spots on the East-West Highway in Kanchanpur District, Nepal

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Abstract

Road traffic crashes remain a pressing public safety concern, particularly along high-traffic corridors such as the East-West Highway in Kanchanpur, Nepal. This study seeks to identify and analyze accident-prone zones commonly referred to as "black spots" along this critical highway segment, with the goal of proposing actionable measures to reduce crash incidence and severity. To systematically assess high-risk areas, secondary crash data spanning multiple fiscal years were obtained from the Traffic Office. The Weighted Severity Index (WSI) was employed to quantify and rank the severity of crashes, enabling the preliminary identification of black spots. Further validation was conducted through field studies, where the Prioritization Index (PI) was calculated to refine risk assessments and prioritize intervention zones. The findings highlight distinct variations in risk levels along the highway, with Gulariya and Kaluwapur emerging as the most hazardous sections, while Bangaun and Suda exhibited comparatively lower crash risks. Major contributing factors included sub-optimal road design, insufficient signage, reckless driving behaviors, and weak enforcement of traffic regulations. In response to these findings, the study proposes targeted mitigation strategies, such as infrastructure upgrades, improved road signage, enhanced traffic law enforcement, and periodic safety audits. Addressing these challenges will enable authorities to enhance traffic safety and minimize the socio-economic impact of road crashes in the region. The study advances road safety discussions by delivering evidence-based recommendations suited to Nepal's East-West Highway. Future research could explore real-time traffic analysis and long-term evaluations of the proposed interventions.

Keywords: Road Crashes, Black Spots, Prioritization Index, Weighted Severity Index, Kanchanpur

1. Introduction

Road crashes, defined as any collision or event on a public road involving at least one vehicle, pose a significant risk of property damage, injury, or death. (WHO,2018)Road traffic crashes have become a major public health problem in Nepal. They are among the leading causes of morbidity and mortality globally, representing a major public health issue. (Wang et al., 2003). According to the WHO,2023 report, annually, approximately 1.19 million fatalities and 20–50 million non-fatal injuries occur due to road crashes. These incidents are the foremost threat to individuals aged 5 to 29. According to the United Nations Global Road Safety Week, one in every four road traffic fatalities worldwide involves pedestrians and cyclists, highlighting the urgent need for safer infrastructure and inclusive mobility systems. Road traffic crashes constitute a global epidemic with profound implications for society, the economy, and public health. (Petridou & Moustaki, n.d.). Beyond causing immense human suffering, road crashes impose a substantial financial burden on societies worldwide, straining healthcare systems and reducing productivity. (Gopalakrishnan, 2012). The premature mortality and morbidity associated with road crashes have both direct and indirect economic consequences, significantly affecting Disability Adjusted Life Years (DALYs) (Khadka et al., 2024). In many countries, the cost of road crashes is approximately 3% of GDP. The primary concern in the current situation is road safety. (Yang & Kim, 2003).

A blackspot is an area with a history of high traffic accident rates. According to Geurts and Wets (2003), there was no universally accepted definition of what should be considered a dangerous location. These high-risk zones

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typically emerge from an interplay of multiple factors: geometric deficiencies such as poor visibility (less than 200 meters), inadequate shoulder width (narrower than 1.5 meters), or absent drainage systems. (Keymanesh et al., 2017)The behavioral issues include speeding, drunk driving, and failure to use proper safety gear like helmets. (Huang et al., 2016)The systemic shortcomings, such as infrequent safety audits and insufficient emergency response mechanisms (Muthunarayanan, n.d.)

Road crashes rise due to improved connectivity facilitated by the swift growth of road infrastructure. Road crashes claim several lives in Nepal, resulting in an enormous detrimental impact on the national economy. Around 1,302 people have perished due to different traffic crashes in the current fiscal year, according to records from the Nepal Police Headquarters from Mid-July 2023 to Mid-February 2024. The top contributors to risk for road crashes include speeding, driving while intoxicated, failing to use safety precautions (such as seat belts and helmets), natural disasters, a lack of roadway signs and signals, road markings, and roads with insufficient geometric designs (Huang et al., 2016). All three components, such as user behavior, vehicle characteristics, and traffic volume, are responsible for the road crashes. (Dave et al., 2021).Adequate knowledge of the influential factors in road crashes enables countries to progressively decrease the rate of road crashes. (Razzaghi et al., 2019).

The Mahendra Highway, formerly designated as the East-West Highway, extends approximately 1,028 kilometers across the terai region of Nepal and has served as the nation's principal route for over five decades. This strategic transportation corridor originates at Banbasa in Kanchanpur District on the western frontier adjoining India and terminates at Kakarbhitta in Jhapa District to the east. As per the 2015/16 national census, the highway corridor influences approximately 2859 inhabitants per kilometer and contributes to a regional population density of 10 km per 100 square kilometers. Due to high access density, conflict points have increased on this highway and subsequently cause accidents. (Mohanlal Damodariya & Patel, 2021). It is necessary to find black spots for such roads through available accident records. The section of the highway traversing Kanchanpur district from Bangaun to Gulariya has been selected as the focus area for this study. Kanchanpur district is a critical geo-strategic location as a trans-border gateway to India, this corridor functions as a major conduit for both intra-national and cross-border transportation. So, there is a pressing need to enhance roadway safety and reduce the incidence of traffic-related injuries and fatalities along this segment. Achieving this objective necessitates a comprehensive analysis of traffic crash patterns and contributing risk factors. The identification and understanding of these variables are imperative for developing evidence-based interventions and optimizing road safety management strategies.

1.1. Objectives

- To locate the high-risk areas and classify them based on their level of risk.
- To examine the geometric components of the black spots at the designated location.

2. Study Zone

This study focuses on the Bangaun–Gulariya segment of the East-West (Mahendra) Highway, a critical transportation corridor traversing the Kanchanpur District of southwestern Nepal. This road section, extending approximately 41 kilometers, has been identified as exhibiting significant transportation and safety challenges due to escalating vehicular activity and population growth. A detailed field investigation was conducted at crash-prone locations along this corridor, with observational data collected at 100-meter intervals covering a total length of 1 kilometer at each identified site. The selected study section passes through multiple administrative units, including Bhimdatta Municipality–Ward 5 (Bangaun), Shuklaphanta Municipality–Ward 11 (Kaluwapur), Krishnapur Municipality–Wards 2 (Baani) and 5 (Aamkhaiya), and Bedkot Municipality–Wards 3 (Daiji), 7 (Suda), and 9 (Lalpur). The corridor is strategically located, with its eastern and western termini connected to Attariya in Kailali District and the Indian border, respectively, thereby serving as a vital link for both domestic and cross-border mobility. This segment of the highway supports a wide range of socioeconomic functions, including local trade, tourism, and goods transportation, contributing to persistent high traffic volumes and associated congestion. The frequency and severity of road traffic crashes along this section have become a growing concern. Therefore, a spatial and causal analysis of high-crash locations commonly referred to as black spots is essential to identify underlying risk factors and propose data-driven, context-specific countermeasures aimed at enhancing road safety and operational efficiency.

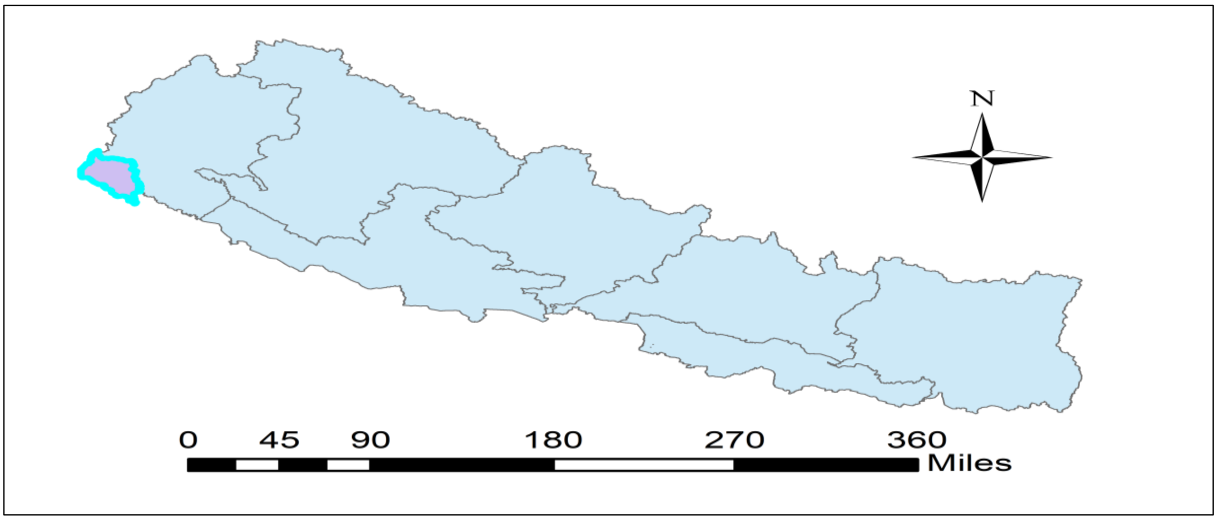

Figure 1. Map of Nepal

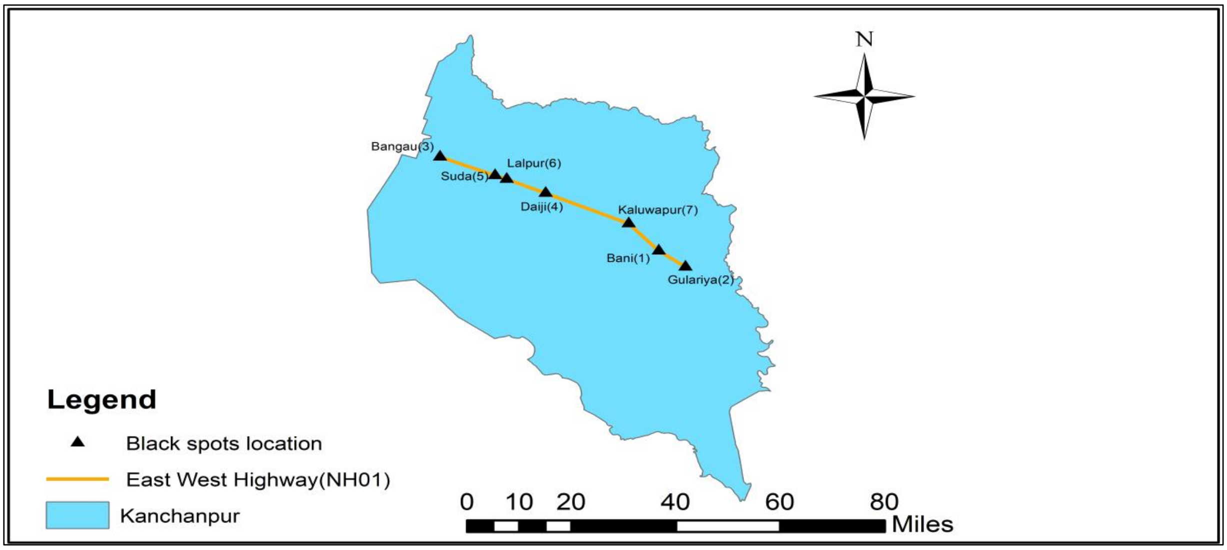

Figure 2.GIS map of study area

3. Methodology

3.1. Primary data

Road inventory surveys have been carried out at identified highway crash black spots to measure the roadway geometric parameters like roadway width, shoulder width, street lighting, visibility, obstructions available, kerbs, speed breakers, and drainage facilities.

3.2. Secondary data

Crash data for the following four fiscal years: 2076–2077, 2077–2078, 2078–2079, and 2079–2080 from the District Traffic Office of Kanchanpur district. The crash data that was gathered includes details about the month, year, and location of the incidents, along with the number of people who died, the extent of major and minor injuries, and the vehicle that was involved. Furthermore, secondary data for the analysis included reports, literature, and data from the Department of Roads (DOR)'s website. A quantitative analysis was conducted to observe the different geometric parameters of the crash black spots that were identified. The significance of each attribute was then examined employing statistical approaches and trends.

4. Results and Discussion

4.1. Weighted severity index (WSI) method

By allocating scores based on the quantity and severity of crashes in that specific location over the previous five years, the Weighted Severity Index (WSI) was used to identify the crash black spots. (Giri et al., 2023).

$$WSI = 41K + 4GI + MI \quad (1)$$

Where,

K = Number of Fatalities

GI = Number of grievous injuries

MI = Number of minor injuries

Table 1. WSI value for different black spots

Location	Number of Fatalities	Grievous Injury	Minor Injury	WSI	Ranking
Bangaun	10	11	4	458	7
Suda	10	15	6	476	6
Lalpur	15	17	11	694	4
Daijee	14	35	13	727	3
Kaluwapur	19	42	13	960	2
Bani	12	8	3	527	5
Gulariya	29	33	12	1333	1

The calculated WSI value for each of the locations has been presented in the following graphs:

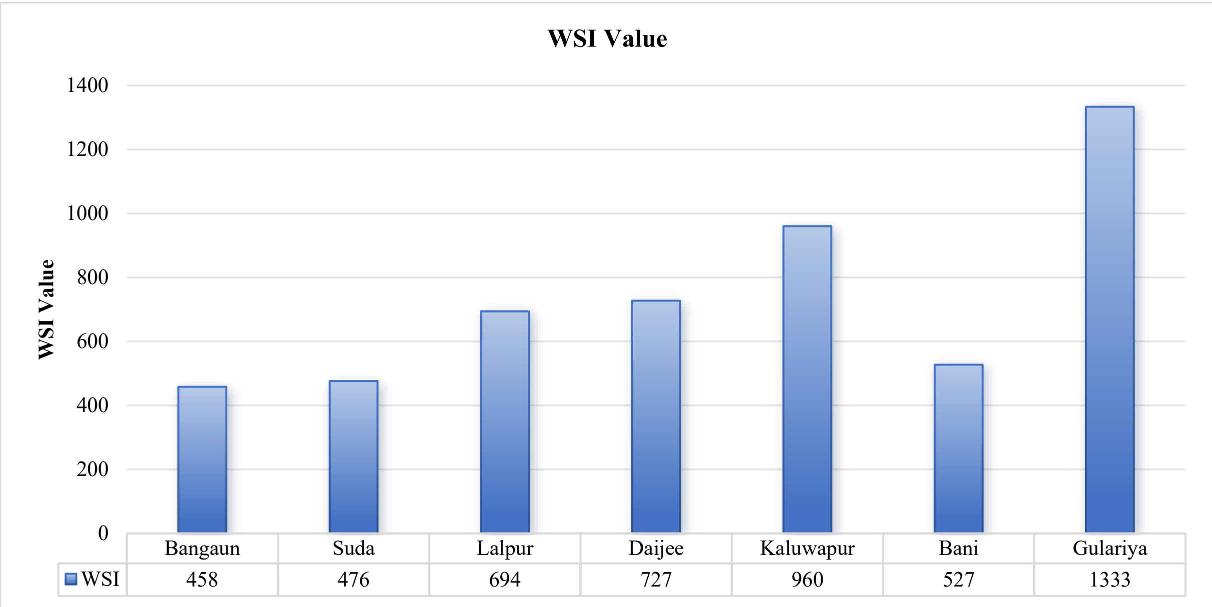

Figure 3. Calculated WSI value for different locations on highway

Based on the WSI value results, Gulariya has the highest WSI value, indicating that it is the zone most likely to have crashes. Following Gulariya, Kaluwapur ranks second in terms of crashfrequency, while Daijee ranks third. In same way ranking for most accident-prone zones, Lalpur, Bani, Suda and Bangaun rank fourth, fifth, sixth, and seventh respectively.

4.2. *Road inventory survey*

Measurements of carriageway widths, shoulder widths, and elevations of the carriageways and shoulders were made throughout the entire identified crash black spots using a comprehensive road inventory survey. These measurements were then compared to the standard values of the Nepal Road Standard (NRS). The width, elevation, and slope of the carriage way and shoulder were found to be observed to be greater in many sections than the standard value, while in some sections they fell short of the NRS standard value. The width of the road and shoulder does not meet national highway standards, nor is it adequate to handle heavy traffic. There are some sections without a median to distinguish between traffic directions. Because of the glare issue, it may result in head-on collisions and crashes during the night. There are numerous sections of the highway without drainage facilities, and potholes in the road can be seen to be filled with water. The poor surface condition further increases braking distance and reduces vehicle stability, elevating crash risk. Moreover, the absence of median dividers in some segments compromises directional separation of traffic, thereby increasing the risk of head-on collisions, particularly during night-time due to glare from oncoming vehicles.

Table 2. Geometrical parameters through observation

Location	Visibility Details	Obstruction Details	Drainage facility (One or Two)	Kerb (Raised or Not)	Speed Breaker	Presence of the shoulder	Co-ordinate
Bangaun	Good straight path >1km	Junction, Electric poles, Animals.	No Provision	No kerb, but culvert and side stamps	Not Exist	Not technically designed, but 1-1.5 m varying width available	28.98371333˚N 80.14703667˚E
Suda	Full Visibility	Electric poles on shoulders, trees, construction materials at the side, Advertising boards.	No Drainage Canals, Water fills potholes in the road.	No kerbs	Not Exist	Full space available, but not well designed	28.96148167˚N 80.21378667˚E
Lalpur	Available	No obstruction except the poor road condition, insufficient lane width.	Natural side drainage	No Kerbs	Not Exist	Deteriorated Shoulder	28.95609167˚N 83.23020667˚E
Daiji	Visibility is about 500 m only.	No obstruction except the poor road condition, insufficient lane width	Natural side drainage, No canal laying Available	No Kerbs	Not Exist	Less than 1m in the embankment	28.93707667˚N 80.28267333˚E
Kaluwapur	Only up to 100m due to curvature in the forest area	No obstruction, traffic signs available	Available on both sides	No Kerbs	Not Exist	Full shoulder available	28.90134000˚N 80.37808000˚E
Bani	Poor visibility about 250m only	Animals, trees, Advertising boards	Natural Drainage (no provision of side drainage)	No Kerbs	Not Exist	Insufficient	28.86662500˚N 80.41714000˚E
Gulariya	Available for about 200 m only	No Obstruction, Lack of sufficient shoulder Width	Natural Drainage	No Kerbs	Not Exist	Insufficient	28.84044667˚N 80.46953833˚E

Table 3. Geometrical parameters through measurement

Chainage(m)	Average Width(m)			Average Elevation (m)							Average Slope (%)				Avg.. Height difference between GSL and FSL		Remarks
	CW	Shoulder		Carriageway (CW)			Shoulder		GSL		Carriageway		Shoulder				
		L	R	L	C	R	L	R	L	R	Observed		Observed		L	R	
											L(%)	R(%)	L	R			
0-1000	5.507	1.41	1.33	1.40	1.30	1.40	1.35	1.46	2.49	2.59	3.47	3.54	8.82	12.28	1.14	1.21	Kaluwapur
0-700	5.523	3.1	3.35	1.24	1.15	1.23	1.36	1.42	1.94	2.17	3.40	3.07	4.13	9.27	0.58	0.75	Suda
0-1000	5.588	2.138	2.27	1.44	1.35	1.45	1.52	1.49	3.05	2.90	3.08	3.56	4.44	6.73	1.52	1.40	Lalpur
0-1000	5.468	1.46	1.62	1.34	1.22	1.29	1.34	1.2	3.17	3.04	4.28	2.51	4.90	5.97	1.88	1.76	Daije
0-1000	5.507	1.41	1.33	1.40	1.30	1.40	1.35	1.46	2.49	2.59	3.47	3.54	8.82	12.28	1.14	1.21	Kaluwapur
0-1000	153.013	2.15	2.16	1.31	1.21	1.29	1.33	1.31	2.22	2.21	3.45	2.81	5.75	5.17	0.89	0.89	Bani
0-1000	5.453	1.84	1.59	1.34	1.23	1.33	1.44	1.46	3.39	2.97	3.82	3.38	5.72	15.15	1.94	1.51	Gulariya

4.3. Prioritization index (pi) method

Without using traffic data, the location of crash black spots can also be determined using geometric parameters and road attributes, which gives the safety status of geometric features. (Keymanesh et al., 2017). To assess the road geometry, which includes the number of lanes, width, drainage provision, visibility, type of vehicle that is frequently driven, shoulder condition, edge obstruction and median barrier, a field survey was conducted. Based on DoR guidelines, the IRI value has been assigned. (Bhele & Rajchal, 2023). This study identifies crash-prone segments along the Bangaun to Gulariya section of Nepal's East-West Highway using road geometry and field survey data in the absence of crash records. A Prioritization Index (PI) was calculated to rank road sections based on geometric and infrastructural risk factors. The findings support proactive road safety management and targeted intervention planning. It is possible to determine the Prioritization Index (PI) for each road section by adding up all of the individual weights and then normalizing the result using the maximum weight, as demonstrated below:

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

The assigned weightage for each parameter and the PI value of each location have been presented in the table below:

Table 4. Assigned value of Prioritization Index (PI) calculation

Location	Number of lanes in each direction	Width of road	Drainage facility	Visibility	Frequent vehicle type	Presence of the shoulder	Edge obstruction	Median Barrier	DoR IRI Index	Total	Rank	Crash Prone Level
Bangaun	6	4	4	10	6	10	4	4	1	54.444	7	Low
Suda	6	4	1	10	6	10	4	4	1	51.111	6	Low
Lalpur	6	4	4	10	6	4	4	4	1	47.778	4	Medium
Daijee	6	4	4	6	6	4	4	4	1	43.333	3	Medium

Location	Number of lanes in each direction	Width of road	Drainage facility	Visibility	Frequent vehicle type	Presence of the shoulder	Edge obstruction	Median Barrier	DoR IRI Index	Total	Rank	Crash Prone Level
Kaluwapur	6	4	7	2	6	4	4	4	1	42.222	2	High
Bani	6	4	4	4	6	10	4	4	1	47.778	5	Medium
Gulariya	6	4	4	2	6	4	4	4	1	38.889	1	High

These findings have led to the identification of three crash locations as critical to traffic safety. According to the site-specific observation, the road has developed patches and potholes without adequate pavement width, lacking sufficient sight distance with recurring edge obstructions like trees and electric poles. There are no road markings, there are no median barriers, and there is not enough shoulder width at all locations. All of these contribute to the lowest Prioritization value and hence the highest crash risk location.

After all road parameters were examined and the Prioritization Index (PI) was determined, the Gulariya section has the lowest PI and is determined to be the most accident-prone area. Ranking as the second-highest accident-prone area, the Kaluwapur section has the second-lowest PI value. Similarly, Daiji has the third-lowest PI value, making it the third-most accident-prone location. Crash risk is moderate at Lalpur and Bani due to the average lane width, moderate visibility, electric poles on shoulders, billboards, and lack of drainage. Conversely, the lack of Kerbs, lack of a median barrier, deteriorated shoulder, inadequate lane width, and bad road conditions make Suda and Bangaun less accident-prone locations. The locations were ranked using the WSI and PI values and mapped using the GPS coordinates of crash Black Spots.

Table 5. Coordinates of road crash black spots

Road Section	Easting	Northing
Bangaun	416905	3206484
Suda	423505.49	3203896.29
Lalpur	424887.21	3203376.02
Daije	429545.4	3201428.54
Kalwapur	439477.9	3197180.29
Baani	443063.34	3193367.28
Gulariya	448250.5	3190399.35

4.4. Annual road crash frequency

The percentage of crash records from the fiscal years 2077–2078 and 2080–2081 decreased overall, according to data acquired on road traffic crashes from the District Traffic Police Office, Kanchanpur. Figure 4 depicts the trend in annual crash frequency. The observed trend demonstrates a steady decline in annual road crash frequency from fiscal year 2077/78 to 2080/81, indicating potential improvements in traffic management, road safety awareness, or enforcement strategies over time. (Rad et al., 2016).

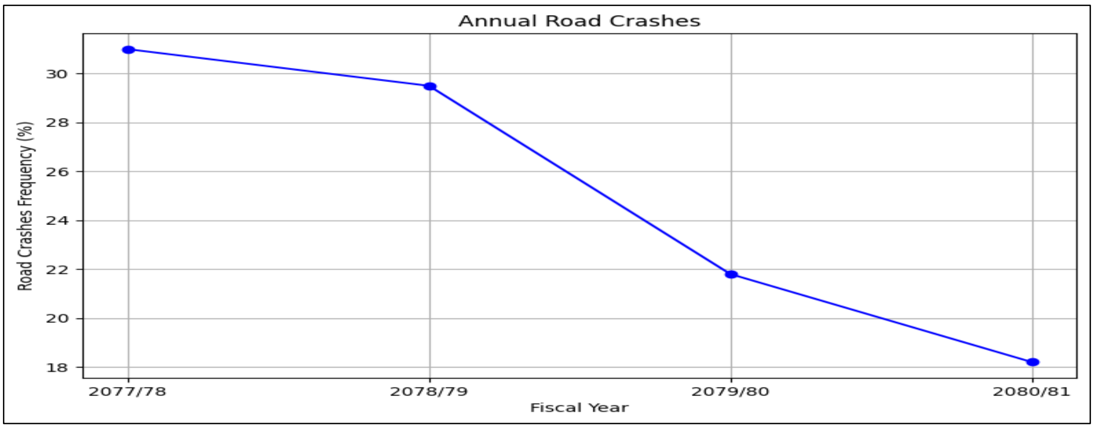

Figure 4. Crash frequency by fiscal years

4.5. Temporal analysis of injury severity

The resulting graph shows the crash frequency (in percentage) for the Bangaun to Gulariya road segment of the East-West Highway between 2077/78 and 2080/81. The graph illustrates how the rate of fatal crashes rose from fiscal year 2077/78 to 2079/80 and then began to decline until 2080/81. From the fiscal year 2077/78 to 2078/79, there is a downward trend in the number of serious crashes. However, after that, the number of crashes resulting in serious injuries increased until 2080/81. As a result, safety performance has dropped, necessitating the adoption of various safety precautions to lower the frequency of crashes. Similar to this, there was an increase in minor crash cases from 2077/78 to 2078/79, a decline from 2078/79 to 2079/80, and then another upward trend from 2079/80 to 2080/81.

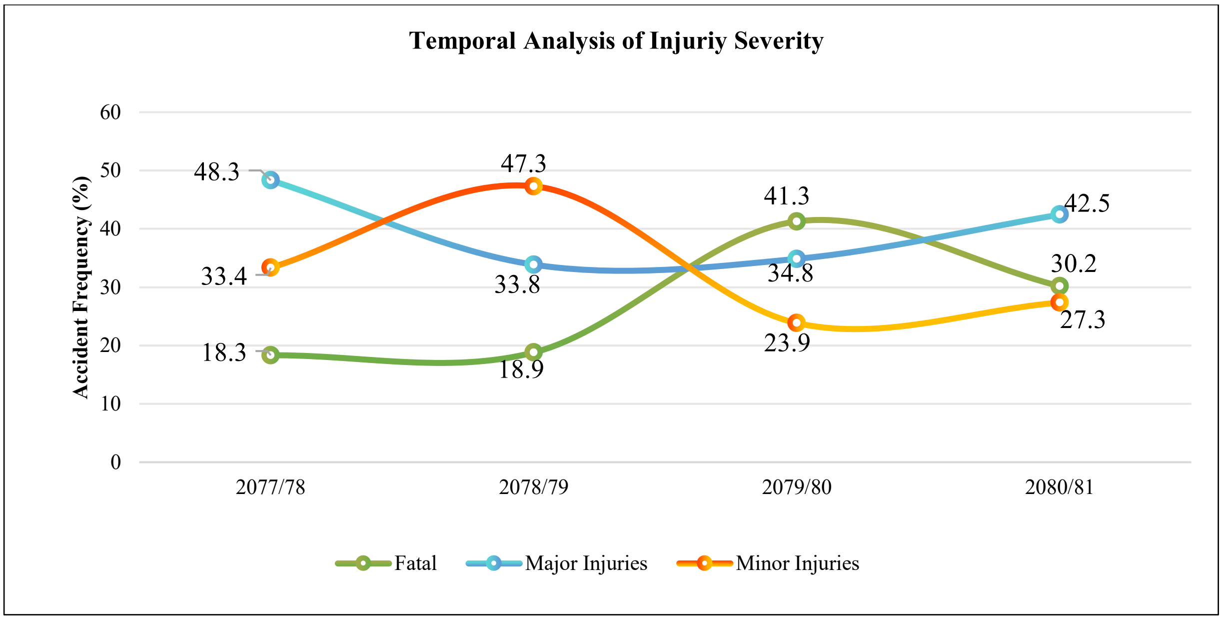

Figure 5. Crash frequency variation based on crash types over a year

4.6. Demographic analysis of crash fatalities

After analyzing all of the crashes from fiscal years 2077/78 to 2080/81, it was discovered that men account for a much higher percentage of crashes than women and children. There is also the great role of gender and drivers' behaviors in road crashes. (Bener & Crundall, 2008). Men account for 80.1% of all crashes, while women make up 15.3%, and children involved in road crashes take into account for just 4.6%. It is evident from the provided pie chart that men have an elevated crash rate compared to women and children.

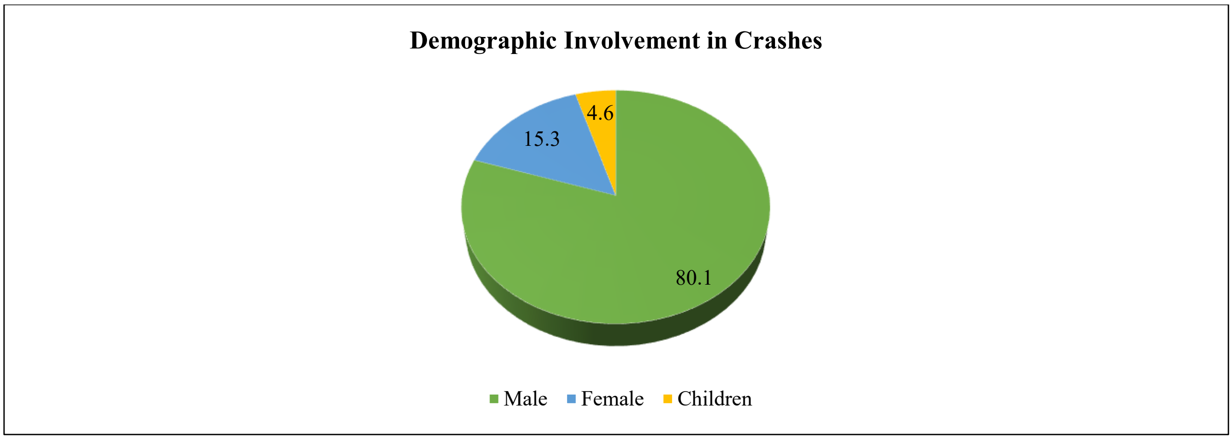

Figure 6. Gender involvement in crashes

4.7. Vehicle-specific crash involvement

Figure 7 shows the trend of different vehicle types involved in collisions on the Bangaun to Gulariya road segment of the East-West Highway. In contrast, motorcycles and scooters have a history of having the most crashes, mostly because of their high speeds.(Valen et al., 2019). Furthermore, Cars and Jeeps were the second-highest category of vehicles involved in collisions, followed by bicycles and tractors, and this pattern has persisted.

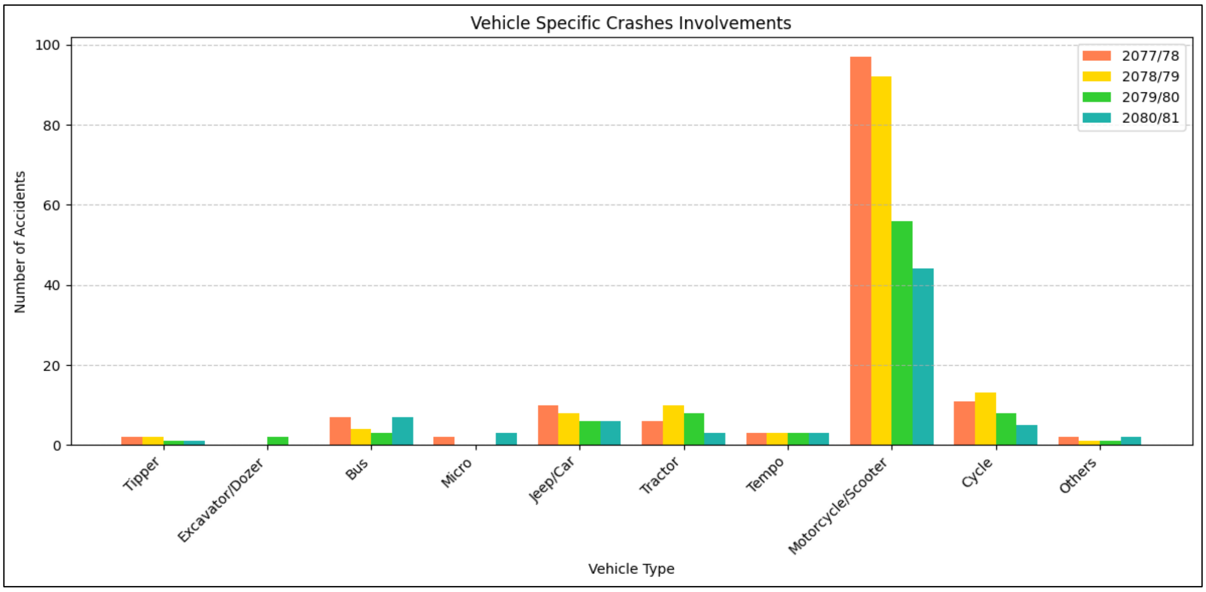

Figure 7. Distribution of the number of crashes based on vehicle types

4.8. Monthly Variations in crash severity

The statistics clearly show a seasonal trend, with some months consistently having higher crash rates in particular severity categories. A notable variation in crash rates is observed in certain months. A higher frequency of minor or serious crashes occurs in some months, while a higher frequency of fatal crashes occurs in others. Given the kinds of crashes that occur more frequently during those times, different months may call for different safety precautions. Records from 2077/78 to 2080/81 show that Jestha Month did not have any minor injuries noted. There are many serious crashes in months like Shrawan and Mangsir. The causes of fatal, non-fatal, and serious crashes during their corresponding peak months must be addressed to increase overall safety. According to data, to lower the high frequency of crashes, safety precautions should be reinforced during the Mangsir, Shrawan, and Magh months. A breakdown of monthly crash trends is provided in the figure below.

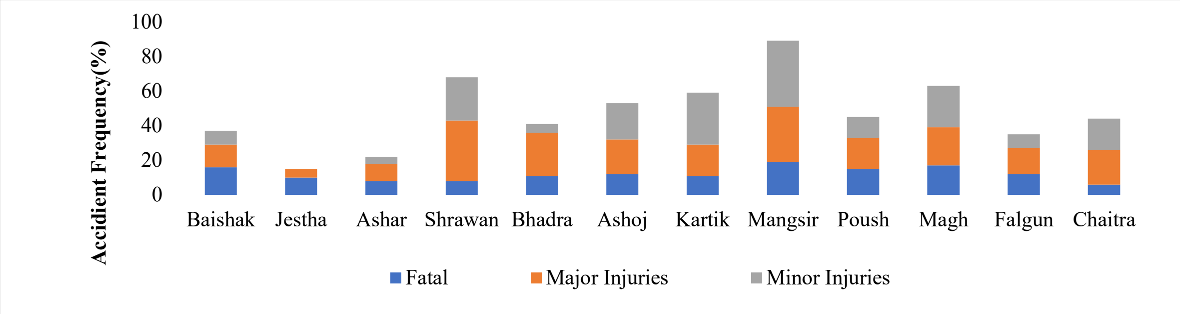

Figure 8. Distribution of the number of crashes by month

5. Conclusion

Globally, road traffic accidents are emerging as a significant concern, resulting in numerous severe and minor injuries, human suffering, and financial losses. Locations where accidents occur frequently and repeatedly are identified as crash black spots. Consequently, research into these "black spots" is essential to ascertain the primary causes of recurring accidents. This study aimed to identify the main causes of traffic accidents in crash hotspots along the Bangaun to Gulariya road segment of the East-West Highway in Kanchanpur, Nepal. The findings from the road inventory survey indicate that roadway geometric data do not meet standard limits. Issues such as visibility, street lighting, proper drainage facilities, camber slope, and shoulder slope require adherence to standard formats to mitigate highway accidents. Crash data from the District Traffic Police Office for the past four fiscal years was collected. Sideways collisions involving two-wheelers and light motor vehicles were identified as the most common type of accident. The distribution of crashes by year indicates a decreasing trend from fiscal year 2077/78 to 2080/81. According to the data, the frequency of male-related crashes is 80.1%, female-related crashes account for 15.3%, and child-related crashes constitute 4.6% over the last four fiscal years. Seasonal trend crash frequency data reveal that most accidents occurred in the month of Mangsir, followed by Shrawan. The PI method was employed to identify critical crash black spots. Based on the PI values of different sections, the Gulariya area was found to have the lowest PI value among all black spots, making it the most crash-prone zone in the Kanchanpur district. Similarly, Kaluwapur and Daijee have the second and third lowest PI values, indicating them as the second and third most hazardous locations for crashes, respectively. Lapur, Bani, Suda, and Bangaun were identified as the fourth, fifth, sixth, and seventh most crash-prone zones, respectively, based on the obtained PI values.

6. Recommendation

Based on the findings and geometric characteristics outlined in the study of black spots on the East-West Highway in Kanchanpur, Nepal, below is a structured table of specific engineering, structural, and planning recommendations tailored to each location’s unique risk profile and observed deficiencies:

Table 6. Purposeful Interventions at specific blackspots

Black Spot Location	Crash Prone Level	Specific Engineering & Planning Interventions
Gulariya	High	- Widen shoulders to min. 2m with pavement markings - Install raised kerbs and roadside barriers - Introduce a median barrier to avoid head-on crashes - Add drainage facilities to prevent waterlogging - Install reflective signs and speed limit boards
Kaluwapur	High	- Implement geometric realignment to improve curvature visibility - Install solar-powered street lights & convex mirrors - Construct kerbs and add reflective signage near curves - Clear foliage for line-of-sight improvement
Daiji	Medium	- Road resurfacing and shoulder strengthening - Regrade embankments to ensure stable shoulders - Install rumble strips and solar blinkers for awareness - Reconstruct and maintain natural side drainage

Black Spot Location	Crash Prone Level	Specific Engineering & Planning Interventions
Lalpur	Medium	- Reconstruct pavement to meet NRS lane width standards - Design and construct durable shoulders - Install adequate speed signs and pedestrian crossing signs
Bani	Medium	- Trim/remove visual obstructions near the ROW - Add physical median separators and clear road edges - Provide a continuous drainage system - Educate locals and install animal crossing signs
Suda	Low	- Pothole repair and resurfacing - Relocate utility poles and remove obstacles from the shoulders - Enforce construction debris removal regulations - Implement shoulder hardening and clear zone development
Bangaun	Low	- Regular roadside vegetation management - Fence or barrier to prevent stray animal access - Reposition utility poles outside the ROW - Design and construct uniform shoulders (min. 1.5m)

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