Proceedings of 14th IOE Graduate Conference
Peer Reviewed
Year: 2023 Month: December Volume: 14
ISSN: 2350-8914 (Online), 2350-8906 (Print)

Safety Level Assessment of Bus Stops A Case Study of Birauta Chowk- Srijana Chowk- Mahendrapool- Prithvi Chowk Road Section in Pokhara

Rabin Panthi [a], Parkash Chandra Joshi [b], Madan Pokhrel [c]

[a, b, c] *Department of Civil Engineering, Paschimanchal Campus, IOE, Tribhuvan University, Nepal*
[a] Panthirabin1@gmail.com, [b] Parkashj469@gmail.com, [c] madan@ioepas.edu.np

Abstract

Ensuring road safety in developing countries, such as Nepal, is critical, especially concerning the design and upkeep of bus stops. However, evaluating safety at these stops in Nepal poses challenges due to unreliable crash data nearby. This study focuses on assessing unsafe acts and causal factors around bus stops along the Birauta Chowk-Srijana Chowk-Mahendrapool-Prithvi Chowk Road Section in Pokhara. It identifies unsafe acts contributing to pedestrian accidents and quantifies associated factors on a scale of Zero to One. Using the Analytical Hierarchy Process (AHP), the study evaluates the danger levels posed by these unsafe acts and prioritizes bus stops for improvements. This approach not only enhances bus stop safety but also offers a systematic method applicable where crash data is scarce. The findings highlight bus stop location at Prithvi Chowk as needing immediate attention due to its low safety level followed by another bus stop in the same area. Factors like inadequate loading area capacity and distant zebra crossings contribute significantly, guiding priority improvements. This research equips road authorities with a roadmap for targeted interventions, enabling strategic resource allocation to uplift overall safety standards at bus stops.

Keywords

Bus stops safety; Unsafe acts; Causal factors; Safety ranking; Pokhara; Analytical Hierarchy Process

1. Introduction

Road traffic crashes have become one of the world's global concern. It has been recorded 1.35 million of deaths due to road accident each year globally and road accident has become the 8th leading cause of death with three times higher death rate in low income countries [1]. Moreover, Pedestrian fatalities and injuries are a foremost problem in road accident. New research emphasizes a clear link between pedestrian-vehicle collisions and places where pedestrian traffic is concentrated, particularly focusing on bus stops. Bus stop activities create conflict areas among different traffic users, increasing the risk for pedestrians around public transport stops and stations [2]. Insufficient amenities, such as pedestrian signals and crosswalks near these stops, promote risky pedestrian movements. This lack of infrastructure significantly heightens the chances of accidents involving pedestrians and vehicles, especially when buses or other vehicles are present on these roads [3].

Similarly, a research conducted in Seattle, utilizing geographic information system (GIS) data, revealed a substantial correlation: 89% of locations with a high incidence of crashes were situated within a mere 150 feet of a bus stop [4]. Every year more than 0.31 million pedestrian fatalities are found to occur on roadways worldwide [5] . Nepal recorded 10733 number of road accidents with 191 fatality and 257 serious cases in the year 2078/79. Figure 1 shows the rising trend of road crashes in Nepal.

Home to 101,669 households, Pokhara's urban landscape is interwoven with an intricate web of privately-operated public transportation systems. The cost associated by Road traffic Crashes of Kaski district were around US $ 82,800 in the year 2017 [6]. The safety of bus stops along the route takes center stage, given their significance as pivotal junctures within the public transportation network. Prioritizing safety assessments in Pokhara's bus stops not only ensures the well-being of passengers but also aligns with the city's tourism goals by enhancing visitor experiences and fostering a safer, more inclusive environment for all residents and visitors alike. This research is devoted to conducting an Safety Level Assessment of these bus stops in a significant sections of Pokhara city using Proactive approach of study.

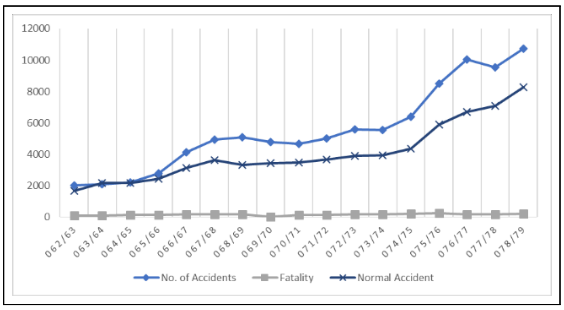

Figure 1: Rising Trend of Road accidents in Nepal

2. Literature Review

2.1 Different approach and challenge in developing countries

The safety of bus stops and their impact on pedestrian-vehicle collisions have been the subject of extensive research globally.

In a survey encompassing 749 transit users across 12 transit stops and stations in metropolitan Los Angeles, it was found that what primarily influences user satisfaction isn't the physical appearance of the facility. Surprisingly, the most crucial factor for riders is the consistency and reliability of the service provided, combined with a sense of personal safety [7]

A reactive approach to road safety involves several stages, including the identification of locations facing safety issues (screening), defining the problems (diagnosis), and subsequently implementing countermeasures to address these issues (cure). In a study, Ulak et al. [2] introduced a Bus Stop Safety Index (SSI) that establishes a correlation between pedestrian crashes and bus stops. This index assigns scores to bus stops based on the severity of pedestrian-involved crashes in their proximity. The SSI offers a valuable tool for identifying high-risk bus stops and conducting safety assessments.

Truong & Somenahalli [8] utilized Geographic Information System (GIS) to identify both Pedestrian-Vehicle Crash Hot Spots and Unsafe Bus Stops. Their approach involved analyzing crash data based on crash counts to pinpoint areas with high crash frequencies and potentially hazardous bus stop locations. Likewise, Pulugurtha & Vanapalli, [3] devised a GIS-based methodology aimed at ranking bus stops situated within areas characterized by high concentrations of auto-pedestrian collisions. Their approach utilized collision data from the Nevada Department of Transportation (DOT) within the Las Vegas metropolitan area, spanning the years 2000 to 2002. The objective was to provide decision makers with a tool for assessing and prioritizing bus stop safety based on collision information.

The reactive approach to road safety has limitations. It relies on identifying high crash locations before improvement plans can be developed, leading to potential delays. Often, the available crash data is outdated or incomplete, hampering accurate diagnosis and intervention. Additionally, implementing improvements on existing roads can be costlier.

In a study conducted by Khadka et al. [9] for the assessment of police reporting completeness for traffic crashes in Nepal, the recording of fatal and serious injuries yielded statistically significant results but reporting of minor injuries is only 7.1 percent and single-vehicle crashes exhibited a reporting rate of 3.8%. In comparison to data from Local Record Keepers, the comprehensive police crash reporting rate stood only 19.7% indicating underestimation and bias in the reporting of the actual burden of road traffic crashes.

Critical literature analysis reveals that many existing methodologies for ranking road safety hazardous locations rely on accident data, which can be both scarce and of poor quality. This limitation underscores the need to establish an alternative methodology that doesn't rely on accident data for ranking such locations. Developing a data-independent approach is essential to accurately assess and prioritize road safety hazardous locations, ensuring effective urban transportation planning and infrastructure enhancement [10].

2.2 Proactive Approaches and Analytical Hierarchy Process

Due to lack of reliable traffic crashes datas, differenct Proactive methods are into implementation for carrying out the safety level assessments.

In an analysis conducted, specific mathematical models were individually crafted for various factors influencing bus stop safety. These models encompassed factors like traffic conflicts, geometric characteristics, signage, pavement conditions, and lighting. By integrating these tailored models, a comprehensive safety assessment system was established, defining six distinct safety levels for bus stops. Regression analysis highlighted a strong relationship between each factor's modeled safety level and the incidence of traffic conflicts [11].

Another method implemented is Traffic conflict analysis. A Research conducted focused on enhancing traffic safety on bicycle paths through an investigation into the conduct of bicyclists and moped riders. Using video-based behavioral observations, the study documented and analyzed mutual conflicts and bicyclist behaviors on these paths. The conflict observation method was employed as a key technique to scrutinize and interpret the recorded data, shedding light on various aspects of interactions and conflicts among users [12].

Kanuganti et al. [13] made use of Simple Additive Weightage (SAW) method and Analytical Hierarchy Process (AHP) together for road safety analysis. The overall result obtained from these two approaches were compared and the results obtained from AHP justified the visual inspection on field.

The Analytical Hierarchy Process (AHP), a versatile Multi-Criteria Decision Making (MCDM) method, plays a pivotal role in prioritizing safety measures. The Analytic Hierarchy Process (AHP) begins by determining the importance of each criterion through pairwise comparisons. These comparisons result in weights, indicating the significance of each criterion. Subsequently, for each criterion, options are evaluated based on attribution of that reflect their performance concerning that specific criterion. Combining these weights and scores, AHP generates a comprehensive assessment for each option [14]. A study was conducted by employing a six-stage methodological framework to rank road safety hazardous locations with integration of Analytical Hierarchy Process (AHP) and field surveys (condition rating) to pinpoint risky spots along the Kalanki Koteshwor Ring Road Section. This approach involved assessing safety parameters, determining weights, and calculating the Safety Hazardous Index (SHI) to identify locations with higher safety risks [15]. Similar, Agarwal et al., [10] ranked safety hazardous locations, Safety hazardous index for different road section using data for section of NH-8 between Jaipur and Kiashangarh India.

Cheranchery et al. [16] and Pandey et. al. [17] utilized AHP methodology to assess the safety level of bus stops along a typical urban corridor. This involved identifying unsafe acts and categorizing causal factors related to design and management deficiencies. Subsequently, safety levels of the bus stop along the corridor were evaluated using a Mathmatical model developed.

3. Need and Objective of the study

3.1 The need of study

In case of Pokhara city, very few researches have been done regarding road safety and no any study has been done regarding bus stop safety. A study of road crashes in Prithvi Highway intersecting Pokhara Municipality using GIS technology using heat maps resulted in that The Chauthe area has the most number of traffic crashes [18] . Within Pokhara's transport tapestry, the Birauta Chowk- Srijana Chowk- Mahendrapool- Prithvi Chowk road section emerges as a vital corridor, with Traffic Volume for New Road is 2,732 PCU/hr and Nayabazar Road is 2148 PCU/hr [19]. All the bus stops in this area are curbside type. As per study, curbside bus stops tend to have a higher rate of traffic collisions resulting in personal injury within a 60-meter radius compared to layby bus stops [20]. This is possibly due to their closer location to junctions and side roads, which increases collision risks.

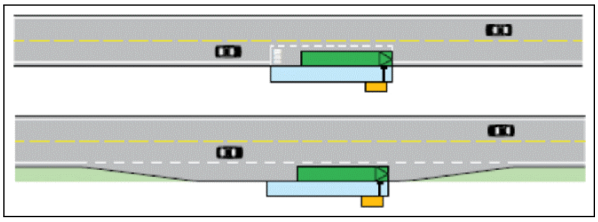

Figure 2: Curbside (Upper) and layby (lower) stops

This indicates bus stop zones are vital for crashes. Also, study conducted for the assessment of police reporting completeness for traffic crashes and came with a finding that the reporting rate by the police was notably higher for fatalities (62.5%) but considerably lower for property damage cases (11.6%) and minor injuries (7.1%) [9]. So, these critical literature analysis reveals that the police recorded data are not reliable in one hand and safety around bus stop zone plays great role in road crashes in other hand. So this limitation underscores the need for Accurately assess the safety level of bus stop zones and prioritize the safety levels of bus stops within significant sections of Pokhara city for targeted improvements according to their urgency and significance.

3.2 The objective of study

The primary objective of our study is to evaluate the safety level of bus stops and prioritize them for improvement according to their urgency and significance. The specific aims are:

- · To evaluate the degree of danger associated with unsafe acts using the Analytical Hierarchy Process.
- · To estimate the relative contribution of causal factors to unsafe acts through expert scoring surveys.
- · To evaluate safety levels using a mathematical model.

4. Methodology

4.1 Study Area

Pokhara Lekhnath Metropolitan City has a large Network of Public transportation with huge number of passengers. The safety of pedestrians along the road section has been a major concern. The study to assess the safety level of bus stops is carried out in Birauta Chowk- Srijana Chowk- Mahendrapool- Birauta Chowk Road Section in Pokhara shown in Figure 3.

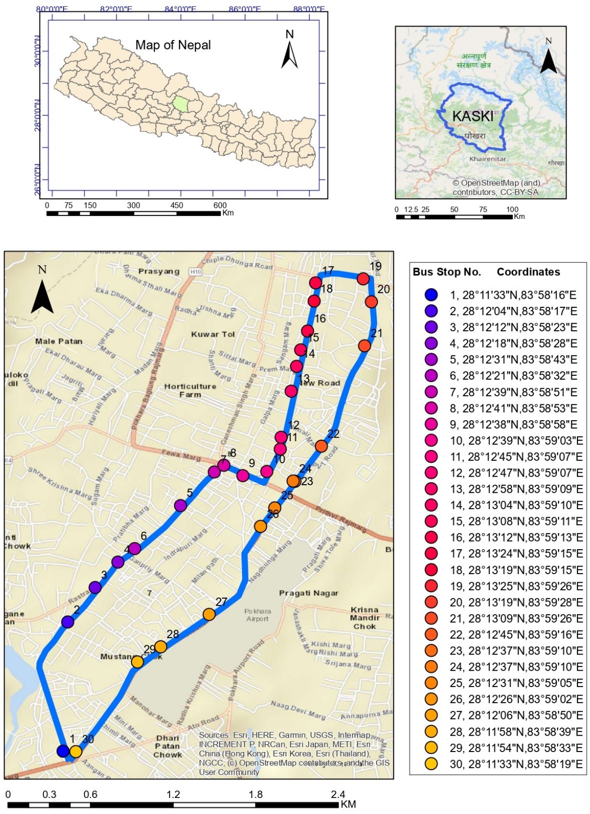

Figure 3: study Area

4.2 Identification of Unsafe acts and Causal Factors

Unsafe acts encompass behaviors conducted by bus users or drivers that could potentially lead to conflicts between vehicles and pedestrians. Based on available literature [21] [22] [2] [5] , five important unsafe acts in and around bus stops were identified. Each unsafe act arises due to the situation and factors that influence. So causal factors associated with all these five unsafe acts has been identified through field visit and available literature [21] [22] [2] [5].

A. Encroachment of the bus users to the roadway (b1) Bus users may wait for the bus in carriageway instead in the waiting area and also pedestrian may use the carriageway instead of using the sidewalks [23]. So, the factors that makes the users to encroach the road way are:

- Inadequate or Absence of the waiting area (b1x1)
- Inadequate or Absence of the sidewalk facility (b1x2)
- No lighting facility along the sidewalk (b1x3)
- No or damaged drainage facility (b1x4)
- Untidy surrounding (b1x5)
- Encroachment of sidewalk by parked vehicles (b1x6)
- Presence of street vendors along the sidewalk (b1x7).

B. Crossing road in front of a stopped bus (b2) In some cases, pedestrian is willing or forced to cross the road soon after the stoppage of the bus from the front. That makes inconvenient

Figure 4: (a) Crossing road in front of stopped bus (b) crossing road at undesignated area (c) Loading/ Unloading of passengers at undesignated location (d) Crossing road where there is no zebra crossing (e) faded zebra crossing signs (f) untidy environment)

to the waiting passengers to see the bus coming from the same direction [22]. This scenario of unsafe act could occur due to multiple factors which includes:

- Cross walk location is away of the loading/landing area (b2x1)
- Presence of intersection near the bus stop (b2x2)

C. Crossing road at locations where sight distance with bus is inadequate (b3) In some cases, sight distance is not enough for the bus drivers so as to stop the bus at a safe distance from the pedestrians who are either crossing the road in front of the bus stop or waiting for the bus in the travel way [24]. So, the possible factors for this act are:

- Parking on street area (b3x1)
- Waiting area is immediately after the curve or high elevation (b3x2)
- Unavailability of lighting facility in the bus stop area (b3x3)
- Obstruction physically (b3x4).

D. Crossing road at undesignated locations (b4) There arises the situation where a passenger needs to cross the road at undesignated location during the arrival or departure due to a number of factors. These are some of the factors that have been put here:

- Width of crosswalk is not enough as per traffic (b4x1)
- Zebra crossing or cross walk is far away from the bus stop (b4x2)
- Faded or invisible marking of cross walks (b4x3)
- Vehicle stoppage is not at safe distance from the crosswalk (b4x4)

E. Loading/unloading of passengers at multiple locations other than the designated bus stop locations (b5) Passengers are sometimes forced to board/alight the bus at different undesignated location. This causes the passenger to expose directly to the vehicles on road. The unsafe act can occur due to the possible factor of:

- Inadequate capacity of the loading area (b5x1)
- Vehicle does not stop at the designated loading area (b5x2)
- Irrational dwell time (b5x3)
- lack of drainage facility (b5x4)

4.3 Study of Presence of Causal Factors on Field

Field observation is carried out in some of the bus stops in the given road section. The causal factor is observed. To represent the presence of the causal factor a value of 1 is assigned to xi (xi=1) and to represent the absence of causal factor in the same bus stop a value of 0 is assigned to xi (xi=0). Similarly, other values of xi=0.5 for moderately present condition and xi=0.2 for low presence is considered. The overall criteria set for to calculate the value of xi is set based on Road Standards of Nepal and literature available.

4.4 Determination of degree of danger of unsafe acts (dj)

The unsafe acts contributing to bus stop safety are identified in above steps. Satty [14] made use of comparative judgment and absolute measurement. Unsafe acts studied through functional judgement. Absolute measurement, sometimes called scoring, is used when it is desired to ignore such structural dependence among elements, while relative measurement is used otherwise. An AHP survey for pairwise comparison has been developed to compare each unsafe act to other unsafe act in terms of their severity using the SAATYs 9-point scale of importance. The present study considered 15 experts for AHP survey of pairwise comparison as an acceptable sample size as most researchers have utilized use of 8 to 15 experts as the expert reviews' sample size [25] [26] [27] .

After completing a pairwise comparison among the unsafe acts, a comparison matrix also called priority matrix of size n*n is prepared. Now, weighted score/Weighted Vector/Priority vector i.e. degree of danger associated with unsafe act (dj) of each unsafe act is calculated by using the mathematical calculation. For a priority vector 'x', it should satisfy the equation Ax = cx, where 'A' represents the comparison matrix, 'x' is the priority vector, and 'c' is a positive constant. This equation means that the priority vector remains proportional to its eigenvalue (c) even after multiplication by the judgment matrix. There is an infinite number of ways to derive the priority vector from the matrix A. An easy way to get an priority vector/eigen vector is to normalize the geometric means of the rows [14]. Similarly, the deviation of the comparison (Consistency of Judgement) is checked through the consistency index test after calculation of eigen value.

Table 1: Satty's 9 Point cale of Importance

Intensity	Definition	Explanation
1	Equal Importance	Two elements contribute equally to the objective.
3	Moderate importance	Experience and judgement slightly favor one element over another
5	Strong Importance	Experience and judgement strongly favor one element over another
7	Very strong importance	One element is strongly favored over another, its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation.
2,4,6,8 can be used to express intermediate values		

$$\text{Matrix} = \begin{bmatrix} 1 & w_1/w_2 & ... & w_1/w_n \\ w_2/w_1 & 1 & ... & w_2/w_n \\ ... & ... & ... & ... \\ w_2/w_1 & 1 & ... & w_2/w_n \end{bmatrix}$$

$$EigenVector, Aij = \frac{\sum_i^n (1 * \frac{w_1}{w_2} * \frac{w_1}{w_3} + .. + \frac{w_1}{w_n})^(1/n)}{\sum[\sum_i^n (1 * \frac{w_1}{w_2} * \frac{w_1}{w_3} + .. + \frac{w_1}{w_n})^(1/n)]}$$

$$EigenValue, \lambda_i = \frac{\sum_j^n (\sum_{i=1}^n A_i j) W_j}{A_{ij}}$$

Here, n= Number of criteria, or the size of matrix w2/w1 represents the intensity of unsafe act 1 to the unsafe act 2 and value is provided as per intensity value of Saaty's 9 Points of Scale of importance. After the matrix is constructed, process is followed by calculation of eigen vector matrix (A_{ij}) and Eigen Value λ_i. Similarly, the deviation of the comparison is checked through the consistency index test after calculation of eigen value.

Table 2: Random Index for different dimensions of Matrix

Dimension	1	2	3	4	5	6	7	8	9
RI	NA	NA	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Consistency test, (CI) = (λ max-n)/(n-1)

Consistency ratio (CI)= CI/RI

4.5 Determination of the contribution index of causal factors (ci)

Relative measurement method sometimes called scoring is used to determine the contribution index of causal factor. An expert scoring survey has been conducted to determine the relative contribution of each causal factor to the corresponding unsafe acts. The questionnaire is given to the experts (Civil Engineers and Transportation Experts) and they were asked to give their score (out of 10) on the contribution of each factor to the unsafe act. The normalized score of the factors taken as the contribution index of the causal factors.

4.6 Calculation of safety level of bus stop

In this stage, mathematical model developed by Cheranchery et. al. (2016) is utilized. According to (Cheranchery et. al, 2016), causal factor (xi), contribution index (ci), and degree of danger (dj) are the three important parameters for assessing the safety level of bus stop. Accordingly, the independent variable being a categorical variable, a model is adopted. The model adopted to assess the safety level of the bus stops is: s=10(1-) Where, S: safety level of a bus stop, Xi: a dummy variable representing the presence (xi=1) or absence (xi=0) and its moderate value of a causal factor in a bus stop, Wij: weightage of the causal factor mathematically expressed as: Wij = ci * dj

Where, Ci: contribution index, which indicates the relative contribution of ith causal factor to the jth unsafe act and dj : degree of danger associated with the jth unsafe act.

4.7 Prioritization of Bus Stops

As discussed in the previous section, the safety level of the bus stops is calculated from the values of ci, dj and xi (obtained through field investigation of the bus stop). Accordingly, the prioritization of the bus stops is performed based on the fact that the "lower the safety level the higher is the priority for improvemen".

5. Result and Discussion

5.1 Calculation of Degree of danger of Unsafe Acts

As discussed earlier, after obtaining the comparison matrix, each element of a column of the matrix is added. Dividing individual element of the matrix by corresponding sum of the elements of column a new matrix is formed. Finally averaging each elements of a row gives the degree of danger associated with that unsafe act. From the data of an expert, calculated degree of danger is shown in Table .

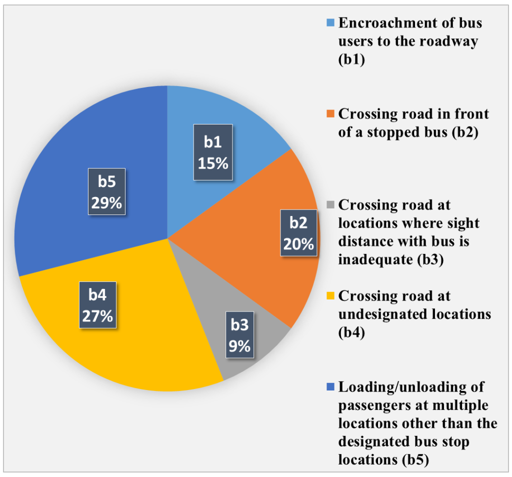

Figure 5: Degree of danger associated with unsafe acts

So, it is obtained that Unsafe Act: Loading/unloading of passengers at multiple locations other than the designated bus stop locations (b5) has highest degree of danger (dj) value of 0.29. Similarly, unsafe act: Crossing road at locations where sight distance with bus is inadequate (b3) has least degree of danger with value 0.09. The unsafe act Enchroachment of bus users to the roadway (b1) has 0.15, crossing road infront of stopped(b2) has 0.20 and crossing road at undesignated location (b4) has value of 0.27.

5.2 Calculation of contribution index of causal factors (ci)

An Expert scoring survey was developed to determine the relative contribution of each causal factors corresponding to each unsafe act. The experts were asked to provide the contribution score ranging from 0 to 10. Similarly, expert scoring survey data of the experts are averaged and normalized. The normalized score thus obtained is taken as the contribution index value. The calculation is shown in table.

5.3 Calculation of weightage value wi

The weightage value of causal factors is obtained by the product of average degree of danger (dj) and Averaged Normalized Contribution Index (ci).

It is found that the causal factor “Vehicle does not stop at the designated loading area (b5x2) got maximum weightage of 0.086. Followed by “Zebra crossing or cross walk is far away from the bus stop (b4x2)” with weightage of 0.077. Likewise, causal factor “Untidy surrounding” got the least weightage of 0.018.

5.4 Calculation of Safety level value

Safety level of bus stop is finally calculated using the mathematical model: S= 10 $(1-\sum xi * wij)$ developed by Cheranchery et al., (2016). Here, S is the safety level, xi indicates absence or presence of causal factors and wij is the weightage value of that causal factor obtained through Degree of danger (dj) and Contribution index (Ci).

Table 3: Normalised score/Contribution Index (Ci) of causal factors

Unsafe Act	Causal Factor	Normalised Score
b1	(b1x1)	0.15
	(b1x2)	0.15
	(b1x3)	0.13
	(b1x4)	0.13
	(b1x5)	0.12
	(b1x6)	0.16
	(b1x7)	0.17
b2	(b2x1)	0.35
	(b2x2)	0.35
	(b2x3)	0.30
b3	(b3x1)	0.25
	(b3x2)	0.28
	(b3x3)	0.22
	(b3x4).	0.24
b4	(b4x1)	0.21
	(b4x2)	0.28
	(b4x3)	0.25
	(b4x4)	0.25
b5	(b5x1)	0.25
	(b5x2)	0.30
	(b5x3)	0.25
	(b5x4)	0.20

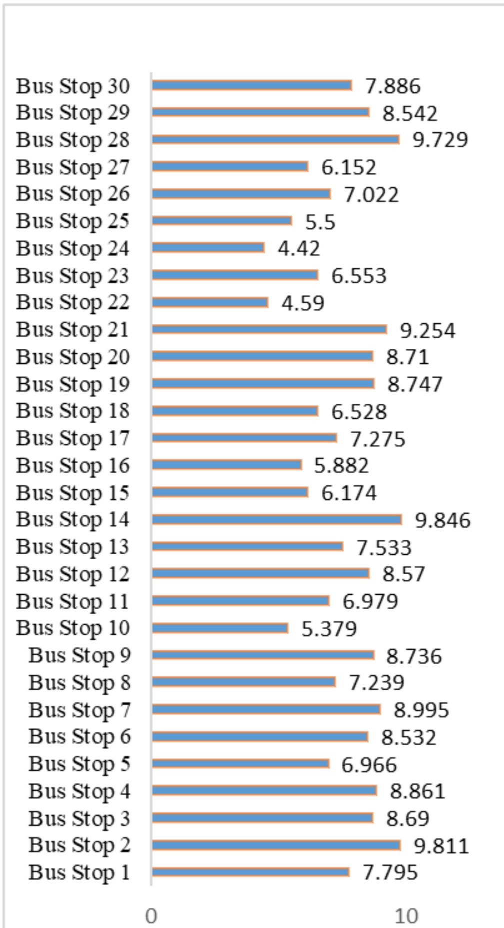

Figure 6: Safety level of bus stops (Value out of 10)

5.4.1 Ranking and Prioritization of Bus Stops based on Safety level

It is found that the safety level to range from 4.420 to 9.846. So, these bus stops can be arranged in increasing order of safety level indicating the prioritization of bus stop based on requirement for intervention for improving safety status. The bus stops have mainly two types of deficiencies, design deficiencies and management deficiencies. So, improvement should be carried out based on causal factors leading to unsafe acts.

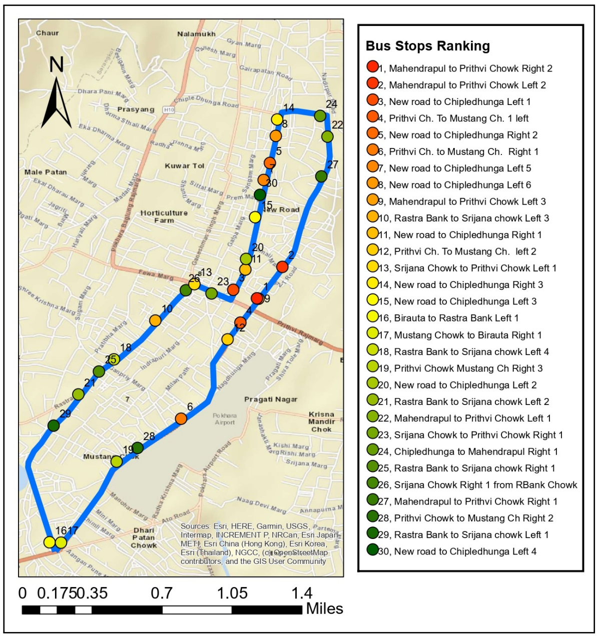

Figure 7: Ranking of Bus Stops based on need for improvement

5.4.2 Use of accidental data to validate safety level

An approach has been done to establish a link between the safety levels of bus stops and the crash data at nearby intersections. The crash data for the three months has been utilised. The robust correlation, evidenced by the R Squarred value of 0.66, suggests that the safety assessment model used is reasonably effective in representing the actual scenario and that the model is acceptable [28].

The trend observed—where bus stops rated lower in safety tend to have higher accident rates, while those rated higher in safety experience fewer accidents—strongly supports the reliability of the safety assessment methodology employed. This correlation underscores the model's capability to reflect the actual safety conditions.

6. Conclusion

The ranking of bus stops based on safety value facilitates strategic prioritization, enabling efficient resource allocation to bus stops with lower safety levels, thereby effectively mitigating risks and fostering a safer pedestrian environment along this specific road section in Pokhara city. Among the identified unsafe acts, Loading/unloading of passengers at multiple locations (b5) emerges with a danger value of 0.29, highlighting its significant impact on pedestrian safety.

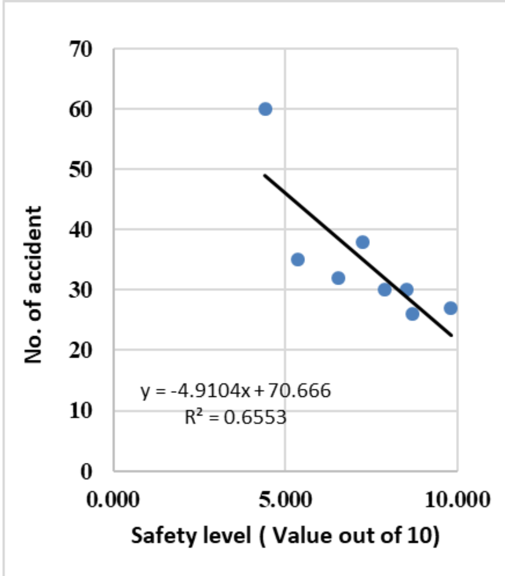

Figure 8: Plot between No. of Accidents and safety level value

Conversely, crossing roads at locations with inadequate sight distance (b3) exhibits the least danger at 0.09, indicating specific areas for targeted interventions. Causal factor weightage emphasizes the pivotal role of infrastructure elements, such as 'Vehicle not stopping at the designated loading area (b5x2)' and 'Zebra crossing or crosswalk far from the bus stop (b4x2),' warranting immediate attention for safety enhancements.

Moreover, safety level assessments yield a diverse range of safety profiles across different bus stops. Bus stop locations like "28°11'58"N,83°58'39"E - Prithvi Chowk to Mustang Ch Right 2" exhibit higher safety levels, while "28°12'37"N,83°59'10"E - Mahendrapul to Prithvi Chowk Right 2" presents lower safety levels, necessitating urgent interventions. The integration of danger values, causal factor weightage, and safety levels offers a strategic approach to prioritize interventions, advocating for stakeholder action at stops with lower safety values and emphasizing high-weightage causal factors, along with mitigating high-danger unsafe acts.

Acknowledgments

Department of Civil Engineering, Paschimanchal Campus, IOE, TU have been pillars of support, offering invaluable guidance and unwavering motivation throughout this endeavor. Their expertise and insights have been instrumental in shaping the research.

Deep appreciation is extended to the MSc. Infrastructure Engineering and Management Coordinator and the entire team at Paschimanchal for their consistent guidance and support at every stage of this study. Their encouragement and feedback have played a pivotal role in refining the scope and direction of the research.

References

[1] Krishna Nath Ojha. Journal of engineering and technology for industrial applications. 2016.

[2] Mehmet Baran Ulak, Ayberk Kocatepe, Anil Yazici, Eren Erman Ozguven, and Ashutosh Kumar. A stop safety index to address pedestrian safety around bus stops. *Safety science*, 133:105017, 2021.

[3] Srinivas S Pulugurtha and Vinay K Vanapalli. Hazardous bus stops identification: An illustration using gis. *Journal of Public Transportation*, 11(2):65–83, 2008.

[4] Curtis M Craig, Nichole L Morris, Ron Van Houten, and David Mayou. Pedestrian safety and driver yielding near public transit stops. *Transportation research record*, 2673(1):514–523, 2019.

[5] Dipanjan Mukherjee and Sudeshna Mitra. What affects pedestrian crossing difficulty at urban intersections in a developing country? *IATSS Research*, 46(4):586–601, 2022.

[6] Sapana Bishwokarma, Chiranjivi Adhikari, Dhurba Khatri, Bikash Gauchan, Vishnu Prasad Sapkota, and Chhabi Lal Ranabhat. Multiple burdens of road traffic crashes in pokhara, nepal: A patient approach. *medRxiv*, pages 2022–05, 2022.

[7] Hiroyuki Iseki and Brian D Taylor. Style versus service? an analysis of user perceptions of transit stops and stations. *Journal of Public Transportation*, 13(3):23–48, 2010.

[8] Long Tien Truong and Sekhar VC Somenahalli. Using gis to identify pedestrian-vehicle crash hot spots and unsafe bus stops. *Journal of Public Transportation*, 14(1):99–114, 2011.

[9] Anish Khadka, John Parkin, Paul Pilkington, Sunil Kumar Joshi, and Julie Mytton. Completeness of police reporting of traffic crashes in nepal: Evaluation using a community crash recording system. *Traffic injury prevention*, 23(2):79–84, 2022.

[10] Pradeep Kumar Agarwal, Premit Kumar Patil, and Rakesh Mehar. A methodology for ranking road safety hazardous locations using analytical hierarchy process. *Procedia-Social and Behavioral Sciences*, 104:1030–1037, 2013.

[11] Zhirui Ye, Chao Wang, Yongbo Yu, Xiaomeng Shi, and Wei Wang. Modeling level-of-safety for bus stops in china. *Traffic injury prevention*, 17(6):656–661, 2016.

[12] A Richard A Van der Horst, Maartje de Goede, Stefanie de Hair-Buijssen, and Rob Methorst. Traffic conflicts on bicycle paths: A systematic observation of behaviour from video. *Accident Analysis & Prevention*, 62:358–368, 2014.

[13] Shalini Kanuganti, Ruchika Agarwala, Bhupali Dutta, Pooja N Bhanegaonkar, Ajit Pratap Singh, and AK Sarkar. Road safety analysis using multi criteria approach: A case study in india. *Transportation research procedia*, 25:4649–4661, 2017.

[14] Roseanna W Saaty. The analytic hierarchy process—what it is and how it is used. *Mathematical modelling*, 9(3-5):161–176, 1987.

[15] Sali Shakya. *Ranking Road Safety Hazardous Locations in Nepal: A Case Study of Kalanki (Ch. 10+ 600)–Koteshwor (Ch. 20+ 994) Road Section*. PhD thesis, Pulchowk Campus, 2020.

[16] Munavar Fairooz Cheranchery, Kinjal Bhattacharyya, Bhargab Maitra, and Manfred Boltze. Assessing safety level of bus stops in the absence of crash data. In *Transportation Research Board 95th Annual Meeting*, number 16-0702, 2016.

[17] Sunita Pandey and Saroj Acharya. Assessing safety level of bus stops a case study of kathmandu ring road (kalanki-koteshwor section). 2020.

[18] Keshav Jimee, Gaurav Poudel, Bishal Khadka, and Bhuwan Karki. Gis-based analysis of road accidents for prithvi highway of pokhara city. 12 2022.

[19] Sushmita Subedi and Roman Pandit. Road network rating based on land use of pokhara. *Journal on Geoinformatics, Nepal*, pages 51–58, 2019.

[20] Ross O Phillips, Oddrun Helen Hagen, and Siri Hegna Berge. Bus stop design and traffic safety: An explorative analysis. *Accident Analysis & Prevention*, 153:105917, 2021.

[21] Mara Chagas Diógenes, Luis Antonio Lindau, and Laboratório de Sistemas de Transportes-LASTRAN. Risk perception of pedestrians at midblock crossings in brazil. In *Proceedings of the 12th World Conference on Transport Research (WCTR)*, pages 1–19, 2010.

[22] Munavar Fairooz Cheranchery, Kinjal Bhattacharyya, Muhammed Salih, and Bhargab Maitra. A proactive approach to assess safety level of urban bus stops. *International journal of injury control and safety promotion*, 26(3):260–270, 2019.

[23] Sanjay Kumar Singh and Ashish Misra. Road accident analysis: A case study of patna city. *Urban Transport Journal*, 2(2):60–75, 2004.

[24] Kay Fitzpatrick, Daniel B Fambro, and Angela M Stoddard. Safety effects of limited stopping sight distance on crest vertical curves. *Transportation Research Record*, 1701(1):17–24, 2000.

[25] Gene Rowe and George Wright. Expert opinions in forecasting: the role of the delphi technique. *Principles of forecasting: A handbook for researchers and practitioners*, pages 125–144, 2001.

[26] Thomas L Saaty and Mujgan Sağır Özdemir. How many judges should there be in a group? *Annals of Data Science*, 1:359–368, 2014.

[27] Carl W Turner, James R Lewis, and Jakob Nielsen. Determining usability test sample size. *International encyclopedia of ergonomics and human factors*, 3(2):3084–3088, 2006.

[28] David LJ Alexander, Alexander Tropsha, and David A Winkler. Beware of r 2: simple, unambiguous assessment of the prediction accuracy of qsar and qspr models. *Journal of chemical information and modeling*, 55(7):1316–1322, 2015.