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Safety-Oriented Evaluation and Prioritization of Informal Public Transport Stops: An AHP-Based Study on Kathmandu's Sundhara-Kirtipur Gate Route

by

Asmit Gautam

A THESIS

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The undersigned certify that they have read and recommended to Institute of Engineering for acceptance, a thesis entitled **"Safety-Oriented Evaluation and Prioritization of Informal Public Transport Stops: An AHP-Based Study on Kathmandu's Sundhara-Kirtipur Gate Route"** submitted by Asmit Gautam in partial fulfillment of the requirements for the degree of Master of Science in Transportation Engineering.

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ABSTRACT

Rapid urbanization and growing travel demand have placed increasing pressure on Kathmandu Valley's public transport system, where informal stopping practices are common due to limited infrastructure and weak enforcement at formal stops. These informal stops often expose pedestrians and passengers to unsafe conditions, especially near intersections and busy commercial areas, where boarding and alighting take place directly within moving traffic. This study develops and applies a Conflict Severity Index (CSI) framework that integrates Analytic Hierarchy Process (AHP) and field-based traffic conflict observations to assess and prioritize informal public transport stops along the selected corridor (Sundhara to Kirtipur Gate). Eight informal stops were identified through video recording and manual field surveys, five key criteria, namely safety, traffic impact, accessibility, land use, and demand density were evaluated using expert judgment. Normalized field data were combined with AHP-derived weights to calculate CSI values and classify stops by severity. The results show that all identified stops fall within medium to high severity levels. The highest-risk locations are mainly concentrated near major intersections due to high pedestrian activity, heavy traffic volume, longer dwell times, and limited roadway space. Validation using Spearman's rank correlation, sensitivity testing, and confidence interval analysis confirmed the consistency and reliability of the rankings. The proposed CSI-AHP framework provides a practical and evidence-based tool to support decision-making for improving safety and managing informal public transport stops in the Kathmandu Valley.

Keywords: Informal public transport stops, Conflict Severity Index, Analytic Hierarchy Process, Traffic conflicts, Urban road safety.

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LIST OF ABBREVIATIONS

AHP	Analytic Hierarchy Process
CI	Consistency Index
CR	Consistency Ratio
CSI	Conflict Severity Index
DoR	Department of Roads
DoTM	Department of Transport Management
DT	Dwell Time
FHWA	Federal Highway Administration
FP	Formal Stop Proximity
GIS	Geographic Information System
GPS	Global Positioning System
IOE	Institute of Engineering
IP	Intersection Proximity
IPTS	Informal Public Transport Stops
JICA	Japan International Cooperation Agency
Km	Kilometer
KMC	Kathmandu Metropolitan City
KV	Kathmandu Valley
KVDA	Kathmandu Valley Development Authority
KVTPO	Kathmandu Valley Traffic Police Office
LC	Lane Change
LOS	Level of Service
LULC	Land Use/Land Cover
M	Meter
MC	Markov Chain
MCT	Mixed-Traffic Conditions
MSTrE	Master of Science in Transportation Engineering

MTPO	Metropolitan Traffic Police Office
MCDM	Multi-Criteria Decision Making
NGO	Non-Governmental Organization
NURS	Nepal Urban Road Standard
PET	Post-Encroachment Time
PV	Pedestrian Volume
RI	Random Index
ROW	Right of Way
SB	Sudden Braking
SD	Standard Deviation
Sqkm	Square Kilometer
TCQSM	Transit Capacity and Quality of Service Manual
TTC	Time-to-Collision
TU	Tribhuvan University
TV	Traffic Volume
UN	United Nations
WHO	World Health Organization

1 INTRODUCTION

1.1 Background

Urban public transportation systems worldwide are experiencing growing pressure due to rapid urbanization, population growth, and increasing travel demand, particularly in cities of developing countries, where infrastructure expansion has not kept pace with urban growth (Cervero & Golub, 2007). The Kathmandu Valley illustrates significant urban transport challenges in developing cities, where rapid population growth and unplanned urban expansion have increased travel demand faster than the road network and transport infrastructure can accommodate, leading to persistent congestion and reduced operational efficiency. Research shows that insufficient public transport infrastructure and services, including overcrowded and unreliable bus systems, contribute to commuter dissatisfaction and increased use of private vehicles, which worsens congestion and reduces overall system performance (Poudyal & Shahi, 2025). Additionally, studies have identified that limited transport infrastructure capacity and uncontrolled growth in vehicle numbers are key factors behind frequent traffic jams and operational inefficiencies in the valley's road network (Bhusal et al., 2023). These conditions also increase traffic safety risks, as overcrowded and inefficient transport systems expose commuters to greater danger during travel (Aryal et al., 2022).

Road traffic crashes have emerged as a major public health and socioeconomic concern in Nepal. International assessments and national records consistently indicate that Nepal experiences a high rate of road traffic fatalities relative to its population, with pedestrians and public transport users among the most vulnerable road users (WHO, 2018). Within the national context of Nepal, the Kathmandu Valley accounts for a disproportionately high share of road traffic accidents, injuries, and fatalities owing to its high population density, concentration of vehicles, and complex urban traffic conditions. Traffic police records show that 9,683 road accidents and 178 fatalities were reported in the Valley during FY 2022–23, indicating a persistently high and increasing burden of road traffic risk. These trends highlight the urgent need for targeted road safety interventions and improved traffic management in Kathmandu Valley (Republica, 2023).

Long-term crash data clearly demonstrate the severity of the problem in the Kathmandu Valley. A decade-long analysis of traffic police records reported 76,752 crashes between FY 2070/71 and FY 2079/80, revealing a continuously increasing crash burden (Gautam & Joshi, 2024).The annual crash frequency increased from 4,672 in FY 2070/71 to 10,675 in FY 2079/80, representing a rise of over 128% within a decade. In addition, Traffic Police records reported 2,376, 2,369, and 2,502 fatalities in FY 2079/80, 2080/81, and 2081/82 respectively, highlighting the growing severity of road safety issues in the Valley. This upward trend, as shown in Figure 1-1, reflects not only increasing motorization but also systemic deficiencies such as limited road space, and inadequate separation between vehicular and pedestrian movements.

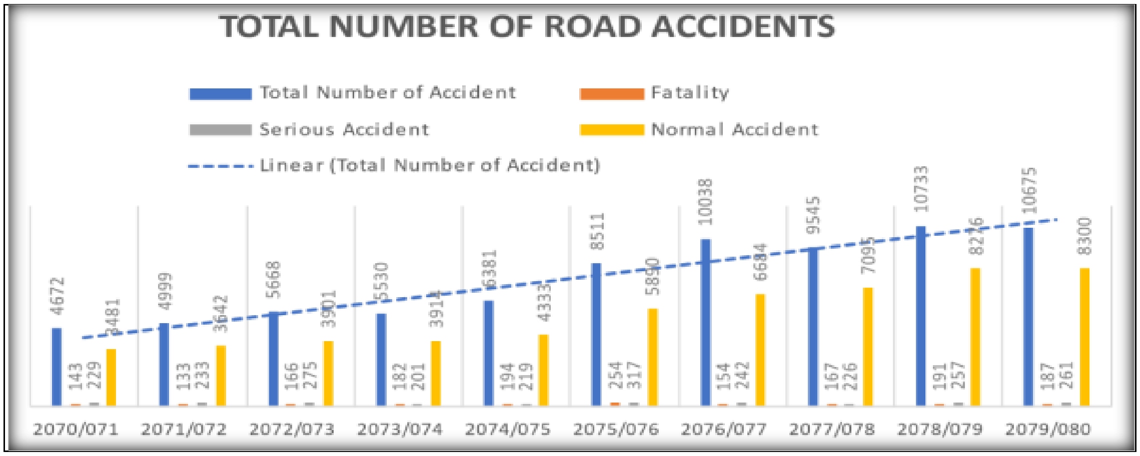

Figure 1-1: Total number of road crashes. Source: (Gautam & Joshi, 2024)

Crash involvement in the Kathmandu Valley is strongly influenced by vehicle composition and operating conditions. Analysis of the same dataset showed that motorcycles and scooters accounted for the largest share of crash involvement, followed by cars, jeeps, and vans; however, buses also represented a significant proportion of crashes due to their extensive daily operation and frequent stopping behavior (Gautam & Joshi, 2024). Over the ten-year period as shown in Figure 1-2, 14,890 buses were involved in reported crashes, indicating that public transport vehicles contribute substantially to overall crash exposure despite their lower numerical presence compared to private vehicles. This highlights the importance of examining public transport operating environments, particularly stopping locations where interactions with pedestrians are concentrated.

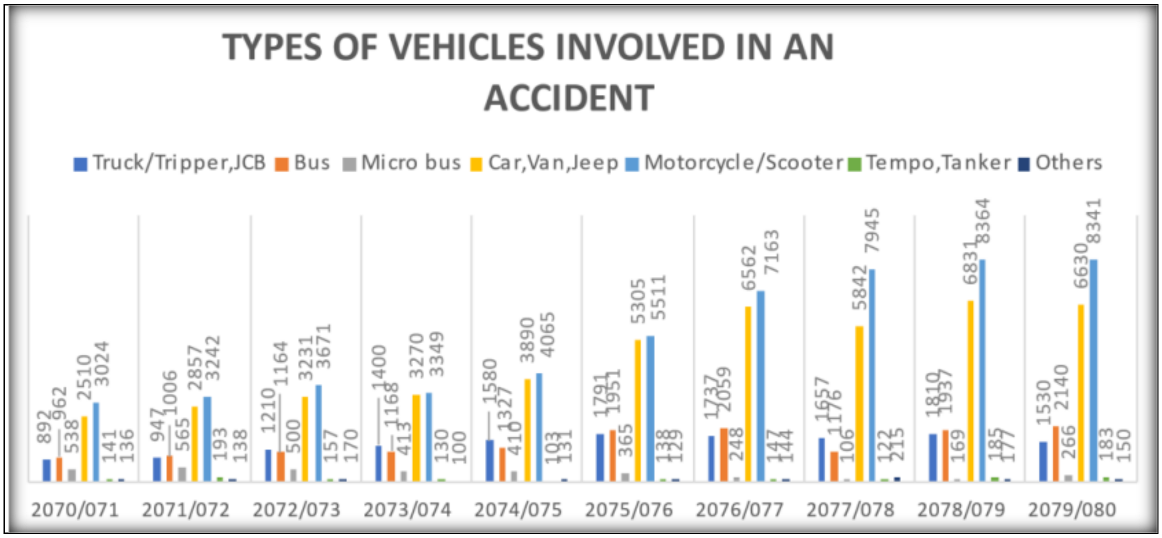

Figure 1-2: Types of vehicles involved in crashes. Source: (Gautam & Joshi, 2024)

Pedestrians constitute a disproportionately high share of traffic casualties in the Kathmandu Valley, with evidence showing that inadequate pedestrian infrastructure and frequent unsafe crossing behaviors contribute to their vulnerability. For example, pedestrians accounted for 18.4% of all road traffic crash victims and 32.4% of road traffic deaths in the Valley over a recent five-year period, reflecting the lack of continuous sidewalks, crossings, and effective traffic control for walkers (K.C & Shahi, 2025). Pedestrian exposure near public transport activity and busy urban roads in the Kathmandu Valley is exacerbated by inadequate sidewalks, discontinuous pedestrian infrastructure, and a lack of safe crossings, forcing pedestrians to share traffic space with vehicles and increasing their risk of conflict and crashes (Shahi & Shahi, 2025). These conditions result in frequent interactions between pedestrians and vehicles, increasing both crash probability and the occurrence of unsafe traffic conflicts.

Informal public transport stops are a key feature of Kathmandu's system due to heavy reliance on transit, but limited formal infrastructure leads operators to pick up and drop off passengers at ad-hoc locations where demand is high (Asian Transport Observatory, 2023). In Kathmandu's largely informal transport system, minibuses often stop at undesignated locations for passenger pickup and drop-off, which, while convenient, disrupts traffic and creates unsafe conditions (Regmi, 2023).

Research from Asian cities similar to Kathmandu shows that informal or poorly planned transport stops lead to irregular stopping, longer dwell times, and traffic disruption, increasing inefficiency and conflict risks for all road users (Regmi, 2023). Bus stops placed very close to intersections (especially near-side stops) can intensify pedestrian-vehicle interactions because stopping buses block lanes, increase dwell time, and trigger weaving/lane-changing near crossing effects that are most pronounced during peak periods when both traffic volumes and passenger activity are highest (Singleton et al., 2024). These findings indicate that safety evaluations at stopping locations must consider operational and behavioral factors in addition to recorded crashes.

The crash risk in the Kathmandu Valley is spatially concentrated, with GIS-based hotspot analysis (2019–2021) identifying significant clusters along major corridors such as the Ring Road, Tribhuvan Highway, Araniko Highway, and key feeder roads, as shown in Figure 1-3 (K.C et al., 2024). These corridors are characterized by high traffic volumes, dense roadside activities, and numerous formal and informal stopping points, making them critical locations for safety assessments.

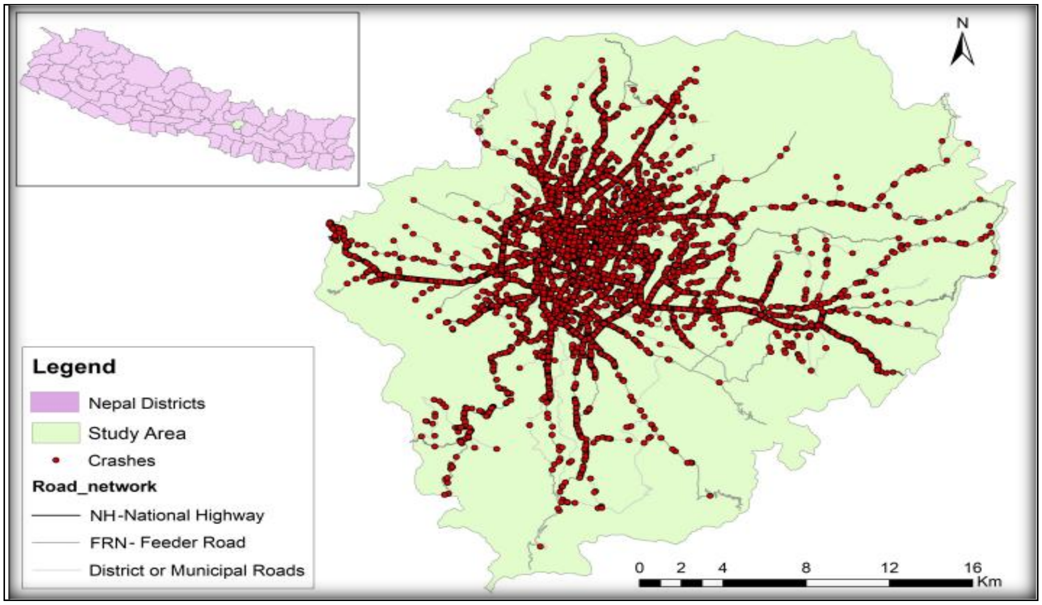

Figure 1-3: Crash Hotspot Map of Kathmandu Valley. Source: (K.C et al., 2024)

Traditional road safety assessments depend heavily on historical crash data; however, in developing urban contexts such as Nepal, crash records maintained by the police are often incomplete and substantially underreport the true number and characteristics of traffic crashes, limiting their usefulness for micro-level safety evaluation and targeted interventions (Khadka et al., 2022). Because crashes are rare at individual locations, making it difficult to assess risk using only historical collision records, traffic conflict analysis and other surrogate safety measures are widely used as alternative or complementary techniques to identify near-miss events and unsafe interactions that precede crashes (Nikolaou et al., 2023).

The concept of traffic conflict analysis has evolved over several decades, starting from early observational studies that formalized measures of near-miss interactions in the 1970s and 1980s with the Swedish Traffic Conflict Technique, which classifies conflicts based on severity and evasive behavior. More recent work has refined and extended these structured methodologies for contemporary road safety assessment (Hydén, 1987; Laureshyn & Várhelyi, 2018). Further validation of surrogate safety measures has been achieved through research showing that proximity-based indicators, such as Time-to-Collision (TTC) and Post-Encroachment Time (PET), which capture sudden braking, evasive actions, and close interactions between vehicles, can be effective proxies for underlying crash risk at locations where traditional crash data are sparse or incomplete (Gettman & Head, 2003). These approaches are particularly suitable for evaluating informal public transport stops, where risky interactions occur frequently even if crashes are not always recorded.

International evidence indicates that pedestrian crash risk around bus stops is elevated, where stop placement and surrounding road conditions contribute to frequent pedestrian-vehicle interactions. Locations with high pedestrian activity near transit stops, combined with insufficient pedestrian infrastructure, have been linked with increased collision likelihood in both lower and middle income urban environments (Yendra et al., 2024). Although traffic conditions vary across cities, the underlying mechanisms high pedestrian activity, frequent stopping, lane obstruction, and unsafe crossings closely resemble conditions observed at informal public transport stops in Kathmandu.

The need for a targeted assessment of informal public transport stops is highlighted by the historical rise in traffic crashes in the Kathmandu Valley, spatial concentration of crash hotspots, vulnerability of pedestrians close to stopping locations, and limitations of crash-based safety assessment. In addition to recorded crashes, frequent traffic conflicts caused by stopping behavior, passenger movements, roadside activities, and nearby land use further influence safety risk at these locations. To prioritize high-risk informal stops and support evidence-based planning to enhance road safety and operational efficiency, it is appropriate for the Kathmandu context to adopt a conflict-based safety evaluation in conjunction with a structured multi-criteria decision-making framework.

1.2 Problem Statement

Kathmandu Valley is experiencing rapid urban growth and increasing travel demand, placing significant pressure on its urban transport system. However, the expansion of road infrastructure, traffic management, and public transport facilities has not kept pace with this growth, resulting in congestion, operational inefficiencies, and increasing road safety concerns (Asian Transport Observatory, 2024; JICA, 2012). Public transport remains the primary mode of travel for a large proportion of residents; however, the system operates under weak regulatory control and limited infrastructure support. One visible outcome of these shortcomings is the widespread emergence of informal public transport stops, where minibuses and microbuses frequently pick up and drop off passengers at undesignated roadside locations rather than at officially designated stops (Asian Transport Observatory, 2023).

Although such informal stops may improve passenger accessibility and reduce walking distances, they often create unsafe and disruptive traffic conditions. Vehicles stopping within traffic lanes obstruct traffic flow, increase dwell time, and generate frequent interactions between vehicles and pedestrians. These conditions are particularly problematic near intersections and along busy urban corridors where pedestrian activity is high and traffic operates under mixed conditions (Cervero & Golub, 2007; Yendra et al., 2024). In the Kathmandu Valley, the absence of adequate pedestrian infrastructure such as sidewalks, waiting areas, and marked crossings further exposes passengers to moving traffic during boarding and alighting, increasing the likelihood of traffic conflicts and crashes (K.C & Shahi, 2025).

Road safety statistics highlight the seriousness of this issue. Crash records indicate a growing number of road traffic incidents in the Kathmandu Valley, with pedestrians and public transport users representing a significant share of casualties. However, relying solely on crash data presents limitations for evaluating safety at specific locations such as individual bus stops, as crashes are relatively rare events and official records may underreport minor incidents (Khadka et al., 2022; Nikolaou et al., 2023).

Traffic conflict analysis has been widely used as a proactive safety assessment approach to overcome these limitations. Conflict-based indicators capture near-miss events and unsafe interactions that occur more frequently than crashes, providing a more sensitive measure of safety risks (Hydén, 1987). Despite its effectiveness, the application of systematic traffic conflict analysis to evaluate informal public transport stops remains limited in Nepal.

Furthermore, current transport planning practices in Kathmandu rarely use structured analytical approaches to evaluate the performance and safety of bus stop locations. Important factors such as safety risks, traffic disruption, pedestrian accessibility, surrounding land use, and passenger demand are often considered individually rather than through a combined assessment. As a result, decisions regarding the management or improvement of public transport stops are frequently made on an ad hoc basis and may rely more on operational convenience than on systematic analysis. This lack of an integrated and data-driven evaluation method makes it difficult for planners and authorities to identify which informal stops pose higher safety risks or require priority intervention.

Therefore, there is a need for a comprehensive framework to evaluate and prioritize informal public transport stops by considering multiple risk factors together. Integrating AHP, CSI, and GIS provides a structured approach that combines expert judgment, field data, and spatial analysis to identify high-risk locations and support informed planning decisions, ultimately improving road safety, traffic management, and overall transport system performance in the Kathmandu Valley

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1.3 Objectives of the Study

The main objective of this study is to evaluate and prioritize informal public transport stops along the Sundhara-Kirtipur Gate corridor in the Kathmandu Valley based on safety and operational risk using a CSI framework.

Specific Objectives

- To identify informal public transport stops along the Sundhara-Kirtipur Gate corridor.
- To determine the relative importance of evaluation criteria using the Analytic Hierarchy Process.
- To assess the safety and operational severity of identified informal stops and identify priority locations for improvement.

1.4 Scope of the Study

The scope of this study is defined as follows:

- This study focuses on the Sundhara–Kirtipur Gate corridor, a mixed road network with varied traffic, frequent informal stops, and high pedestrian activity, making it ideal for safety evaluation.
- It includes a field survey to collect spatial, operational, and safety-related data such as stop location, dwell time, traffic volume, and pedestrian movement.
- The Analytic Hierarchy Process will be applied to determine the weight of key criteria, and a CSI will be developed to evaluate and rank the stops.
- Geographic Information Systems will be used to map, analyze, and identify spatial clusters of high-risk informal stops for prioritization.
- The study is limited to safety and operational aspects of informal stops along the Sundhara-Kirtipur Gate route, with potential application of the developed framework to other routes in Kathmandu.

1.5 Limitations of the Study

The limitations of this study are outlined as follows:

- The study is limited geographically to the Sundhara-Kirtipur Gate route of Kathmandu and does not include other transport routes or areas within the Valley.
- This study focuses on the safety evaluation and prioritization of informal stops, excluding formal stops from severity analysis and comparison while only considering their distance-based influence on nearby informal stops.
- Data collection relies on field observations and short-term surveys, which may not capture long-term variations in traffic volume, passenger behavior, or seasonal patterns.
- The study's AHP-based evaluation depends partly on expert judgment, which may introduce subjective bias despite consistency checks.
- The study considers only mini and micro buses, as these vehicle types were used to identify informal public transport stops along the route, while all other vehicle categories were excluded.
- The results and recommendations are context-specific to Kathmandu's traffic and regulatory conditions and may require adaptation before being applied to other cities or countries.

1.6 Organization of this Thesis

This thesis is organized into the following chapters:

- Chapter 1: Introduction.
- Chapter 2: Literature Review.
- Chapter 3: Methodology.
- Chapter 4: Data Analysis, Results and Discussion.
- Chapter 5: Conclusions and Recommendations
- Finally, the References and APPENDIX are also attached at the end of this thesis.

2 LITERATURE REVIEW

2.1 Public Transport Growth, Informality, and the Kathmandu Context

In many developing cities, public transport systems operate under rapidly growing travel demand and limited road space, while formal infrastructure development has struggled to keep pace with urbanization. As a result, informal and demand-responsive transport services have emerged as a dominant feature of daily mobility. In these contexts, public transport systems often develop a strong informal character, with vehicles stopping flexibly in response to passenger demand rather than at formally designed stops. Kathmandu Valley clearly reflects this pattern: mixed traffic conditions, narrow road widths, and intense roadside activity mean that bus and microbus stopping behavior frequently overlaps with pedestrian movement and general traffic flow, creating complex and often unsafe interactions (Cervero & Golub, 2007; Regmi, 2023). Regional urban transport assessments consistently show that many developing cities operate with a mix of officially mapped stops and numerous informal, unmapped stopping locations. When analysis relies only on formal stop inventories, it often fails to capture the full operational reality and associated safety risks of public transport systems (Asian Transport Observatory, 2023).

In Kathmandu, public transport stops do more than simply facilitate boarding and alighting; they also act as key points where pedestrian movement connects with the main traffic stream. This interface becomes especially important in dense urban areas, where passengers frequently cross the road, wait close to the carriageway, and interact with roadside activities such as street vending. These behaviors increase pedestrian exposure and create frequent conflict situations, particularly when stops are located near intersections or along narrow road sections. Research on public transport accessibility in the Kathmandu Valley highlights the need for improved access infrastructure and planning as part of sustainable transport development, indicating that support facilities such as well-designed stops are essential components of system performance rather than optional extras (Prajapati et al., 2020).

2.2 Safety Risk around Bus Stops and the Role of Pedestrian Exposure

A consistent finding in international research is that areas around bus stops can carry elevated pedestrian safety risk because they draw pedestrians to the roadside and generate frequent crossing movements near stopped vehicles. A matched case control study in Lima found that the presence and characteristics of bus stops were significantly associated with pedestrian–motor vehicle collision patterns even after taking exposure factors into account (Quistberg et al., 2015). Although traffic conditions and enforcement practices differ between Lima and Kathmandu, the underlying mechanisms are similar: higher concentrations of pedestrians around stopping points, unpredictable vehicle movements, and limited crossing control create comparable safety risks in Kathmandu's informal stop environment.

More recent reviews of pedestrian safety around bus stops emphasize that risk is influenced by a combination of interacting factors, such as where stops are located, the availability of safe crossing facilities, traffic speed and volume, visibility, and the complexity of surrounding roadside activities. This evidence supports the need for a multi-factor approach to safety assessment rather than relying on single indicators alone (Yendra et al., 2024). This perspective directly aligns with the present study, which evaluates informal stops using multiple criteria covering safety, traffic impact, pedestrian accessibility, land-use suitability, and demand intensity and applies a structured decision-making method (AHP) to prioritize high-risk locations.

2.3 Use of Conflict/Near-Miss Approaches When Crash Data Are Limited

Traditional approaches to road safety assessment rely primarily on historical crash records. In practice, however, crash data are often incomplete, under-reported, or too sparse at small spatial scales such as individual informal public transport stops making it difficult to draw reliable conclusions about local safety risk. To overcome these limitations, researchers have long used traffic conflicts, defined as near-miss interactions that require evasive action, as surrogate safety measures that allow proactive safety assessment without waiting for serious crashes to occur, as shown in Figure 2-1 (Hydén, 1987). The Swedish Traffic Conflict

Technique provided a systematic framework for observing and interpreting such conflicts, introducing severity assessment based on time margins and interaction dynamics between road users. This approach is particularly relevant for Kathmandu, where informal stops may generate frequent risky interactions even when few crashes are formally recorded at the exact location.

Federal Highway Administration (FHWA) a U.S. government agency supported surrogate safety research highlights that crash events are relatively rare and stochastic, making them difficult to use for detailed, location-specific safety evaluation. In contrast, conflict-based indicators can be observed much more frequently and provide timely insight into how design features and operational conditions influence safety performance (Gettman et al., 2008; Gettman & Head, 2003). This body of work provides a strong theoretical foundation for using observed conflicts and severity measures to construct a composite CSI, enabling systematic comparison and ranking of informal public transport stops based on underlying safety risk rather than recorded crashes alone.

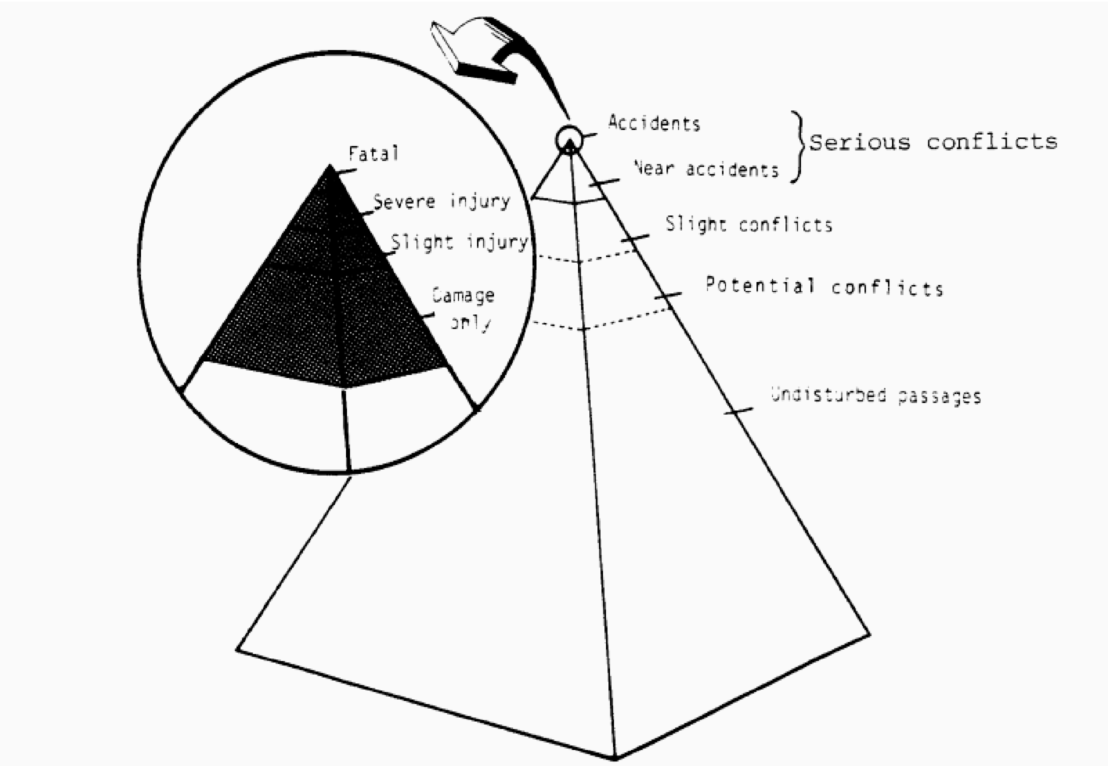


Figure 2-1: Safety pyramid. Source: (Hydén, 1987)

2.4 Bus Stop Operational Effects

Beyond safety considerations, bus stops also play an important role in shaping overall corridor performance. When buses stop within the travel lane a common condition at informal stops they can reduce effective roadway capacity, disrupt traffic flow, and trigger sudden lane changes and shockwave effects, particularly on corridors with narrow right-of-way. Transit and traffic engineering literature consistently shows that stop design (such as in-lane stops versus bus bays), stop spacing, and proximity to intersections strongly influence travel time reliability, traffic disturbance, and merging behavior (Kittelson & Associates et al., 2003).

The traffic impact indicators adopted in this study mean dwell time, number of lanes blocked, distance to intersections, and distance to the nearest formal stop are therefore consistent with established operational research, as they represent practical and measurable proxies for the severity of disruption caused by stopping activity. For analytical purposes, the study corridor is classified as a sub-arterial road based on its limited road width, constrained roadside space, inadequate pedestrian facilities, and frequent roadside activities. All operational assessments and calculations are conducted in accordance with the sub-arterial road specifications outlined in the Nepal Urban Road Standard 2076, as shown in Figure 2-2 (Ministry of Urban Development, 2019).

Nepal’s Urban Road Standard 2076 provides clear guidance that directly relates to these operational issues. The standard recommends the provision of bus bays by recessing the kerb in order to minimize conflicts between stopped buses and moving traffic. It specifies typical design dimensions, such as a recess length of around 15 m for a single bus, with additional length required where multiple buses stop, along with appropriate taper lengths. The standard also outlines typical stop spacing of approximately 200–400 m and recommends locating stops at least 40 m away from intersections on either approach. In addition, it emphasizes that stops should be placed near cross streets while ensuring safe pedestrian crossing conditions. Together, these provisions offer a standards-based rationale for assessing indicators such as distance from intersections and the presence or absence of formal stop infrastructure (Ministry of Urban Development, 2019).

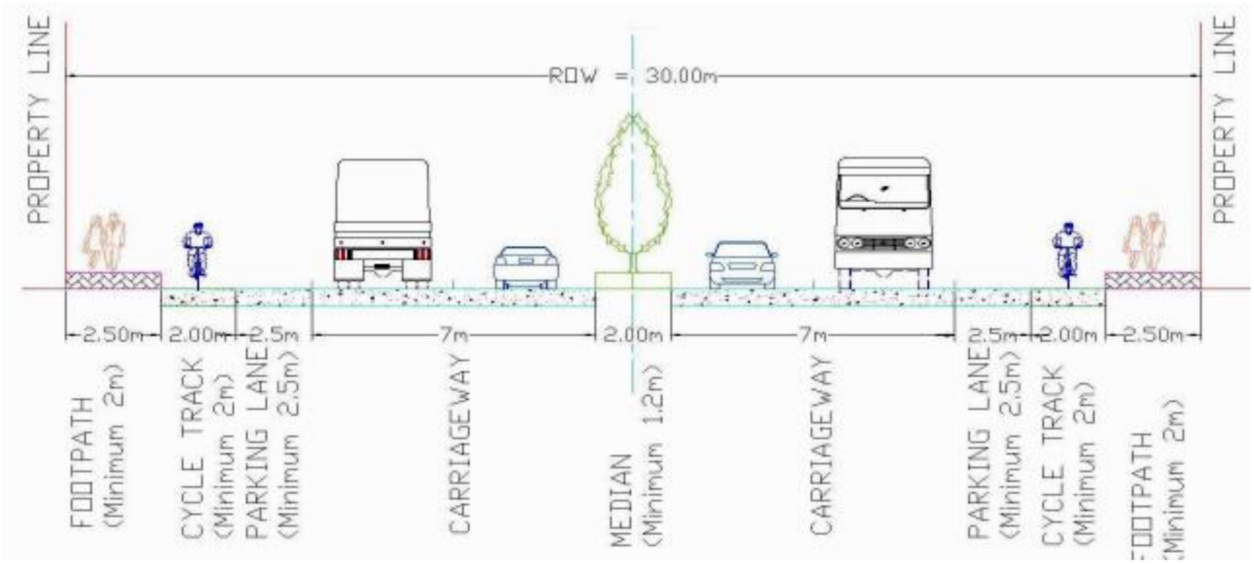


Figure 2-2: Sub Arterial Road Section. Source: (Ministry of Urban Development, 2019)

2.5 Accessibility and Walkability

Pedestrian accessibility plays a central role in shaping safety conditions around bus stops. When a stop attracts passengers but lacks sufficient footpath width, waiting space, or safe crossing opportunities, pedestrians are often pushed toward the edge of the carriageway and are more likely to make unsafe crossing movements. Nepal's Urban Road Standard 2076 specifies a minimum clear footpath width of 2.0 m, with wider provision such as 2.4 m recommended on higher-order roads. It also notes that footpaths may need to be widened near locations with concentrated pedestrian activity, including bus stops (Ministry of Urban Development, 2019). In addition, the standard provides capacity-based guidance for footpath design and discusses the importance of pedestrian refuge features. These requirements directly inform the Accessibility criteria used in this study, including sidewalk width, available shoulder or road cross-section space, the presence of pedestrian facilities (such as crossings, signals, and refuge islands), and obstructions along pedestrian approach paths.

In informal stop settings, physical obstructions such as street vendors, encroachments, and parked vehicles often narrow the usable walking space and push passengers to wait in exposed or unsafe locations. International reviews of bus stop safety similarly emphasize that pedestrian accessibility depends not only on whether a sidewalk exists, but also on its continuity, effective width, and the availability of safe crossing protection near the stop (Yendra et al., 2024). Including indicators related to obstructions and pedestrian safety facilities therefore strengthens the assessment by capturing functional accessibility, rather than relying solely on geometric sidewalk width.

2.6 Land Use Suitability and Sensitive Receptors near Stops

Safety and operational risk at public transport stops are influenced not only by road design but also by the surrounding land-use context. Stops located near schools, hospitals, markets, and other high-activity areas typically attract larger pedestrian volumes, include more vulnerable users such as children and older adults, and generate frequent road-crossing movements. For this reason, proximity to sensitive land uses is widely recognized in transport planning as an important factor in safety screening and access management. In Kathmandu, pedestrian activity along corridors is closely tied to roadside commercial development and clusters of institutional land uses, which intensify interactions between pedestrians and stopping vehicles near informal stops (Asian Transport Observatory, 2023). The Land Use criteria applied in this study covering available space for stop infrastructure and proximity to sensitive land uses reflect this understanding by identifying locations where higher levels of protection and formalization may be required, even in the absence of recorded crashes.

2.7 Demand Density

Exposure is important in transport safety, as risk increases with more interaction between road users. At bus stops, passenger movement represents pedestrian exposure, while traffic flow represents vehicle exposure. Including these in the study helps better understand conflict patterns showing whether risks are due to poor design or simply high usage levels.

This approach is consistent with broader urban transport evaluation practice, where service accessibility and performance are commonly assessed using indicators such as stop activity levels, population coverage, and proximity to transit services (Prajapati et al., 2020). It also aligns with international conventions on stop access, including typical walking distance thresholds. However, in Kathmandu's informal operating environment, flexible stopping behavior may reduce walking distances while increasing operational disorder, making direct measurement of demand at individual stops particularly important for balanced and evidence-based prioritization.

2.8 Multi-Criteria Decision-Making (MCDM) for Stop Prioritization

Safety risk at public transport stops is influenced by multiple factors such as traffic conflicts, pedestrian facilities, lane blockage, land use, and demand; therefore, MCDM methods are commonly used to integrate both qualitative and quantitative indicators. Among these, the AHP is widely applied as it structures complex problems into a clear hierarchy and derives relative weights using pairwise comparisons with a built-in consistency check.

AHP-based approaches have been successfully used to prioritize bus stops, especially where crash data are limited, by evaluating design and management-related risk factors (Cheranchary, 2016; Cheranchery et al., 2019). More broadly, AHP and similar methods are effective for ranking transport facilities across multiple dimensions such as safety and operational performance (Alkharabsheh et al., 2021). These studies provide a strong foundation for this research, which integrates expert-based weights with field data to compute the CSI for prioritizing informal public transport stops.

2.9 GIS Mapping and Spatial Prioritization of Risky Locations

Spatial analysis strengthens stop-level evaluation because crashes and traffic conflicts rarely occur at random; instead, they tend to cluster along corridors characterized by high activity levels, constrained road geometry, and elevated exposure. GIS-based transport profiles and urban transport scoping studies for Kathmandu highlight this corridor-oriented structure, showing how mobility patterns and associated externalities concentrate in specific parts of the network (Asian Transport Observatory, 2023). When integrated with stop-level CSI scores, GIS enables the production of practical decision-support outputs such as risk maps, stop prioritization categories, and corridor-based intervention plans. These spatial outputs are particularly valuable for communicating results to planning agencies and for directing limited resources toward locations with the greatest combined safety and operational risk.

2.10 Statistical Validation of Surrogate Safety Indices and Severity Thresholds

Surrogate safety measures are widely used in transport studies when reliable crash data are limited, as they capture short-term traffic interactions rather than relying only on historical accident records. Conflict-based indices such as the CSI are therefore useful for identifying and prioritizing high-risk locations. However, because CSI values depend on local traffic conditions, weighting approaches, and data processing methods, standard severity thresholds are not universally established. For this reason, statistical validation is important to support the interpretation of severity classifications (De Ceunynck, 2017; Gettman et al., 2008).

Spearman's rank correlation is commonly applied to evaluate the consistency of results, particularly when dealing with small datasets and ranked outcomes. Instead of predicting exact crash risk, it assesses whether higher-risk locations are identified in a consistent order across different observations or validation datasets. Previous studies have shown that this method is effective in confirming the stability of conflict-based rankings and relative prioritization (Astarita et al., 2020).

In addition, confidence intervals based on Student's *t* distribution are used to examine uncertainty in severity classification. By comparing the ranges of different groups (such as low, medium, and high severity), it becomes possible to assess whether these categories are clearly distinguishable. While 95% confidence intervals are generally reported, smaller sample sizes, especially in higher-severity groups, can lead to wider ranges that make interpretation difficult. In such cases, a 90% confidence interval is often used as a supplementary check to improve clarity while still acknowledging uncertainty. This does not replace the standard 95% interval but helps test the robustness of the classification (De Ceunynck, 2017; Serdar et al., 2021).

Overall, combining Spearman's rank correlation with confidence interval analysis provides a practical validation framework for CSI-based studies. This approach allows both the consistency of rankings and the separation of severity levels to be assessed effectively, particularly in data-limited urban environments (Gettman et al., 2008).

2.11 Institutional Context and Existing Transport Planning in Kathmandu

Urban transport management in the Kathmandu Valley involves multiple agencies with shared responsibilities, and this arrangement has further changed after the introduction of the federal system in Nepal. While the Department of Roads (DoR) remains responsible for major road infrastructure, the management of urban roads, roadside activities, and public spaces, including bus stop areas, has increasingly become a concern of local municipalities. The Department of Transport Management (DoTM) continues to oversee transport operations and service regulation, and Nepal Traffic Police are responsible for traffic control and enforcement. In addition, the Urban Area Public Transport (Management) Authority Act, 2079 (2022) provides a legal basis for establishing a provincial-level public transport authority to manage urban transport services in an integrated manner across municipalities. This indicates that, after the new constitutional structure, urban public transport management is gradually moving toward greater provincial and local responsibility, although coordination among institutions remains limited in practice, particularly in the management of informal bus stops.

Several major studies have examined Kathmandu's transport system and highlighted ongoing challenges. The Asian Development Bank (ADB) has identified issues such as traffic congestion, weak public transport infrastructure, and the need for improved traffic and pedestrian management (Asian Development Bank, 2020). Similarly, the JICA Kathmandu Valley Transport Master Plan outlines long-term strategies for improving mobility, including strengthening public transport systems and enhancing traffic management (JICA, 2017). However, these studies mainly focus on network-level planning and policy directions, with limited emphasis on detailed stop-level analysis and the prioritization of informal stopping locations. As a result, despite the presence of policy frameworks and emerging legal provisions, the management of informal public transport stops remains largely unstructured in practice.

2.12 Summary of Gaps and Study Contributes

The review of literature highlights three key gaps that motivate the focus of this study. First, while informal public transport stopping environments in developing cities are widely recognized, much of the existing research remains at the corridor level, with limited attention to stop-specific assessment and prioritization. Second, reliance on crash data alone is often impractical at micro locations such as individual informal stops, where crashes are infrequent or underreported, making conflict-based indicators an essential surrogate for safety evaluation (Gettman & Head, 2003; Hydén, 1987). Third, although the Nepal Urban Road Standard 2076 provides clear design guidelines, its implementation in Kathmandu remains inconsistent, highlighting the need for a structured framework to prioritize formalization and safety improvements.

The methodology used in this study combines field observation, traffic conflict assessment, AHP weighting, CSI computation, and GIS mapping to address these gaps. It provides a clear and evidence-based approach to identify and prioritize high-risk informal public transport stops.

This study can support authorities by helping them identify which locations require immediate attention and where safety improvements should be focused. It can assist in better planning, resource allocation, and decision-making for safer transport operations. The framework can be adopted by agencies such as the Department of Roads, local municipalities, and traffic management authorities, as well as planners and engineers working on urban transport systems in the Kathmandu Valley.

3 METHODOLOGY

3.1 Research Design

This study adopts a quantitative and analytical research design with a case study approach to evaluate and prioritize informal public transport stops along the Sundhara-Kirtipur Gate corridor in the Kathmandu Valley. The research design was structured to systematically assess safety and operational conditions at informal stopping locations using measurable indicators supported by expert judgment.

The overall methodological framework followed in this study is illustrated in Figure 3-1:

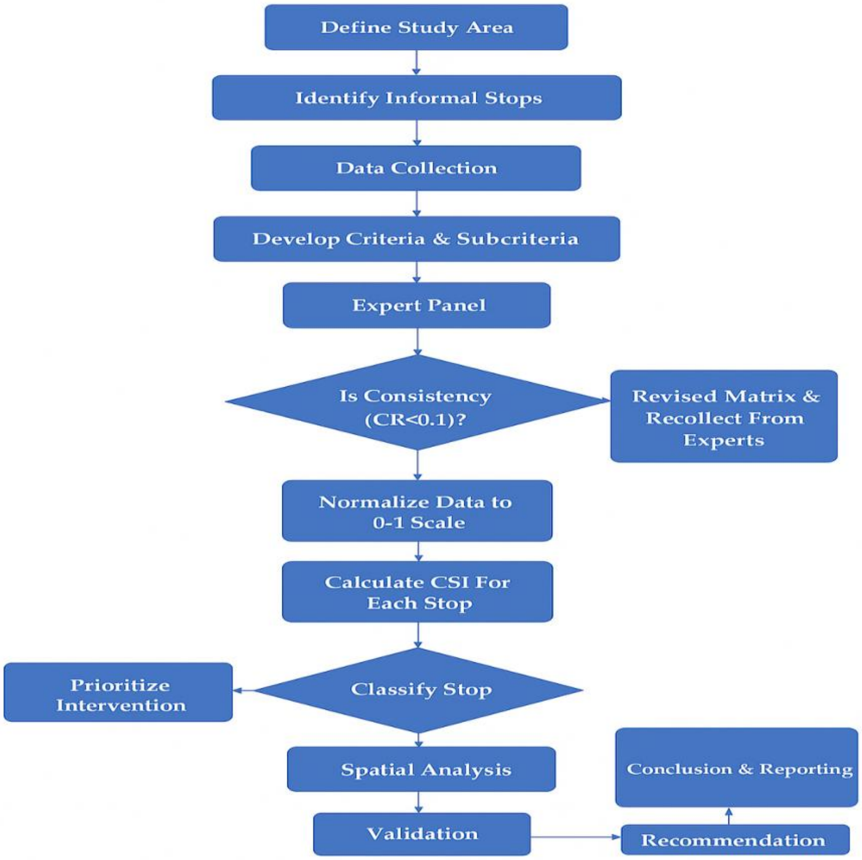


Figure 3-1: Methodology Flowchart.

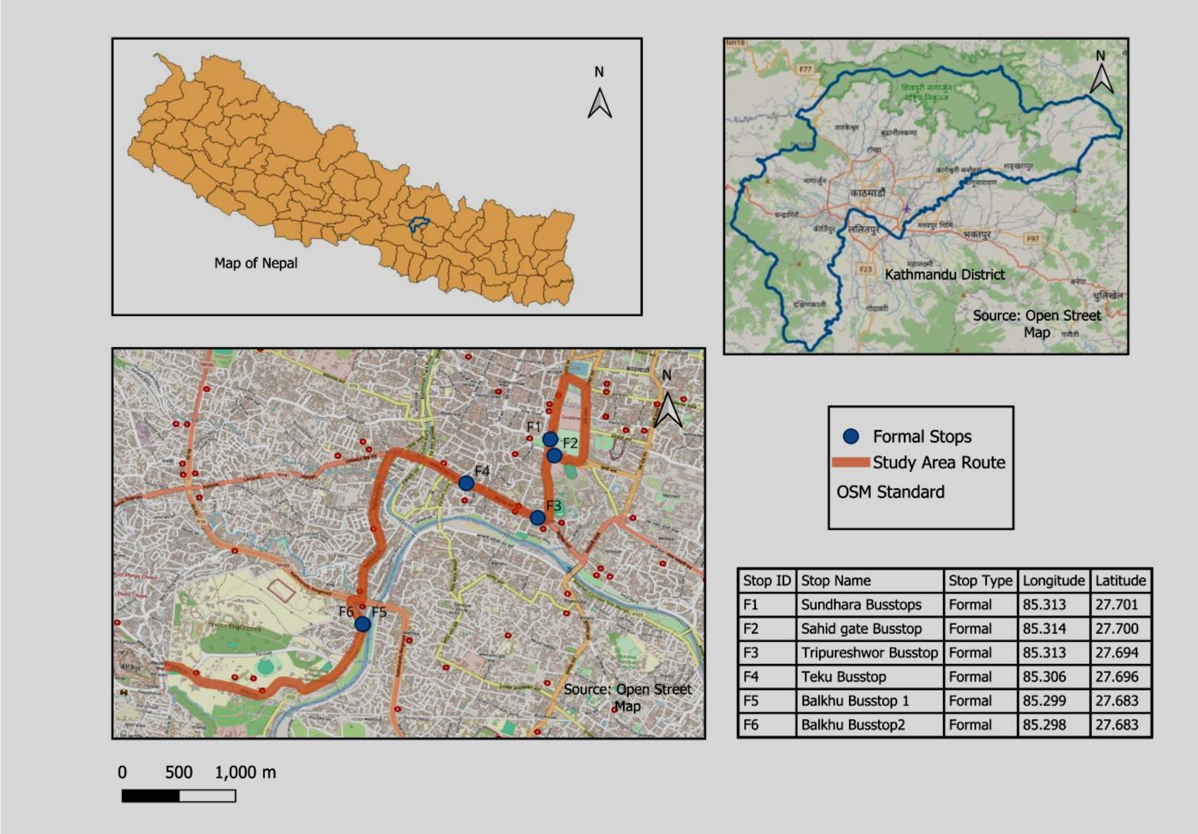
3.2 Study Area

The study area selected for this research is the Sundhara-Kirtipur Gate corridor, located within the Kathmandu Valley, Nepal. This corridor extends from Sundhara in the northeastern part of Kathmandu Metropolitan City to Kirtipur Gate in Kirtipur Municipality, covering an approximate length of 8.45 km. The corridor lies between latitudes 27°39′N to 27°41′N and longitudes 85°17′E to 85°18′E.

The Sundhara–Kirtipur Gate corridor is a major urban route passing through densely developed commercial, residential, and institutional areas. It experiences high traffic volumes under mixed traffic conditions, including minibuses, microbuses, motorcycles, private cars, and pedestrians. Public transport along this corridor is heavily used by daily commuters, with vehicles frequently stopping at both designated and undesignated locations. A total of six formal stops were identified along the study route, classified as formal based on the presence of supporting infrastructure and validation through field observation and consultation with traffic police. The study route, along with the locations and coordinates of these stops, is shown in Figure 3-2.

Corridors are characterized by narrow right-of-ways, limited roadside spaces, inadequate pedestrian facilities, and frequent roadside activities. Due to these conditions, it is considered a sub-arterial road, and all calculations and analyses in this study are based on this classification (NURS-2076). The study route primarily consisted of a combination of national highways, feeder roads, and strategic urban road segments. Specifically, the Tripureshwor to Kalimati section forms part of the national highway; the Sundhara to Tripureshwor and Balkhu to Laboratory Higher Secondary School sections function as feeder roads, and the Kalimati to Balkhu and Laboratory Higher Secondary School to Kirtipur Gate sections fall under the strategic urban road network. The widespread presence of informal public transport stops, particularly near intersections, markets, and high-demand zones, makes this corridor suitable for evaluating the safety and operational effects of informal stopping behavior.

Due to its strategic importance, high passenger demand, and diverse land-use characteristics, the Sundhara-Kirtipur Gate corridor was selected as a representative case study for assessing informal public transport stops in the Kathmandu Valley. The findings from this corridor are expected to provide insights applicable to other urban corridors with similar traffic and operational characteristics.



Stop ID	Stop Name	Stop Type	Longitude	Latitude
F1	Sundhara Busstops	Formal	85.313	27.701
F2	Sahid gate Busstop	Formal	85.314	27.700
F3	Tripureshwor Busstop	Formal	85.313	27.694
F4	Teku Busstop	Formal	85.306	27.696
F5	Balkhu Busstop 1	Formal	85.299	27.683
F6	Balkhu Busstop2	Formal	85.298	27.683

Figure 3-2: Study area showing the locations of formal bus stops along the route.

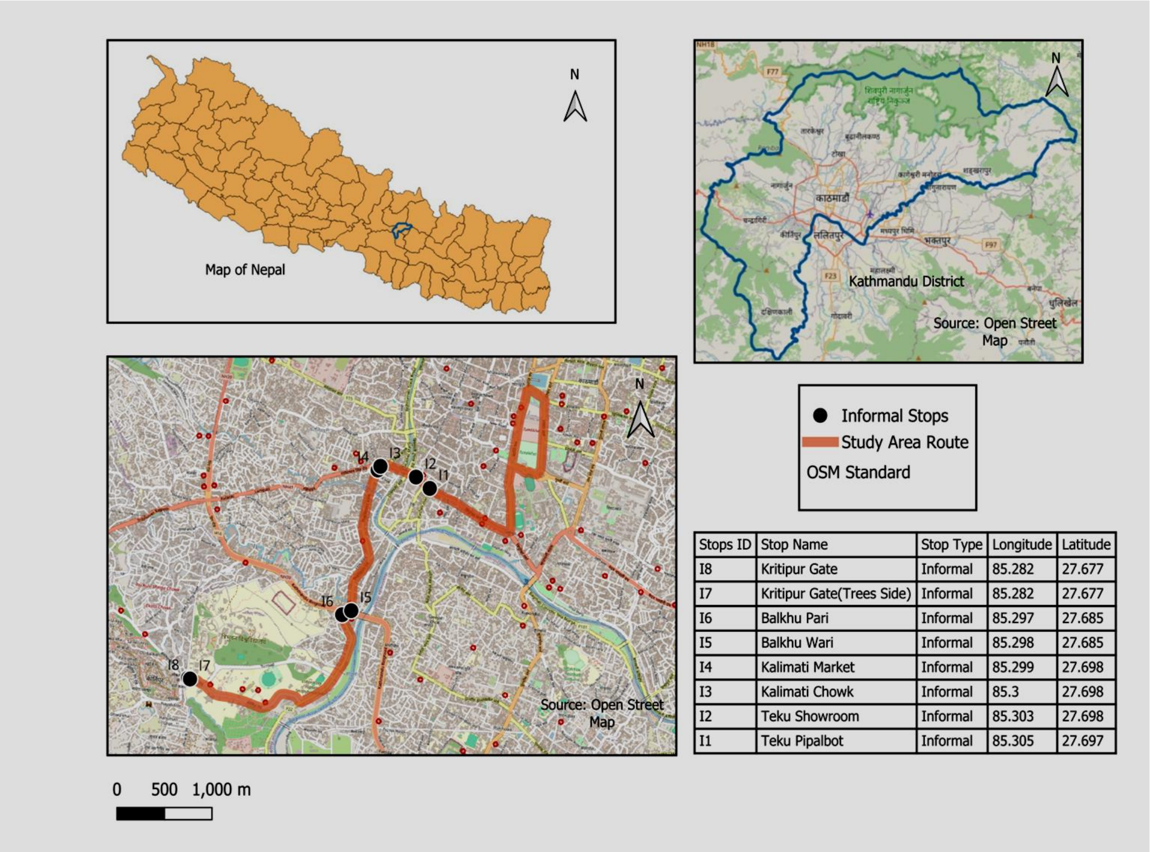
3.3 Identification of Informal Public Transport Stops

In this study, informal public transport stops (IPTS) are defined as locations where public transport vehicles regularly stop for passenger boarding and alighting outside officially designated bus stops. Temporary or occasional stopping points with very short dwell times were not considered informal stops.

Informal stops along the Sundhara–Kirtipur Gate corridor were identified using a combination of videographic surveys and manual field observations. Video recordings were used to observe traffic activity and stopping behavior, and additional onboard and roadside observations were conducted using mini and micro buses operating on the route.

Observations were conducted during the morning peak, off-peak, and evening peak periods to capture variations in stopping patterns.

Locations where vehicles repeatedly stopped for 15 seconds or more were considered potential informal stops, whereas short and occasional pick-up or drop-off points were excluded. The identified locations were verified through repeated observations, geo-referenced using GPS, assigned identification codes, and documented with nearby landmarks and surrounding land-use information.This process resulted in a validated list of informal public transport stops along the study corridor, which were later used for further analysis and CSI computation. The spatial distributions of the identified stops (I1–I8) are shown in Figure 3-3 and Figure 3-4.



Stops ID	Stop Name	Stop Type	Longitude	Latitude
I8	Kritipur Gate	Informal	85.282	27.677
I7	Kritipur Gate(Trees Side)	Informal	85.282	27.677
I6	Balkhu Pari	Informal	85.297	27.685
I5	Balkhu Wari	Informal	85.298	27.685
I4	Kalimati Market	Informal	85.299	27.698
I3	Kalimati Chowk	Informal	85.3	27.698
I2	Teku Showroom	Informal	85.303	27.698
I1	Teku Pipalbot	Informal	85.305	27.697

Figure 3-3: Location of 8 Informal Bus stops with Coordinate along the Study Route.

I1 I2 I3

I4 I5 I6

I7 I8

Figure 3-4: Informal Bus Stops (Stops ID I1-I8) in study area.

3.4 Evaluation Criteria and Sub-Criteria

The safety and operational performance of informal public transport stops is influenced by several factors related to traffic conditions, pedestrian activity, infrastructure characteristics, surrounding land use, and passenger demand. To systematically evaluate these aspects, a hierarchical evaluation framework was developed based on a literature review, national urban road standards, and expert consultation.

In this study, five main criteria were identified to represent key factors affecting the safety and operational conditions of informal stopping locations in Kathmandu's mixed-traffic environment. Each main criterion was further divided into measurable sub-criteria to allow objective assessment using field observations and expert judgment. The hierarchy of criteria and sub-criteria used in this study is presented in Table 3-1.

Table 3-1: Evaluation Criteria and Sub-Criteria for Assessing Informal Public Transport Stops.

Main Criteria	Sub-Criteria	Description
Safety (S)	Number of Crashes Observed (S1)	Number of crashes recorded near the stop location during the survey period.
	Traffic Conflicts (S2)	Frequency of near-miss interactions between vehicles and pedestrians.
	Pedestrian Exposure (S3)	Level of pedestrian activity that is, boarding and alighting at the stop location.
	Driver Behaviour Issues (S4)	Risky driving behaviors include sudden braking or unsafe stopping.
Traffic Impact (T)	Average Dwell Time (T1)	The time a public transport vehicle remains stopped for boarding and alighting.
	Waiting Length (T2)	Length of roadway occupied by stopped vehicles.
	Distance from Intersection (T3)	Proximity of the stop to nearby intersections.

	Distance from Formal Stop (T4)	Distance between informal and formal bus stops.
Accessibility (A)	Sidewalk Width (A1)	Available width for pedestrian movement near the stop.
	Roadway Cross-section (A2)	Width of the road available for traffic flow.
	Pedestrian Safety Facilities (A3)	The presence of crossings, signals, or other pedestrian facilities.
	Obstructions on Approach Pat (A4)	Obstacles such as vendors or parked vehicles affect pedestrian movement.
Land Use Suitability (L)	Space for Stop Infrastructure (L1)	Availability of space to develop formal stop infrastructure.
	Proximity to Sensitive Land Uses (L2)	Presence of schools, hospitals, markets, etc. near the stop.
Demand Density (D)	Passenger Demand (D1)	The number of passengers boarding and alighting at the stop.
	Traffic Volume (D2)	Number of vehicles passing through the stopped area.

The evaluation framework in this study follows a hierarchical structure consisting of an overall goal, main criteria, and corresponding sub-criteria. This structure was used to develop pairwise comparison matrices for the AHP. Using Saaty’s 9-point scale, experts compared the importance of different criteria to determine their relative weights. The consistency of these judgments was checked to ensure that the comparisons were logically acceptable before proceeding with further analysis. The selected criteria, sub-criteria, and evaluation directions are summarized in Table 3-2. These weighted factors were then used to calculate the CSI, which helps assess and prioritize informal public transport stops based on their safety and operational risk.

Table 3-2: Main Criteria, Sub-Criteria, and Remarks.

Main Criteria	Sub- Criteria	Remarks
Safety(S)	Number of Crashes Observed(S1)	Higher number of crashes indicates poorer safety performance. Higher = Worse.
	Number of Traffic Conflicts(S2)	Higher number of conflicts indicates poorer safety performance. Higher = Worse.
	Pedestrian Exposure(S3)	Higher = Worse
	Drivers Behaviour Issues(S4)	Higher = Worse
Traffic Impact (T)	Average Dwell Time (sec)(T1)	Stops with dwell time ≥ 15 s considered operationally significant; <15 s treated as transient and excluded. Longer dwell causes lane blockage and congestion. Higher = Worse (Kittelson & Associates, 2003).
	Waiting Length (m)(T2)	Higher = Worse
	Distance from Intersection (m)(T3)	Stops should be at least 40m from intersection as per Nepal Urban Road Standards-2076.(Higher= Best)
	Distance from Nearest Formal Stop (m)(T4)	Recommended bus stop spacing 200–400 m in urban roads. Shorter spacing reflects disorder. Lower = Worse (NURS-2076).
Accessibility (A)	Sidewalk Width (m)(A1)	Minimum clear footpath width 2.0 m recommended; wider footpaths preferred near bus stops. Higher = Better (NURS-2076).
	Roadway Cross-section(A2)	Higher = Better
	Pedestrian Safety Facilities(A3)	Higher = Better(Cross walk presence=0, Cross walk non presence=1)
	Obstructions on Pedestrian Path(A4)	Higher = Worse(High vendors=1, Median=0.5, Low=0)
Land Use Suitability (L)	Available Space for Stop Infrastructure(L1)	Higher = Better
	Proximity to Sensitive Land Uses(L2)	Near Sensitive Land(1), Far=0
Demand Density (D)	Passenger Demand (persons/30min)(D1)	Higher = Worse
	Traffic Volume (veh/30min)(D2)	Higher = Worse

3.5 Application of Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process was applied in this study to determine the relative importance of evaluation criteria and sub-criteria associated with informal public transport stop safety and operational performance. AHP is a structured multi-criteria decision-making technique that uses pairwise comparisons and expert judgment to quantify the relative weights of decision elements (Saaty, 2008). The method is particularly suitable for complex problems involving both quantitative and qualitative factors, such as safety evaluation of informal public transport stops.

Based on the evaluation framework developed in Section 3.4, five main criteria Safety (S), Traffic Impact (T), Accessibility (A), Land Use (L), and Demand Density (D) along with their respective sub-criteria were considered for AHP analysis. These criteria represent the key dimensions influencing risk and operational severity at informal public transport stops under Kathmandu's mixed traffic conditions.

3.5.1 Expert Survey and Pairwise Comparison

An expert-based AHP survey was conducted to obtain pairwise comparisons of the selected criteria and sub-criteria. Sixteen experts with professional backgrounds in transportation engineering, traffic safety, urban planning, road users and public transport operations participated. This number is suitable for AHP because the method relies on informed judgment rather than statistical representativeness, and the literature notes that there is no fixed minimum sample size; the quality and relevance of expert knowledge are more important than sample size (Shrestha et al., 2025).

Experts compared each criterion against the others and each sub-criterion against the other sub-criteria within the same main criterion, based on their relative importance for informal stop safety and operational severity. All comparisons used Saaty's fundamental 1–9 scale, where 1 indicates equal importance and 9 indicates extreme importance of one element over another, with reciprocals applied for the opposite direction (Saaty, 2008).The chart of the main criteria and sub-criteria is shown in Table 3-3, and Saaty's 9 Point scale of importance is shown in Table 3-4.

Table 3-3: Chart for comparison of main criteria and sub-criteria.

Section A – Main Criteria Comparison		
Pairwise Comparison	**More Important Criterion**	**Scale (1–9)**
Safety vs Traffic Impact		
Safety vs Accessibility		
Safety vs Land Use Suitability		
Safety vs Demand Density		
Traffic Impact vs Accessibility		
Traffic Impact vs Land Use Suitability		
Traffic Impact vs Demand Density		
Accessibility vs Land Use Suitability		
Accessibility vs Demand Density		
Land Use Suitability vs Demand Density		
Section B – Safety Sub-criteria		
Pairwise Comparison	**More Important Sub-criterion**	**Scale (1–9)**
Crash frequency vs Traffic conflicts per hour		
Crash frequency vs Pedestrian exposure		
Crash frequency vs Driver behavior issues		
Traffic conflicts per hour vs Pedestrian exposure		
Traffic conflicts per hour vs Driver behavior issues		
Pedestrian exposure vs Driver behavior issues		
Section B – Traffic Impact Sub-criteria		
Pairwise Comparison	**More Important Sub-criterion**	**Scale (1–9)**
Mean dwell time impact vs Waiting Length		
Mean dwell time impact vs Distance from formal stops		
Mean dwell time impact vs Distance from intersection		
Waiting Length vs Distance from formal stops		
Waiting Length vs Distance from intersection		
Distance from formal stops vs Distance from intersection		
Section B – Accessibility Sub-criteria		
Pairwise Comparison	**More Important Sub-criterion**	**Scale (1–9)**
Sidewalk continuity & width vs Road cross-section		

Sidewalk continuity & width vs Pedestrian facilities		
Sidewalk continuity & width vs Obstruction on approach path		
Road cross-section vs Pedestrian facilities		
Road cross-section vs Obstruction on approach path		
Pedestrian facilities vs Obstruction on approach path		
Section B – Land Use Suitability Sub-criteria		
Pairwise Comparison	**More Important Sub-criterion**	**Scale (1–9)**
Space for infrastructure vs Proximity to sensitive land uses		
Section B – Demand Density Sub-criteria		
Pairwise Comparison	**More Important Sub-criterion**	**Scale (1–9)**
Passenger count vs Traffic count		

Table 3-4: Saaty’s 9 Point scale of Importance (Saaty, 2008).

Intensity	Definition	Explanation
1	Equal Importance	Two elements contribute equally to the objective.
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong Importance	Experience and judgment 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		

The comparison matrix and comparison index testing equations are as follows:

$$\text{Comparision matrix (A)} = \begin{vmatrix} 1 & w1/w2 & \ldots\ldots\ldots & w1/wn \\ w2/w1 & 1 & \ldots\ldots\ldots & w2/wn \\ : & : & : & : \\ : & : & : & : \\ wn/w1 & wn/w2 & \ldots\ldots\ldots & 1 \end{vmatrix} \qquad \ldots(i)$$

Here, n= Number of criteria, or the size of matrix w2/w1 represents the intensity of main criteria 1 to main criteria 2 and sub criteria 1 to sub criteria 2 and the value is provided as per the intensity value of Saaty's 9 Points of Scale of importance.

$$\text{Eigen Vector, Aij} = \frac{\sum_{i=1}^{n}(\frac{w1}{w2} * \frac{w1}{w2} * \dots\dots \frac{w1}{w2})^\wedge(\frac{1}{n})}{\sum\left[\sum_{i=1}^{n}(\frac{w1}{w2} * \frac{w1}{w2} * \dots\dots \frac{w1}{w2})^\wedge(\frac{1}{n})\right]} \quad \dots\text{(ii)}$$

$$\text{Eigen Value,} \quad \lambda i = \frac{\sum_{j}^{n}(\sum_{i=1}^{n} \text{Aij})\text{wj}}{\text{Aij}} \quad \dots\text{(iii)}$$

$$\text{Consistency index, (CI)} = \frac{\lambda\text{max} - \text{n}}{\text{n} - 1} \quad \dots\text{(iv)}$$

$$\text{Consistency ratio (CI)} = \frac{\text{CI}}{\text{RI}} \quad \dots\text{(v)}$$

The Random Index (RI) used in above equation is based on Random Index for different dimension of Relative Weight Matrix shown in Table 3-5.

Table 3-5: Random Index for different dimensions of Matrix (Saaty, 2008).

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

In the AHP, a Consistency Ratio (CR) of up to 10% is generally considered acceptable, while values above this threshold require a review and revision of expert judgments. In practical decision-making, achieving perfect consistency is difficult because expert evaluations often involve subjective judgment. Therefore, allowing a small degree of inconsistency helps maintain flexibility while still ensuring reliable and meaningful results. This commonly accepted threshold supports the development of a balanced and robust decision-making framework (Saaty, 2008).

3.5.2 Aggregation of Weights

Only expert judgments that satisfied the consistency requirements were included in the final analysis. The validated priority vectors obtained from individual experts were then aggregated by averaging to obtain a single set of weights for each criterion and sub-criterion. These aggregated weights represent the relative contribution of each factor to the overall safety and operational severity of informal public transport stop.

The resulting weights were subsequently used to compute the CSI to quantify and prioritize the degree of risk associated with each identified informal public transport stop.

3.6 Field Data Collection, Data Normalization, and Preparation for CSI Computation

This study used a systematic field data collection approach to examine the safety and operational characteristics of informal public transport stops along a selected study corridor. Data were collected at different times of the day to capture variations in traffic conditions and passenger behavior, ensuring that the observations were representative of real operating conditions. This approach provided a more reliable understanding of how informal stops function within the daily traffic environment of the corridor.

3.6.1 Field Data Collection

Field data were collected using a combination of videographic surveys and manual observation techniques. Based on preliminary reconnaissance, eight informal public transport stops were identified where public transport vehicles and passengers consistently preferred to stop, wait, and interact. These locations were selected for detailed data collection because they represent the most frequently used informal stopping points along the corridor.

At each identified informal stop, preliminary reconnaissance surveys were conducted continuously over an approximate two-week period to identify representative time periods reflecting variations in traffic flow and passenger demand. Based on these observations, three daily periods were established for data collection: morning peak (8:00 AM–11:00 AM), daytime off-peak (11:00 AM–4:00 PM), and evening peak (4:00 PM–7:00 PM). Following this identification, data collection was performed within the predefined periods.

A 30-minute video recording was conducted at each stop during each time period. Videographic surveys were used to extract information on traffic conflicts, dwell time, pedestrian movements, vehicle interactions, and operational behavior. In addition, manual field sheets were completed on-site to document supplementary attributes, including infrastructure condition; accessibility features, surrounding land use, and observable demand-related parameters.

To minimize bias from day-to-day traffic variation, data were collected on different days, with morning and off-peak observations on the same day and evening peak data collected a few days later. This approach captured varying traffic conditions and improved data reliability, and the same method was applied to all eight informal stops.

The combined use of video and manual surveys allowed cross-verification of observations and improved data accuracy. The raw field data obtained from these surveys formed the basis for subsequent normalization and index computation. The format of the field data collection sheet is shown in APPENDIX A.

3.6.2 Data Normalization

The collected field data consisted of parameters measured in different units and scales, such as time (seconds), count, distance (meters), and categorical observations. To enable meaningful comparison and aggregation of these parameters, data normalization was performed prior to CSI computation.

All sub-criteria values were normalized to a common scale ranging from 0 to 1, where higher normalized values represented higher safety and operational severity. The normalization method applied depends on the direction of the impact of each sub-criterion.

3.6.2.1 Sub-Criteria where Higher Value Indicates Worse Condition

For sub-criteria where higher observed values indicate greater risk or poorer conditions (such as number of conflicts, dwell time, pedestrian exposure, and traffic volume), min–max normalization was applied, as in equation vi to scale the values between a common range, ensuring that higher values correspond to higher severity and allowing consistent comparison across all indicators.

$x_{ij}^{norm} = (x_{ij} - x_{min}) / (x_{max} - x_{min})$ …. (vi)

where:

x_{ij}^{norm} = normalized value of sub-criterion i at stop j

x_{ij} = observed field value

x_{min} , x_{max} = minimum and maximum observed values across all stops

Under this formulation, higher normalized values indicate higher severity.

3.6.2.2 Sub-Criteria where Higher Value Indicates Better Condition

For sub-criteria where higher values indicate better or safer conditions (such as sidewalk width or the availability of pedestrian facilities), an inverse normalization approach was applied using equation vii, so that these improved conditions are reflected as lower severity values, maintaining consistency in how all indicators are interpreted.

$x_{ij}^{norm} = (x_{max} - x_{ij}) / (x_{max} - x_{min})$ … (vii)

This transformation ensures that better infrastructure conditions are reflected as lower severity values, making it easier to interpret the results consistently across all sub-criteria and compare them more clearly.

3.6.3 Preparation of Normalized Dataset for CSI Computation

The normalized values obtained using the above equations were reviewed to confirm that all values fell within the 0–1 range. These normalized sub-criteria values were then organized into a structured dataset corresponding to each of the eight informal public transport stops.

The normalized dataset was combined with the AHP-derived weights obtained in Section 3.5 to compute the CSI for each stop. Only normalized values were used in CSI computation to ensure that the resulting index reflects relative severity rather than absolute magnitude, enabling fair comparison and prioritization of informal public transport stops.

3.7 Conflict Severity Index (CSI) Computation

The CSI was developed to represent the combined safety and operational severity of each identified informal public transport stop. The CSI integrates normalized field data with the relative importance weights derived from the AHP to produce a single composite indicator for each stop.

Following the normalization process described in Section 3.6, each informal public transport stop was characterized by a set of dimensionless normalized values corresponding to the selected sub-criteria. These values reflect the relative severity of safety, traffic impact, accessibility, land use, and demand-related conditions at each location.

The CSI for each informal public transport stop was computed using a weighted linear aggregation approach, expressed as:

$$\mathrm{CSI_j} = \sum_{i=0}^{n} w_i \times x_{ij}^{norm} \qquad \ldots \text{(viii)}$$

Where:

$\mathrm{CSI_j}$ = Conflict Severity Index for stop $_j$

w_i = AHP-derived weight of sub-criterion $_i$

x_{ij}^{norm} = normalized value of sub-criterion $_i$ at stop $_j$

n = total number of sub-criteria

The values obtained from this formula were first summed across the sub-criteria of each corresponding main criterion and then multiplied by the main criterion’s weight. This process ensured that main criteria with higher relative importance contributed proportionally more to the final CSI value.

In this study, the CSI is used as a relative measure to prioritize informal bus stops based on their conflict risk. As CSI is a surrogate safety indicator and the literature does not define universally accepted threshold values, it is not interpreted as an absolute measure of safety. To support clarity in presentation and comparison, normalized CSI values were grouped into low (0–33%), medium (34–66%), and high (67–100%) severity zones using an equal interval approach. Such threshold-based grouping is commonly applied in surrogate and traffic conflict studies to aid interpretation and visualization of relative risk, while final prioritization remains based on the relative ranking of CSI values (Gettman & Head, 2003; Hydén, 1987; Tarko et al., 2009). In addition, to assess whether these severity thresholds meaningfully separated the groups, confidence intervals at both the 95% and 90% levels were examined for overlap between adjacent classes. This supplementary analysis provides an indication of the statistical robustness of the low–medium–high classification, recognizing the exploratory nature of surrogate safety assessment and the limited sample size.

3.8 GIS-Based Mapping of CSI Values

GIS was used to map the CSI values along the study corridor. During the field survey, the geographic coordinates of each identified informal stop were recorded and later imported into the GIS software to create a location-based dataset. The calculated CSI values were then linked to their respective stop locations.

Based on the CSI classification, each stop was categorized as low, medium, or high severity and displayed on the map using different symbols. This made it easy to visually identify where higher-risk and lower-risk stops are located along the corridor.

The mapping clearly shows how safety levels vary from one location to another and helps in quickly recognizing the areas with higher severity that may require attention.

3.9 Validation of CSI Results

To improve the reliability of the CSI framework, a multi-method validation approach was used. Because relying only on expert judgment in AHP may introduce bias, this study combined field verification, statistical testing, and sensitivity analysis to strengthen the robustness of the results.

Field validation involved an additional round of data collection at the same eight informal stops using the same procedures as the main survey. Video recording and manual observation were conducted, with an extra 20-minute video collected at each stop during morning peak, off-peak and evening peak periods on different days to capture temporal variation. The validation data were processed and normalized using the method described in Section 3.6.

Spearman’s rank correlation was applied to compare the CSI rankings between the primary and validation datasets to determine whether the prioritization of stops remained consistent. Sensitivity analysis was performed by introducing a ±33% change in expert weightage, where a portion of the original expert inputs was replaced with new judgments.

In addition, 95% and 90% confidence intervals were examined to assess the separation between low, medium, and high severity groups. Overlap between adjacent classes was used to indicate uncertainty in the selected thresholds.

Overall, these validation procedures helped evaluate the consistency, stability, and uncertainty of CSI-based prioritization, supporting a more transparent and systematic assessment of informal public transport stops in data-limited urban environments.

4 DATA ANALYSIS, RESULTS AND DISCUSSION

This chapter presents the analysis, results, and discussion based on the methodology described in Chapter 3. The chapter represents a continuation of the analytical framework developed earlier, where expert judgment, field-based observations, and quantitative computation are integrated to assess the safety condition of informal public transport stops. The analysis was carried out using expert reviews collected through the AHP, field data obtained from video and manual surveys at selected informal public transport stops, and the computation of the CSI. A total of twelve expert judgments that satisfied the consistency requirement were considered in the analysis. The expert-derived weights were combined with normalized field data to quantify the relative severity of conflicts at each informal stop.

This chapter systematically presents the results of AHP-based weight determination, field data normalization, CSI computation, severity classification of informal stops, spatial interpretation using GIS, and validation of the results through additional field observations. The discussion links the numerical findings with on-site conditions observed during field surveys to provide a comprehensive understanding of safety issues associated with informal public transport stops.

4.1 Determination of AHP-Based Weights of Criteria and Sub-Criteria

The pairwise comparison survey was conducted using Saaty’s 9-point scale of importance and was administered to 16 experts, including transport planners, traffic police personnel, transportation engineers, road users and other transportation professionals as shown in Figure 4-1. Consistency analysis revealed that 12 of the 16 expert responses met the acceptable consistency threshold and were therefore considered valid, while 4 responses were excluded due to inconsistency. A sample AHP weightage derived from a single expert is presented in the Table 4-1, whereas the remaining experts AHP weightage are provided in the APPENDIX B.

Table 4-1: Sample AHP-Based Weights of Criteria and Sub-Criteria from a single expert.

Section A – Main Criteria Comparison		
Pairwise Comparison	**More Important Criterion**	**Scale (1–9)**
Safety vs Traffic Impact	9	
Safety vs Accessibility	7	
Safety vs Land Use Suitability	9	
Safety vs Demand Density	9	
Traffic Impact vs Accessibility	1/7	
Traffic Impact vs Land Use Suitability	1	
Traffic Impact vs Demand Density	1	
Accessibility vs Land Use Suitability	7	
Accessibility vs Demand Density	7	
Land Use Suitability vs Demand Density	1	
Section B – Safety Subcriteria		
Pairwise Comparison	**More Important Subcriterion**	**Scale (1–9)**
Crash frequency vs Traffic conflicts per hour	1/9	
Crash frequency vs Pedestrian exposure	1/9	
Crash frequency vs Driver behavior issues	1/7	
Traffic conflicts per hour vs Pedestrian exposure	1	
Traffic conflicts per hour vs Driver behavior issues	1	
Pedestrian exposure vs Driver behavior issues	3	
Section B – Traffic Impact Subcriteria		
Pairwise Comparison	**More Important Subcriterion**	**Scale (1–9)**
Mean dwell time impact vs Waiting Length	1/7	
Mean dwell time impact vs Distance from formal stops	1/7	
Mean dwell time impact vs Distance from intersection	1/5	
Waiting Length vs Distance from formal stops	5	
Waiting Length vs Distance from intersection	3	
Distance from formal stops vs Distance from intersection	1	
Section B – Accessibility Subcriteria		

Pairwise Comparison	**More Important Subcriterion**	**Scale (1–9)**
Sidewalk continuity & width vs Road-cross-section	7	
Sidewalk continuity & width vs Pedestrian facilities	9	
Sidewalk continuity & width vs Obstruction on approach path	9	
Road-cross-section vs Pedestrian facilities	1/3	
Road-cross-section vs Obstruction on approach path	1/3	
Pedestrian facilities vs Obstruction on approach path	1	
Section B – Land Use Suitability Subcriteria		
Pairwise Comparison	**More Important Subcriterion**	**Scale (1–9)**
Space for infrastructure vs Proximity to sensitive land uses	5	
Section B – Demand Density Subcriteria		
Pairwise Comparison	**More Important Subcriterion**	**Scale (1–9)**
Passenger count vs Traffic count	7	

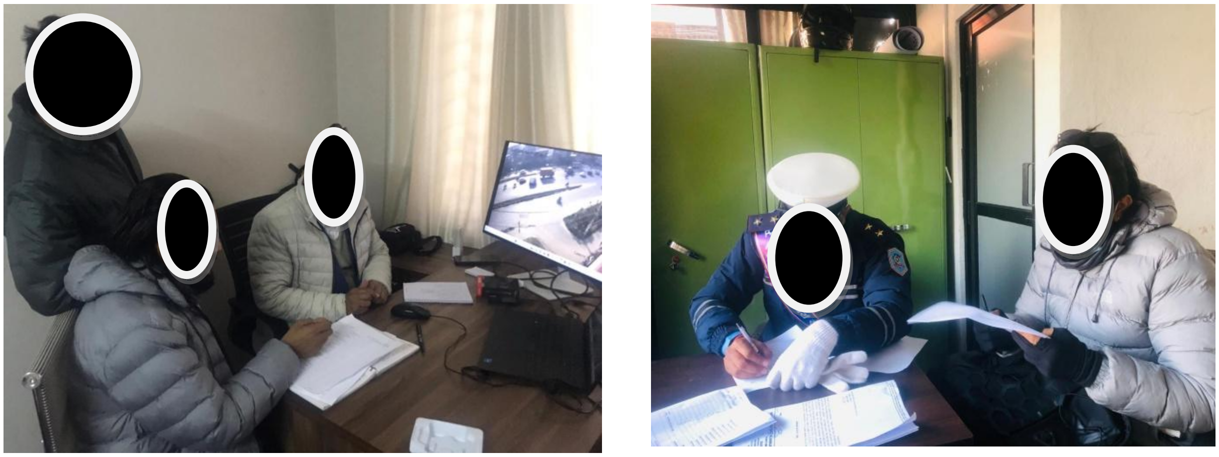
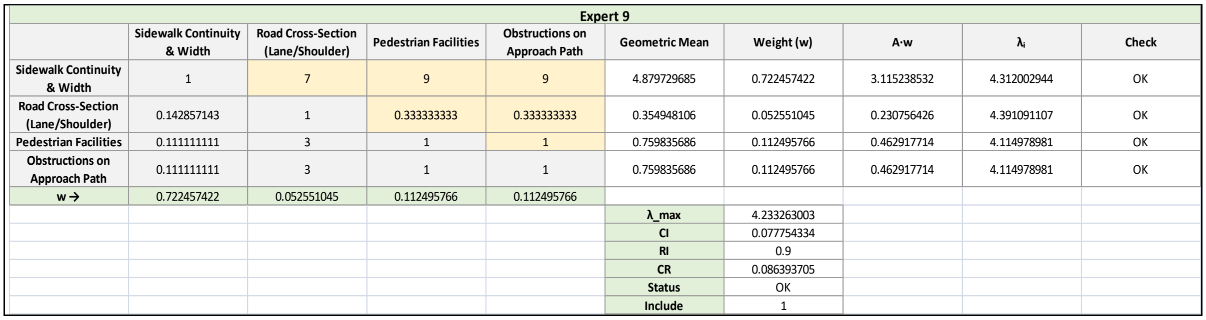


Figure 4-1: Photographic evidence of collection expert opinions for AHP analysis.

After collecting expert responses, the pairwise comparisons were processed in an Excel-based framework to compute the priority vector, eigenvalue, CI, CR, and RI, following the procedures in Chapter 3. Random index values corresponding to different matrix dimensions were adopted from standard AHP guidelines. Sample Computation of comparison matrix, Eigen vector (priority vector), Eigen value, CI, CR, and RI is shown in Table 4-2 whereas the remaining computation and results are provided in the APPENDIX C.

Table 4-2: Computation of comparison matrix, Eigen vector (priority vector), Eigen value, CI, CR, and RI (Only Sample of Single Expert).



Expert 9

	Sidewalk Continuity & Width	Road Cross-Section (Lane/Shoulder)	Pedestrian Facilities	Obstructions on Approach Path	Geometric Mean	Weight (w)	A·w	λ_i	Check
Sidewalk Continuity & Width	1	7	9	9	4.879729685	0.722457422	3.115238532	4.312002944	OK
Road Cross-Section (Lane/Shoulder)	0.142857143	1	0.333333333	0.333333333	0.354948106	0.052551045	0.230756426	4.391091107	OK
Pedestrian Facilities	0.111111111	3	1	1	0.759835686	0.112495766	0.462917714	4.114978981	OK
Obstructions on Approach Path	0.111111111	3	1	1	0.759835686	0.112495766	0.462917714	4.114978981	OK
w →	0.722457422	0.052551045	0.112495766	0.112495766					
					λ_max	4.233263003			
					CI	0.077754334			
					RI	0.9			
					CR	0.086393705			
					Status	OK			
					Include	1			

Each expert's judgment was checked using the consistency ratio, and only those meeting the acceptable limit (CR ≤ 0.10) were included in the analysis. The final weights for criteria and sub-criteria were then obtained by combining these valid responses, and used for CSI computation.

Table 4-3: Aggregated weight of single valid expert of main criteria.

Item	**Weight**
Safety (S)	0.612594388
Traffic Impact (T)	0.048499782
Accessibility (A)	0.241906265
Land Use Suitability(L)	0.048499782
Demand Density (D)	0.048499782

For illustration, a sample AHP calculation as in Table 4-3 showing the complete computation procedure for a representative expert is presented in this chapter. Detailed calculation sheets for all remaining experts, are provided in the APPENDIX D.

4.2 Aggregated Weights of Main Criteria and Sub-Criteria

The final weights of the main criteria also called the main weight and sub-criteria also called the local weight were obtained by aggregating the judgments of all valid experts whose consistency ratios satisfied the acceptable limit. The aggregated weights represent the average relative importance assigned by experts and provide a consolidated measure of influence for each criterion within the AHP framework.

The aggregated AHP weights of the main criteria indicate a clear hierarchy in terms of their influence on safety conditions at informal public transport stops. As shown in Figure 4-2, Safety (32.57%) received the highest weight, highlighting the dominant role of safety-related factors in determining conflict severity. This was followed by Accessibility (23.76%) and Traffic Impact (18.79%), reflecting the importance of pedestrian access conditions and operational traffic effects at informal stopping locations. Land Use (15.11%) and Demand Density (9.74%) were assigned comparatively lower weights, indicating relatively lesser influence in comparison to direct safety and operational factors as in Figure 4-2 below.

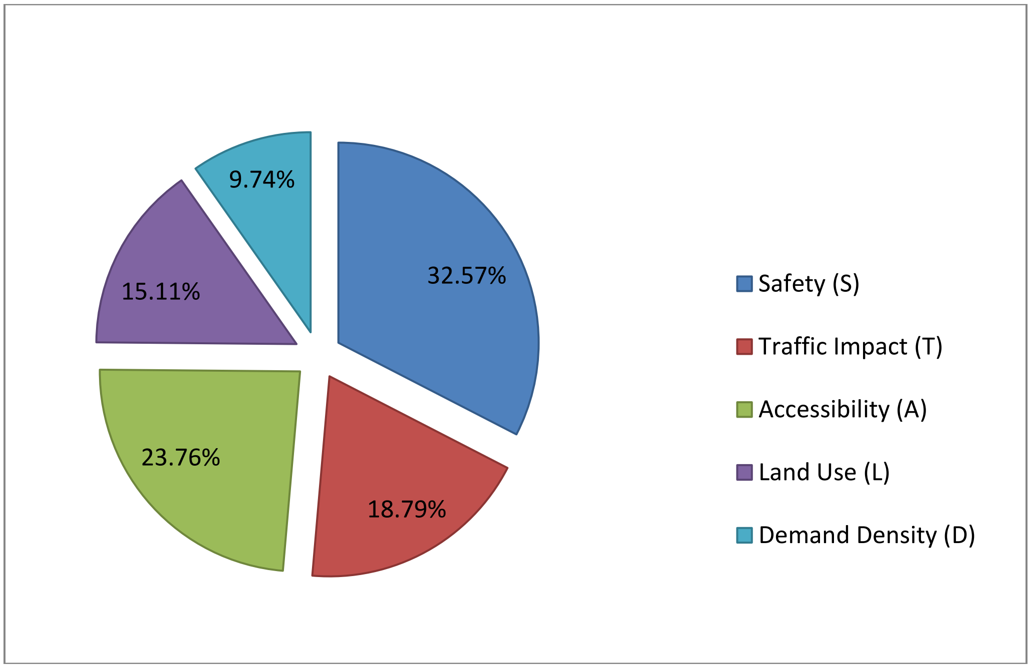


Figure 4-2: Representation of aggregated weights of the main criteria.

Similarly, the aggregated sub-criteria weight further illustrate the relative importance of individual contributing factors within each main criterion, as presented in Figure 4-3. Sub-criteria associated with Demand Density, such as Passenger Count (Boarding and Alighting) (62.58%) and Land Use, Such as Available Space for Infrastructure (57.29%) received higher weights, indicating stronger influence on conflict severity at informal stops. Conversely, sub-criteria such as Crash Frequency (13.89%) and Road Cross-Section Characteristics (10.26%) were assigned lower weights, suggesting relatively lesser contribution within the overall assessment framework.

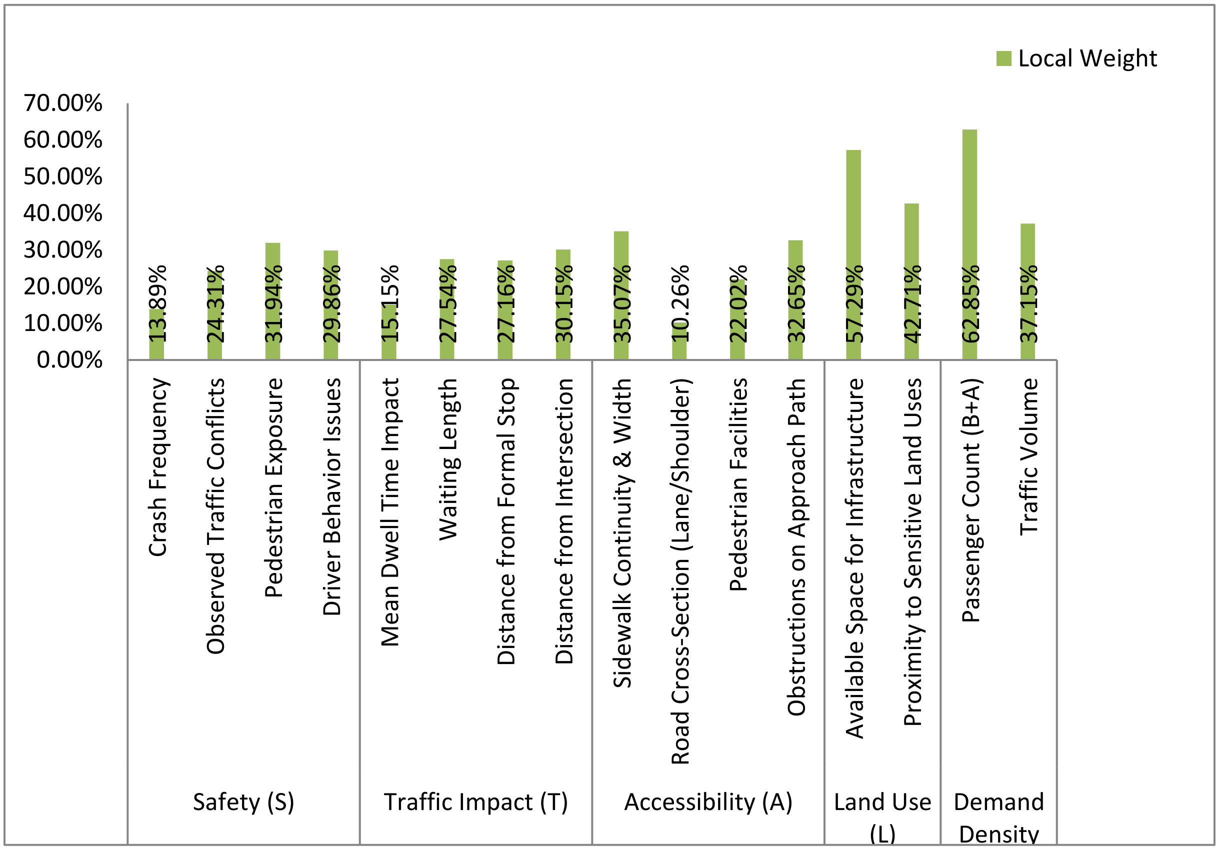


Figure 4-3: Representation of aggregated weights of the sub criteria.

The aggregated weights obtained through the AHP analysis form the basis for integrating normalized field data and computing the Conflict Severity Index (CSI) in the subsequent sections.

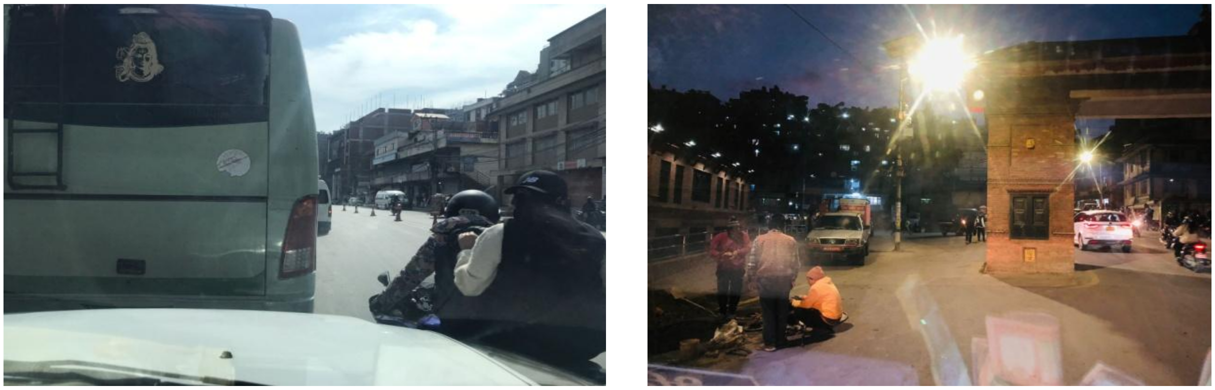
4.3 Field Data Analysis and Normalization

Field data collection was carried out to identify informal public transport stops and to quantify the criteria and sub-criteria influencing safety conditions along the selected study corridor from Sundhara-Kirtipur Gate. The identification of informal stops was conducted through extensive travel-based observation using public transport vehicles operating along the corridor.

During the preliminary survey, repeated trips were undertaken using different mini buses and microbuses operating on the selected route. These trips were conducted during morning peak, daytime off-peak, and evening peak periods over a period of approximately one week. While travelling, locations where public transport vehicles stopped informally for passenger boarding and alighting were carefully observed. Particular attention was given to distinguishing between temporary pick-and-drop locations and locations where drivers and passengers consistently preferred to stop.

To differentiate informal stops from short-duration pick-and-drop points, vehicle dwell time was used as a key criterion. Locations where vehicles stopped for more than 15 seconds were identified as potential informal stops, while locations with dwell times less than 15 seconds were excluded from further analysis. Although drivers were observed stopping at approximately 12–16 locations as shown in Figure 4-4 along the corridor for opportunistic passenger pick-up or drop-off, only those locations exhibiting consistent stopping behavior and longer dwell times were considered true informal stops. Based on this criterion, eight informal stops were identified and selected for detailed analysis.

Field data for the eight informal stops were collected following the procedure described in Section 3.6.The collected field data included both operational and physical characteristics corresponding to all defined sub-criteria. Photographic documentation was also collected at each informal stop to capture roadway geometry, pedestrian facilities, roadside activities, and obstruction conditions.



Balku Pari Kirtipur Gate

Figure 4-4: Sample photographs of identified informal stops and surrounding conditions.

To bring different field data together into a single analytical framework, all collected values were normalized to a 0–1 scale. For quantitative variables, normalization was performed using appropriate linear transformation techniques. For sub-criteria where a higher value represents worse safety conditions (e.g., observed conflicts, pedestrian exposure, traffic volume), a "higher-value-worse" normalization approach was adopted. Conversely, for sub-criteria where a higher value represents improved safety or infrastructure quality (e.g., sidewalk width, road-cross-section, available space for infrastructure), a "higher-value-better" normalization approach was applied.

For binary and categorical sub-criteria, values were assigned based on safety relevance. For example, the presence of pedestrian facilities was given 0 (low severity) and absence 1 (high severity), while proximity to sensitive land uses was assigned 1 when present and 0 when absent. Obstructions were categorized as low (0), medium (0.5), and high (1) based on observed conditions.

Normalization was guided, when appropriate, by the threshold and limiting values suggested by NURS-2076, especially for characteristics like sidewalk width, road-cross-section, distance from crossings, and distance from official bus stops. This ensured fulfillment to national safety and design standards.

A summary of field data for one representative informal stop under demand density is shown in Table 4-4 with normalized values for all stops in Table 4-5. The complete data and normalization for all criteria are provided in APPENDIX E.

Table 4-4: Summary of field data collection of Stop 1.

Teku Pipalbot (Stop 1)				**Peak Morning**	**Off Peak**	**Peak Night**	
S.N	**Main Criteria**	**Sub Criteria**		8:32 AM	2:10 PM	5:42 PM	**Mean**
1	Demand Density[D]	Passenger count	Boarding + Alighting	92	42	85	**73**
		Traffic Count	Veh/30min	31	18	30	**26**

Table 4-5: Normalized values for Demand Density (D) at all informal stops.

Mean 30 Minute Data			**Normalizing**			
Demand Density[D]				**Demand Density[D]**		
Stops	**Passenger count**	**Traffic Count**		**Stops**	**Passenger count**	**Traffic Count**
Stops 1	70	26		Stops 1	0.17	0.56
Stops 2	100	34		Stops 2	0.52	1.00
Stops 3	126	24		Stops 3	0.82	0.44
Stops 4	91	20		Stops 4	0.41	0.22
Stops 5	105	22		Stops 5	0.57	0.33
Stops 6	142	22		Stops 6	1.00	0.33
Stops 7	96	22		Stops 7	0.47	0.33
Stops 8	55	16		Stops 8	0.00	0.00
				Max	142	34
				Min	55	16

The normalized field data prepared through this process served as the primary input for the computation of the CSI. The CSI combines the normalized values of all criteria with their corresponding AHP-derived global weights to quantify the relative severity of conflicts at each informal public transport stop. This integration allows for a consistent and comparable assessment of safety conditions across all identified locations.

4.4 Conflict Severity Index (CSI) Computation, Classification and Discussion

4.4.1 CSI Computation

The Conflict Severity Index was computed to quantify the level of safety risk associated with each identified informal public transport stop. The CSI calculation integrates the normalized field data of individual sub-criteria with their corresponding AHP-derived global weights, enabling the aggregation of multiple safety-related factors into a single composite index.

For the safety criterion, CSI values were calculated by combining the normalized values of key safety-related factors such as crash frequency, observed traffic conflicts including near-miss events and sudden braking, pedestrian exposure from boarding and alighting activities, and driver behavior issues like sudden lane changes and horn usage with their respective local weights. These weighted values were then added together to obtain the overall safety-related CSI score for each informal stop, allowing a clear comparison of risk levels across different locations.

Table 4-6 presents a sample CSI computation for the demand density criterion, showing how each sub-criterion contributes to the overall demand severity at each stop. The CSI values reflect the relative level of demand, where higher values indicate heavier passenger activity and greater demand pressure, while lower values represent comparatively lower usage and demand levels across the stops.

Table 4-6: Sample CSI computation for safety-related sub-criteria.

Conflict Severity Index(CSI)= Local Weight * Normalizing value				
	Passenger count	**Traffic Count**	**Total**	**Demand Density[D]**
Local Weight	**0.62847222**	**0.37152778**		**0.097470795**
Stops 1	0.108357280	0.206404321	0.314761601	**0.030680063**
Stops 2	0.325071839	0.371527778	0.696599617	**0.067898118**
Stops 3	0.512891124	0.165123457	0.678014581	**0.06608662**
Stops 4	0.260057471	0.082561728	0.342619200	**0.033395366**
Stops 5	0.361190932	0.123842593	0.485033525	**0.047276603**
Stops 6	0.628472222	0.123842593	0.752314815	**0.073328723**
Stops 7	0.296176564	0.123842593	0.420019157	**0.040939601**
Stops 8	0.000000000	0.000000000	0.000000000	**0.000000000**

The same computation procedure was applied to all remaining criteria to obtain the overall CSI values for each informal stop. Detailed CSI computation tables for all criteria and stops are provided in the APPENDIX F.

4.4.2 CSI Classification and Ranking of Informal Public Transport Stops

Based on the computed CSI values, the identified informal public transport stops were classified into three severity levels to support interpretation and prioritization: low severity (0.00–0.33), medium severity (0.34–0.66), and high severity (0.67–1.00). These equal-interval thresholds were adopted to distinguish relatively safer locations from those exhibiting higher levels of conflict risk.

Using these thresholds, each informal stop was assigned a severity category according to its CSI value. Higher CSI values represent locations with greater conflict exposure, including increased pedestrian activity, frequent traffic conflicts, unsafe driver behavior, and inadequate roadside infrastructure. In contrast, lower CSI values indicate comparatively safer operational conditions.

To assess whether the adopted thresholds meaningfully separated the severity groups, confidence interval (CI) analysis was applied. Initially, 95% confidence intervals were computed for the medium- and high-severity groups. The results revealed overlap between these two categories, particularly due to the limited sample size (two high-severity stops and six medium-severity stops), indicating that the separation between medium and high severity was not statistically distinct under this conservative confidence level. The CI calculations and corresponding graphical representation are presented in Table 4-7 and Figure 4-5.

Table 4-7: 95% Confidence Intervals for CSI-Based Severity Groups

Group	**n**	**Mean CSI**	**Std Dev (manual)**	**Std Error**	**df**	**t critical (table)**	**Half-width**	**Lower CI**	**Upper CI**
High	2	0.910039854	0.079324168	0.0560907	1	12.706	0.7126879	0.197352	1.6227277
Medium	6	0.478955027	0.072334955	0.0295306	5	2.571	0.0759232	0.4030318	0.5548783
Overlap test		**Result**	OVERLAP						

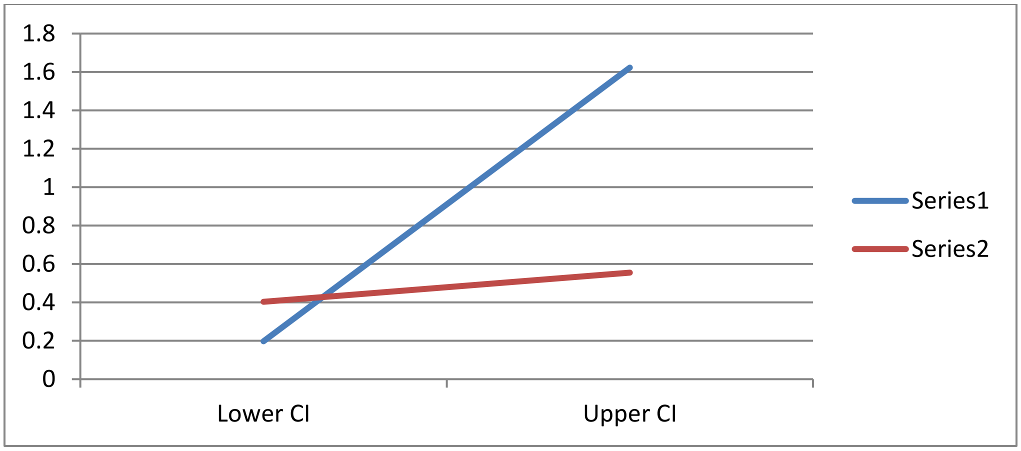


Figure 4-5: Comparison of CSI Groups Using 95% Confidence Intervals.

Given the exploratory nature of the study and the small number of observations in the higher severity classes, a supplementary sensitivity analysis using 90% confidence intervals was subsequently undertaken. At the 90% confidence level, the confidence bounds between medium and high-severity groups no longer overlapped, suggesting clearer separation between these categories. This approach does not replace the 95% confidence analysis but complements it by examining the robustness of the threshold classification under a slightly less conservative criterion. The use of 90% CI is appropriate in applied, small-sample surrogate safety studies where the objective is relative prioritization rather than strict population-level inference. The 90% CI results and graphical comparison are shown in Table 4-8 and Figure 4-6.

Table 4-8: 90% Confidence Intervals for CSI-Based Severity Groups

Group	**n**	**Mean CSI**	**Std Dev (s)**	**Std Error**	**df**	**t critical**	**Half-width**	**Lower CI**	**Upper CI**
High	2	0.91003	0.079324	0.05609	1	6.31375	0.35414	0.55589	1.26418
Medium	6	0.47895	0.0723349	0.02953	5	2.0150	0.05950	0.41944	0.53846
Overlap test		**Result**	NO OVERLA						

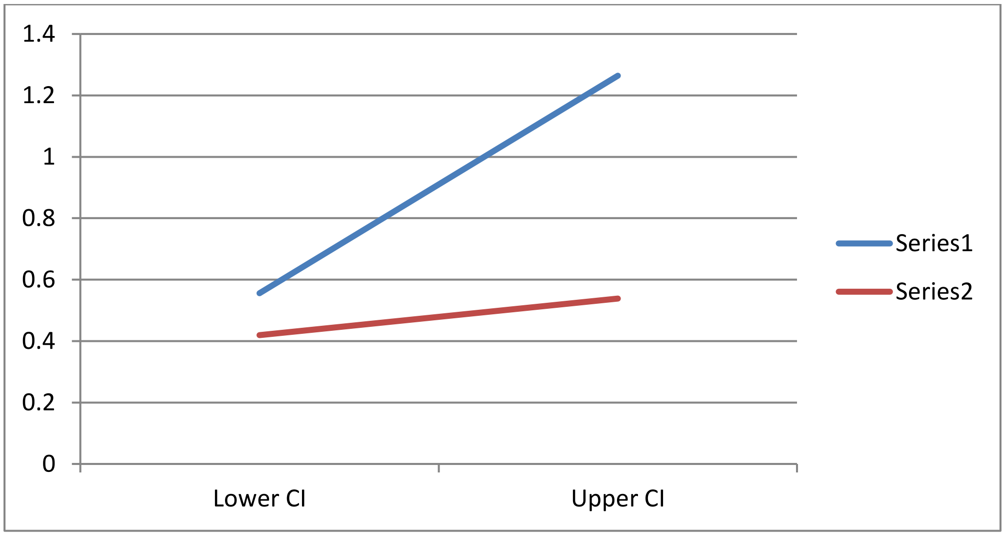
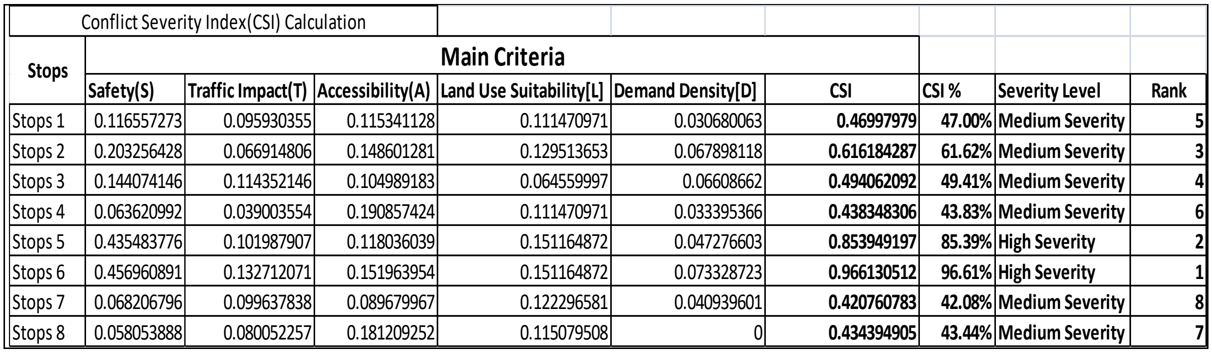


Figure 4-6: Comparison of CSI Groups Using 90% Confidence Intervals.

Following this statistical verification, the final CSI values were used to rank all informal public transport stops and identify priority locations for intervention. Table 4-9, Figure 4-7 and Figure 4-8 present the summarized CSI scores, severity classifications, and relative ranking of all identified informal stops, providing a clear basis for comparing risk levels across the study corridor.

Table 4-9: CSI values and severity classification of all informal public transport stops.



Conflict Severity Index(CSI) Calculation									
Stops	**Main Criteria**								
	Safety(S)	**Traffic Impact(T)**	**Accessibility(A)**	**Land Use Suitability[L]**	**Demand Density[D]**	**CSI**	**CSI %**	**Severity Level**	**Rank**
Stops 1	0.116557273	0.095930355	0.115341128	0.111470971	0.030680063	**0.46997979**	**47.00%**	**Medium Severity**	5
Stops 2	0.203256428	0.066914806	0.148601281	0.129513653	0.067898118	**0.616184287**	**61.62%**	**Medium Severity**	3
Stops 3	0.144074146	0.114352146	0.104989183	0.064559997	0.06608662	**0.494062092**	**49.41%**	**Medium Severity**	4
Stops 4	0.063620992	0.039003554	0.190857424	0.111470971	0.033395366	**0.438348306**	**43.83%**	**Medium Severity**	6
Stops 5	0.435483776	0.101987907	0.118036039	0.151164872	0.047276603	**0.853949197**	**85.39%**	**High Severity**	2
Stops 6	0.456960891	0.132712071	0.151963954	0.151164872	0.073328723	**0.966130512**	**96.61%**	**High Severity**	1
Stops 7	0.068206796	0.099637838	0.089679967	0.122296581	0.040939601	**0.420760783**	**42.08%**	**Medium Severity**	8
Stops 8	0.058053888	0.080052257	0.181209252	0.115079508	0	**0.434394905**	**43.44%**	**Medium Severity**	7

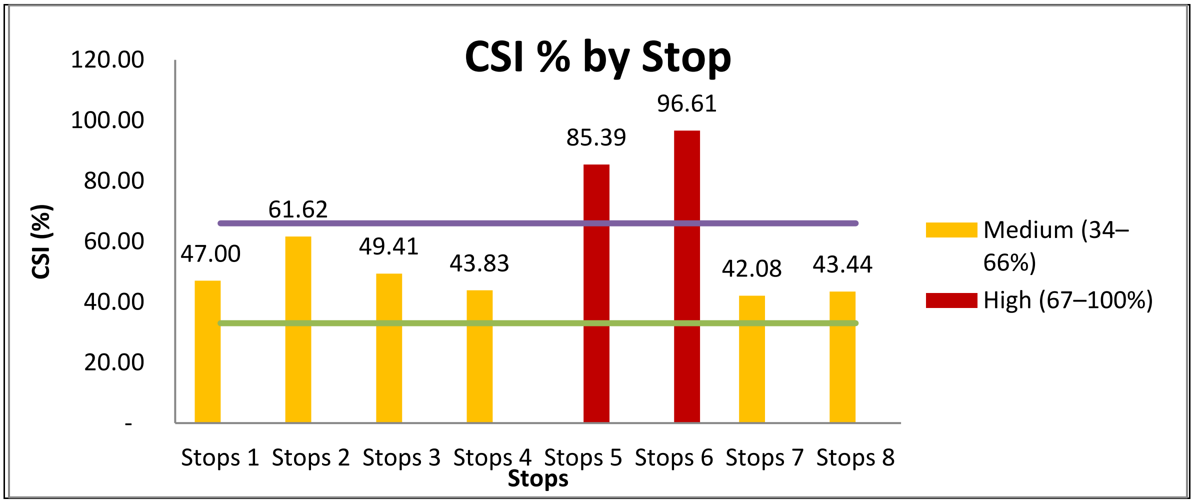


Figure 4-7: Severity Classification of Informal Bus Stops Based on CSI (%).

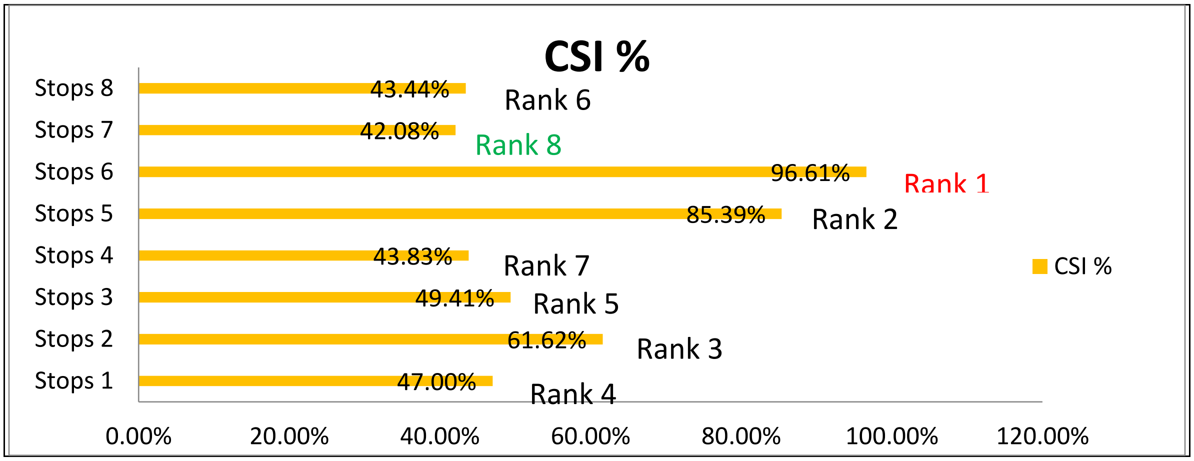


Figure 4-8: Ranking of Informal Bus Stops Based on CSI (%).

4.4.3 Discussion of High-Severity Informal Stops Based on Field Observations

4.4.3.1 Balkhu Pari (Stop 6)

Among the identified informal public transport stops, Balkhu Pari (Stop 6) recorded the highest CSI value of 96.61%, ranking it as the most critical location within the study corridor. The exceptionally high severity at this location is strongly supported by field observations and prevailing site conditions.

Balkhu Pari (Stop 6) is located in feeder highway immediately adjacent to the Balkhu intersection, a major traffic node along the Kathmandu Ring Road. This intersection functions as an important gateway connecting Kathmandu with Hetauda and other southern and eastern regions. As a result, the area experiences extremely high vehicular and pedestrian volumes. Field observations indicate intense pedestrian movement generated by nearby sensitive land uses, including markets, educational institutions, healthcare facilities, and informal boarding locations for long-distance travel, as shown in Figure 4-9(i). These conditions substantially increase pedestrian exposure and interaction with moving traffic.

The severity at Stop 6 is further aggravated by the absence of effective traffic control measures. Traffic signals and regulatory signs were observed to be either absent, poorly maintained, or non-functional. Sidewalks in the vicinity are discontinuous and heavily encroached by vendors and parked vehicles, forcing pedestrians to stand and walk within the carriageway, as illustrated in Figure 4-9(ii). The road cross-section and pedestrian facilities at this location do not comply with recommended standards, and the stop is positioned very close to the intersection approximately 15 m, contrary to established guidelines for public transport stop placement.

A major reason for the high CSI is the presence of informal brokers who interact with passing vehicles to attract passengers, leading to frequent sudden stops, lane changes, and longer waiting times, as observed during field surveys and is shown in Figure 4-9(iii). The observed waiting length of approximately 70 m causes partial blockage of traffic lanes and significantly disrupts intersection operations.

Although a formal bus stop is located approximately 225 m away, weak enforcement has rendered it ineffective. Field observations revealed that the formal stop is largely unused and instead occupied by parked vehicles, while boarding and alighting activities continue at the informal stop near the intersection, as shown in Figure 4-9(iv). This ineffective use of formal infrastructure significantly contributes to unsafe operating conditions at Stop 6.

In addition, high passenger demand and traffic volume at this location, combined with heavy pedestrian activity, mixed traffic conditions, longer dwell times, roadside encroachment, and limited infrastructure, contribute to higher risk levels, making Stop 6 the most critical location in the CSI assessment.

i) ii)

iii) iv)

Figure 4-9: Field conditions at Balkhu Pari (Stop 6) associated with High Conflict Severity.

4.4.3.2 Balkhu Wari (Stop 5)

Balkhu Wari (Stop 5) was ranked second with a CSI value of 85.39% and was also classified as a high-severity informal stop. Similar to Stop 6, this location is situated near the Balkhu intersection; however, it lies along a strategic urban roadway and is characterized by high pedestrian activity and frequent informal boarding and alighting.

Field observations indicate that Stop 5 experiences roadside encroachment and limited space for organized passenger waiting areas, resulting in pedestrians frequently standing within the carriageway while accessing public transport. The stop is located close to the intersection, and vehicles were often observed stopping for extended periods, contributing to localized traffic disruption, as illustrated in Figure 4-10(ii). In addition, inconsistent traffic signal operation was observed during the survey period, with signals functioning intermittently and, at times, being replaced by manual traffic control. This irregular traffic management created confusion among road users and significantly increased conflict occurrences around the stop S shown in Figure 4-10(ii).

Compared to Balkhu Pari (Stop 6), Stop 5 experiences relatively lower interference from long-distance vehicles, as most traffic activity is driven by local public transport operations rather than through-moving intercity traffic. As a result, the observed traffic conflicts are mainly related to frequent stopping, passenger boarding and alighting, and short-distance vehicle interactions. Although some passenger movement associated with longer journeys is present, the overall vehicular interaction is less complex than at Stop 6, leading to comparatively lower conflict intensity.

However, safety conditions at Stop 5 remain concerning. Weak enforcement, informal stopping behavior, and inconsistent traffic control create uncertainty for road users, while inadequate pedestrian facilities expose passengers to moving traffic. These factors together explain its classification as a high-severity stop and its ranking as the second most critical location along the study corridor.

i) ii)

Figure 4-10: Field conditions at Stop 5 associated with High Conflict Severity.

4.4.4 Discussion of Medium-Severity Informal Stops Based on Field Observations

The informal public transport stops ranked from third to eighth fall within the medium-severity category, with CSI values ranging from 42.08% to 61.62%. While these locations are less critical than the two high-severity stops, they still experience noticeable conflicts resulting from informal stopping behavior, proximity to intersections, and variations in roadway and pedestrian infrastructure. Differences in ranking within this group are mainly influenced by traffic volume, pedestrian exposure, dwell time, footpath width, road cross-section, and roadside encroachment.

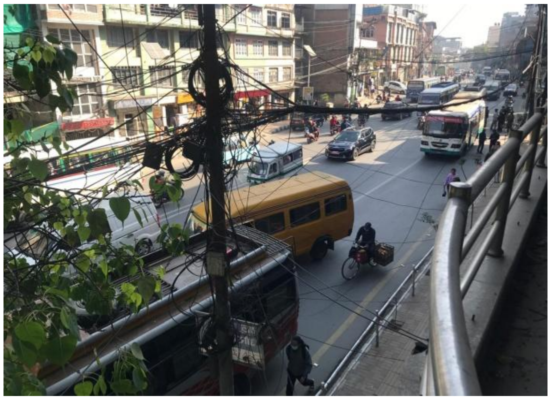
Among the medium-severity locations, Stops 2, 3, and 1 exhibit comparatively higher CSI values due to heavier traffic flow and stronger pedestrian–vehicle interaction. Stop 2 records the highest CSI within this category, largely because it is situated on a national highway between busy intersections and near a bridge, resulting in high vehicle movement and roadside activity. The narrow footpath forces pedestrians closer to moving traffic, and informal stopping near the showroom further increases conflicts. However, the stop remains within the medium-severity range because pedestrian accumulation is lower than at high-severity locations and the very short dwell time (approximately 15–25 seconds) limits prolonged lane blockage and sudden maneuvers.

Stop 3 ranks next, primarily due to high passenger activity and elevated pedestrian exposure. Although this location benefits from the widest road cross-section among the informal stops, which helps reduce vehicle-to-vehicle conflicts, pedestrian risk remains high. Shop encroachment along the footpath restricts pedestrian movement, forcing many pedestrians onto the carriageway, while passengers frequently wait in areas lacking proper pedestrian facilities. These conditions explain its relatively high ranking despite improved roadway width.

Stop 1 follows closely, influenced by narrow footpaths and the second-highest traffic volume along the corridor due to its position on a national highway. Nevertheless, its comparatively wider roadway and lower pedestrian exposure than Stop 3, together with shorter dwell times, help moderate overall conflict severity.

Lower-ranked medium-severity stops 4, 8, and 7 generally experience reduced conflict intensity owing to lower traffic volumes, improved roadside space, or better pedestrian conditions. Stop 4 records fewer conflicts mainly because of relatively low traffic flow and the presence of additional roadside space that allows safer vehicle movement and pedestrian waiting despite substandard carriageway width. At Stop 8, conflict is locally influenced by a gate structure that narrows the effective road width; however, overall severity remains low due to limited pedestrian activity and the availability of waiting space beyond the gate. Stop 7 records the lowest CSI value, largely attributable to its wide roadway, generous footpath width, and minimal roadside obstructions, which together promote smoother traffic operation and reduce pedestrian–vehicle interaction.Overall, the medium-severity group highlights the combined influence of traffic intensity, pedestrian exposure, physical roadway conditions, and informal operational behavior on conflict severity. Stops with high traffic flow and constrained pedestrian infrastructure tend to rank higher, whereas locations offering wider road sections, better footpath conditions, and lower demand exhibit reduced conflict levels and lower CSI rankings. These contrasting field conditions across all medium-severity stops are illustrated in Figure 4-11.

Stop 2



Stop 1

Stop 3

Stop 4

Stop 7 Stop 8

Figure 4-11: Field conditions at medium-severity informal stops along the study corridor.

4.5 GIS-Based Mapping Results of Informal Stop Severity

The GIS map, as shown in Figure 4-12 clearly presents how the severity of informal stops varies along the corridor based on CSI classification. It can be seen that high-severity stops are mainly concentrated around the Balkhu area, where traffic conditions are more complicated due to multiple road connections, mixed vehicle movements, and heavy pedestrian activity. Stops 5 and 6 stand out as the most critical locations, reflecting frequent conflicts, longer stopping durations, and unstable operating conditions observed during field surveys.

The remaining stops fall under the medium severity category, which suggests that while safety and operational issues are still present, their intensity is relatively lower compared to the Balkhu area. It is also important to note that no stops fall under the low severity category, indicating that all informal stops contribute to some level of risk due to their unregulated and demand-driven nature. Overall, the GIS mapping provides a clear visual understanding of how risk is distributed along the corridor and strongly supports the CSI results by highlighting the locations that require greater attention and priority for improvement.

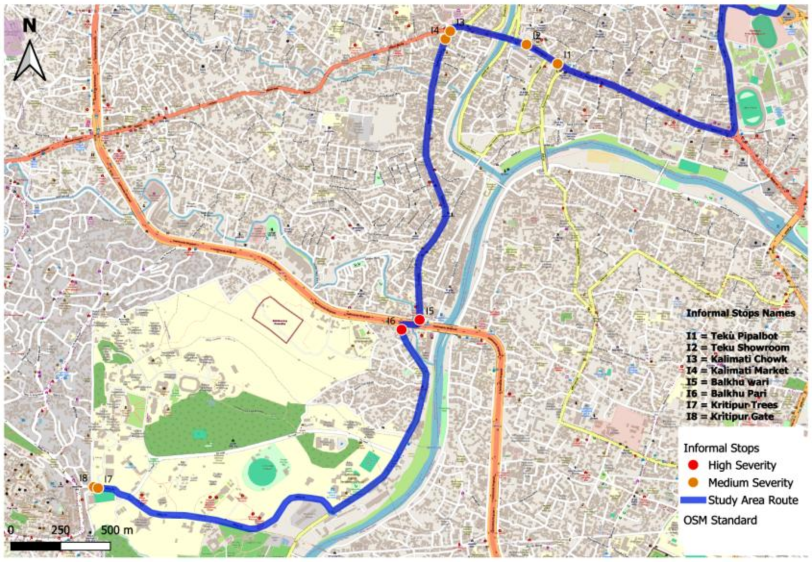


Figure 4-12: GIS Mapping of informal public transport stops classified by CSI severity.

4.6 Validation of Conflict Severity Index (CSI) Results

To assess the reliability of the Conflict Severity Index (CSI) outcomes, a multi-stage validation process was undertaken using independent field data, statistical correlation tests, and sensitivity analyses. This approach was adopted to ensure that the CSI-based severity classification and prioritization were stable and not overly influenced by observation duration, data variability, or weighting assumptions.

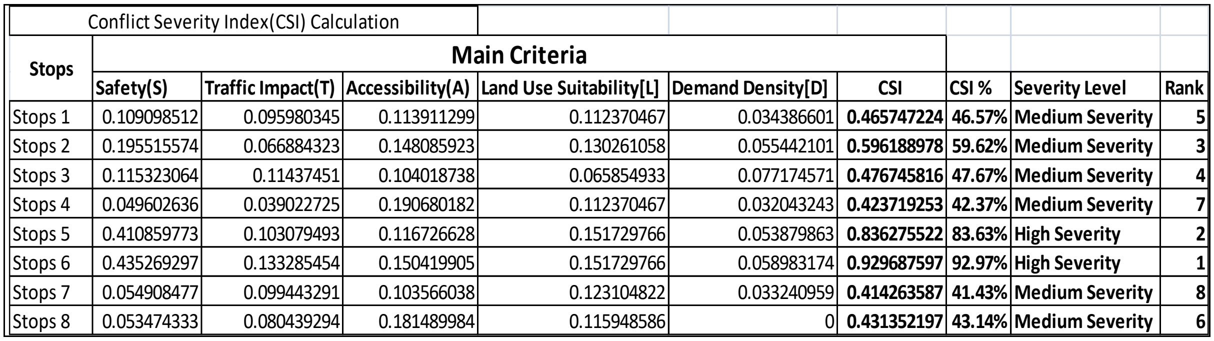
4.6.1 Field-Based Validation Using Independent Observations

To evaluate the stability of the Conflict Severity Index (CSI) results, an independent field-based validation was conducted at the same eight informal public transport stops. The validation surveys followed the same methodological framework described in Chapter 3, including identical criteria, sub-criteria, AHP-derived weights, normalization procedures, and CSI computation methods. The primary difference between the main and validation datasets was the duration of observation.

For the main analysis, 30-minute video and manual surveys were carried out at each stop during the morning peak, daytime off-peak, and evening peak periods. For validation, similar surveys were conducted for 20 minutes during the same time periods but on different dates to minimize the influence of day-specific traffic conditions. Although the exact observation times differed (for example, main data collection at 08:30 and validation at 09:30), both surveys were performed within the same defined peak or off-peak periods (08:00–11:00 for morning peak, 11:00–16:00 for daytime off-peak, and 16:00–19:00 for evening peak). This ensured temporal consistency while allowing assessment of variability under comparable traffic conditions.

A summary of the validation field data collection for all informal stops is provided in the APPENDIX G. Using the same AHP-based weights, the validation data were normalized and used to compute CSI values for each stop. The final CSI values along with their corresponding severity classifications and rankings are presented in Table 4-10.

Table 4-10: CSI values, severity classification and rank of all informal public transport stops.



Conflict Severity Index(CSI) Calculation									
Stops	**Main Criteria**								
	Safety(S)	**Traffic Impact(T)**	**Accessibility(A)**	**Land Use Suitability[L]**	**Demand Density[D]**	**CSI**	**CSI %**	**Severity Level**	**Rank**
Stops 1	0.109098512	0.095980345	0.113911299	0.112370467	0.034386601	**0.465747224**	**46.57%**	**Medium Severity**	**5**
Stops 2	0.195515574	0.066884323	0.148085923	0.130261058	0.055442101	**0.596188978**	**59.62%**	**Medium Severity**	**3**
Stops 3	0.115323064	0.11437451	0.104018738	0.065854933	0.077174571	**0.476745816**	**47.67%**	**Medium Severity**	**4**
Stops 4	0.049602636	0.039022725	0.190680182	0.112370467	0.032043243	**0.423719253**	**42.37%**	**Medium Severity**	**7**
Stops 5	0.410859773	0.103079493	0.116726628	0.151729766	0.053879863	**0.836275522**	**83.63%**	**High Severity**	**2**
Stops 6	0.435269297	0.133285454	0.150419905	0.151729766	0.058983174	**0.929687597**	**92.97%**	**High Severity**	**1**
Stops 7	0.054908477	0.099443291	0.103566038	0.123104822	0.033240959	**0.414263587**	**41.43%**	**Medium Severity**	**8**
Stops 8	0.053474333	0.080439294	0.181489984	0.115948586	0	**0.431352197**	**43.14%**	**Medium Severity**	**6**

A detailed comparison between the main and validation datasets was carried out to examine whether changes in observation duration or survey timing affected the results. This indicated only minor variation in dataset, generally within ±2% across all stops. These variations, presented in APPENDIX H, are attributed to natural fluctuations in traffic flow, passenger demand, and operational behavior during different observation periods.

Despite small numerical variations in CSI values across all informal stops, the overall severity classification remained unchanged. Although a minor interchange was observed between ranks 6 and 7, with CSI variation of less than 1%, both stops continued to fall within the same severity category. Figure 4-13 illustrates the CSI-based severity classification derived from the validation dataset, while Figure 4-14 presents the corresponding ranking of stops. This level of consistency indicates that, although slight changes in CSI percentages were observed for all locations, the severity classes remained stable. Overall, these results suggest that the CSI framework is not sensitive to moderate changes in observation duration or timing within the same traffic periods, supporting the reliability of the adopted methodology.

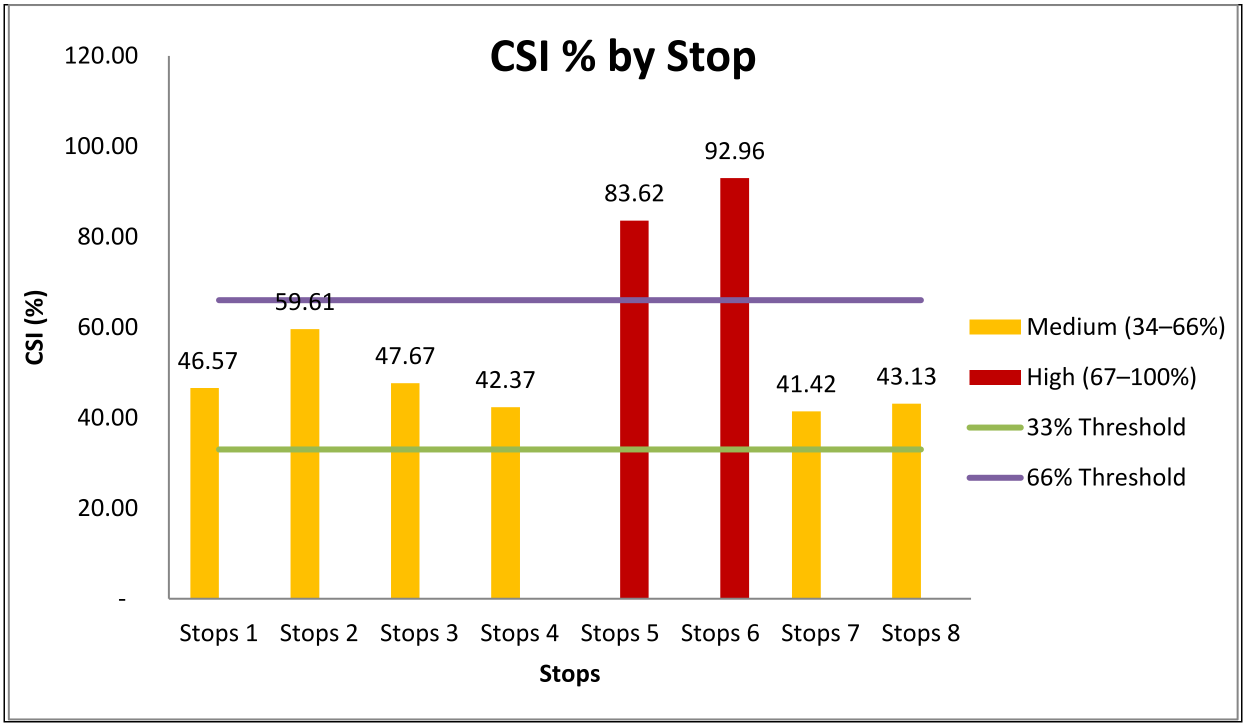


Figure 4-13: Severity Classification of Informal Bus Stops Based on CSI (%) (Validation).

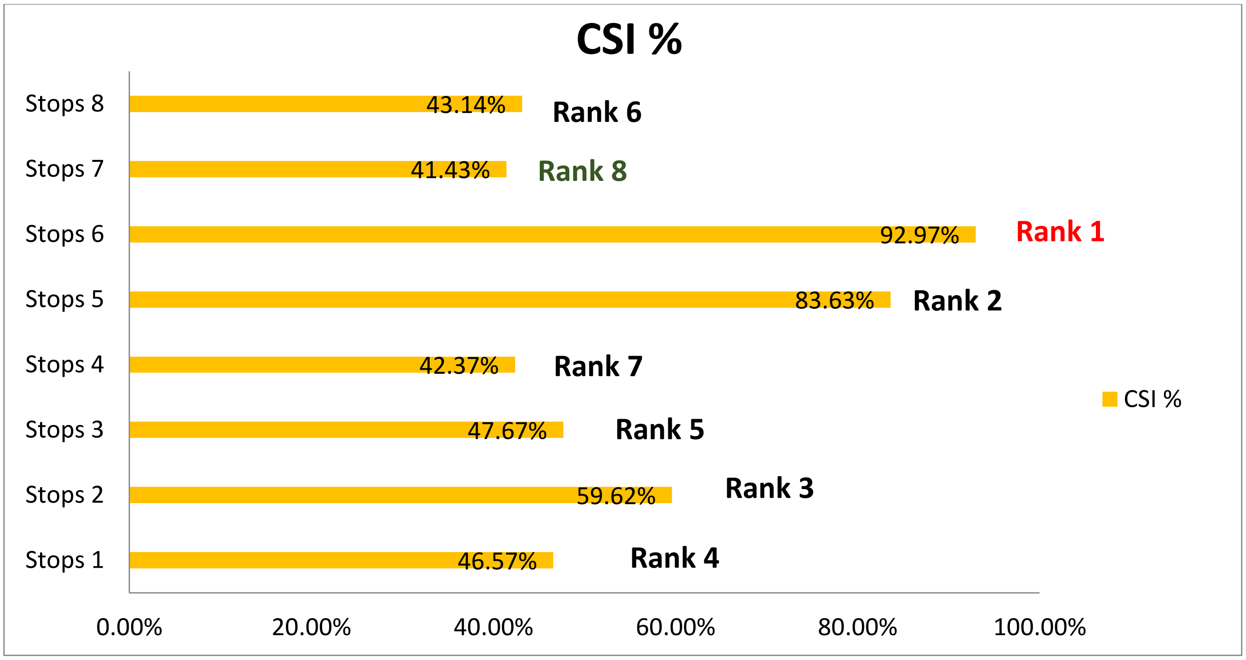
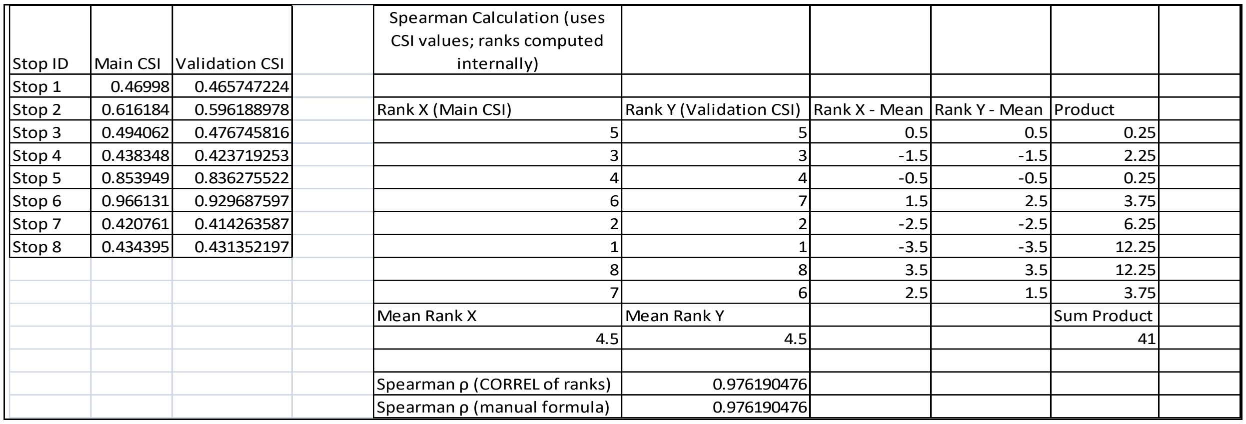


Figure 4-14: Ranking of Informal Bus Stops Based on CSI (%) (Validation).

4.6.2 Spearman Rank Correlation Analysis

Spearman's rank correlation analysis was conducted to assess consistency between CSI values obtained from the main and validation datasets. The results, presented in Table 4-11 and Figure 4-15, show a very strong positive correlation (ρ = 0.976), indicating that the relative ranking of informal stops remains highly consistent despite minor numerical differences in CSI values.

Table 4-11: Spearman rank correlation between main and validation CSI values.



Stop ID	Main CSI	Validation CSI		Spearman Calculation (uses CSI values; ranks computed internally)					
Stop 1	0.46998	0.465747224							
Stop 2	0.616184	0.596188978		Rank X (Main CSI)	Rank Y (Validation CSI)	Rank X - Mean	Rank Y - Mean	Product	
Stop 3	0.494062	0.476745816		5	5	0.5	0.5	0.25	
Stop 4	0.438348	0.423719253		3	3	-1.5	-1.5	2.25	
Stop 5	0.853949	0.836275522		4	4	-0.5	-0.5	0.25	
Stop 6	0.966131	0.929687597		6	7	1.5	2.5	3.75	
Stop 7	0.420761	0.414263587		2	2	-2.5	-2.5	6.25	
Stop 8	0.434395	0.431352197		1	1	-3.5	-3.5	12.25	
				8	8	3.5	3.5	12.25	
				7	6	2.5	1.5	3.75	
				Mean Rank X	Mean Rank Y			Sum Product	
				4.5	4.5			41	
				Spearman ρ (CORREL of ranks)	0.976190476				
				Spearman ρ (manual formula)	0.976190476				

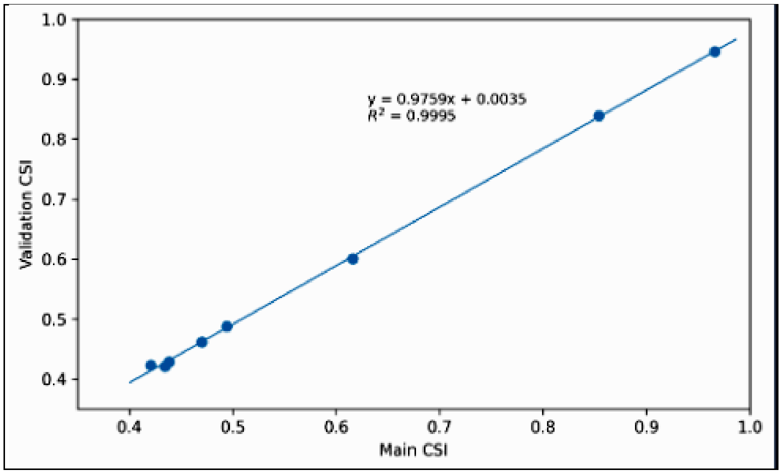


Figure 4-15: Spearman Rank Correlation between Main and Validation CSI Results.

Although a small interchange occurred between two lower-ranked stops, all locations retained the same severity classifications. This confirms that CSI-based prioritization is stable and not sensitive to moderate changes in observation duration or survey timing within the same traffic periods. Spearman Rank Correlation performed between final CSI values and selected raw field data is shown in APPENDIX I.

$\rho \geq 0.60$ → Good / strong relationship

$\rho \geq 0.40$ → Acceptable / meaningful relationship

$\rho < 0.40$ → Weak support

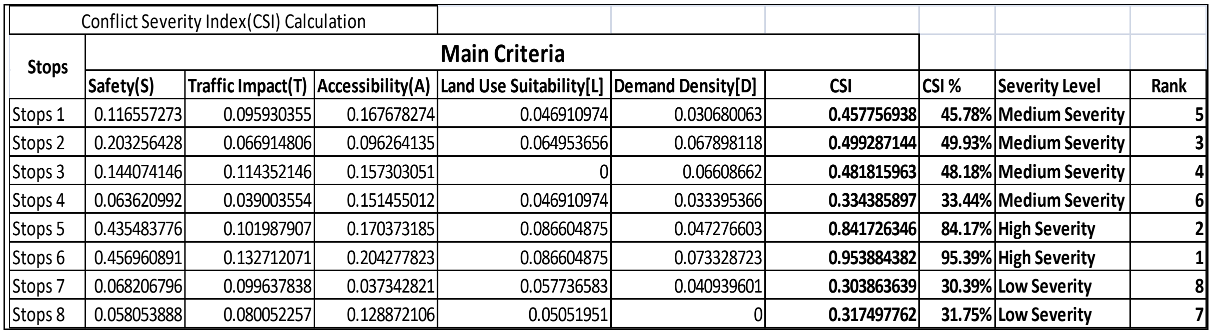
Overall, the correlation results provide strong statistical evidence supporting the reliability of the CSI framework.

4.6.3 Sensitivity Analysis of Binary Sub-Criteria

To further assess the robustness of the CSI framework, a sensitivity analysis was performed on two binary sub-criteria: pedestrian facilities (presence of crosswalk signals) and proximity to sensitive land uses (such as schools, markets, and hospitals). These parameters were selected as they are represented using yes-or-no values and could influence CSI outcomes.

For this analysis, the original binary values were reversed to examine whether opposite conditions would significantly affect CSI results. The recalculated CSI values showed minor numerical variation; however, the overall severity classification and ranking of informal stops remained unchanged. The results of this sensitivity test are presented in Table 4-12.

Table 4-12: Sensitivity Analysis Results for Binary Sub-Criteria.



Conflict Severity Index(CSI) Calculation									
Stops	**Main Criteria**								
	Safety(S)	**Traffic Impact(T)**	**Accessibility(A)**	**Land Use Suitability[L]**	**Demand Density[D]**	**CSI**	**CSI %**	**Severity Level**	**Rank**
Stops 1	0.116557273	0.095930355	0.167678274	0.046910974	0.030680063	**0.457756938**	**45.78%**	**Medium Severity**	**5**
Stops 2	0.203256428	0.066914806	0.096264135	0.064953656	0.067898118	**0.499287144**	**49.93%**	**Medium Severity**	**3**
Stops 3	0.144074146	0.114352146	0.157303051	0	0.06608662	**0.481815963**	**48.18%**	**Medium Severity**	**4**
Stops 4	0.063620992	0.039003554	0.151455012	0.046910974	0.033395366	**0.334385897**	**33.44%**	**Medium Severity**	**6**
Stops 5	0.435483776	0.101987907	0.170373185	0.086604875	0.047276603	**0.841726346**	**84.17%**	**High Severity**	**2**
Stops 6	0.456960891	0.132712071	0.204277823	0.086604875	0.073328723	**0.953884382**	**95.39%**	**High Severity**	**1**
Stops 7	0.068206796	0.099637838	0.037342821	0.057736583	0.040939601	**0.303863639**	**30.39%**	**Low Severity**	**8**
Stops 8	0.058053888	0.080052257	0.128872106	0.05051951	0	**0.317497762**	**31.75%**	**Low Severity**	**7**

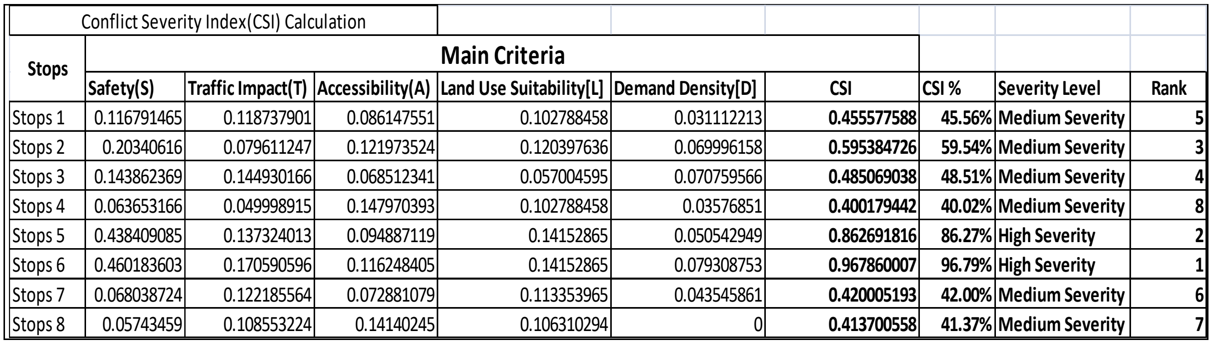
This confirms that the CSI framework is not overly sensitive to individual binary parameters and remains stable under reasonable variations in input conditions.

4.6.4 Sensitivity Analysis of AHP-Derived Weights

To assess the influence of expert judgment on CSI outcomes, a sensitivity analysis was conducted by introducing a ±33% change in expert weightage, where a portion of the original expert inputs was replaced with new judgments while the remaining inputs were retained. This adjustment was applied to examine whether such variations would significantly affect the CSI results and the overall prioritization of stops.

Revised CSI values and rankings were recalculated using the modified weights. The results, presented in Table 4-13, show that only minor numerical changes occurred in CSI values across all informal stops, and the overall severity classifications remained unchanged. The ranking of the top five most critical stops was consistent, indicating stability in the results. Small rank interchanges were observed only among the lower-ranked stops (Stops 6, 7, and 8), where differences in CSI values were below 2%, suggesting that the results are minimally sensitive within this range.

Table 4-13: Sensitivity Analysis of CSI Results under AHP Weight Variation.



Conflict Severity Index(CSI) Calculation									
Stops	Main Criteria								
	Safety(S)	Traffic Impact(T)	Accessibility(A)	Land Use Suitability[L]	Demand Density[D]	CSI	CSI %	Severity Level	Rank
Stops 1	0.116791465	0.118737901	0.086147551	0.102788458	0.031112213	**0.455577588**	**45.56%**	**Medium Severity**	**5**
Stops 2	0.20340616	0.079611247	0.121973524	0.120397636	0.069996158	**0.595384726**	**59.54%**	**Medium Severity**	**3**
Stops 3	0.143862369	0.144930166	0.068512341	0.057004595	0.070759566	**0.485069038**	**48.51%**	**Medium Severity**	**4**
Stops 4	0.063653166	0.049998915	0.147970393	0.102788458	0.03576851	**0.400179442**	**40.02%**	**Medium Severity**	**8**
Stops 5	0.438409085	0.137324013	0.094887119	0.14152865	0.050542949	**0.862691816**	**86.27%**	**High Severity**	**2**
Stops 6	0.460183603	0.170590596	0.116248405	0.14152865	0.079308753	**0.967860007**	**96.79%**	**High Severity**	**1**
Stops 7	0.068038724	0.122185564	0.072881079	0.113353965	0.043545861	**0.420005193**	**42.00%**	**Medium Severity**	**6**
Stops 8	0.05743459	0.108553224	0.14140245	0.106310294	0	**0.413700558**	**41.37%**	**Medium Severity**	**7**

The results show that while small score and ranking changes happened at lower severity levels, the overall priority pattern stayed similar. This suggests the CSI framework gives stable results and is not heavily affected by differences in expert judgment. It appears reliable for identifying higher-risk informal public transport stops along the corridor. To ensure transparency and allow verification of the analysis, all expert survey responses, pairwise comparison matrices, and detailed AHP calculation results are provided in APPENDIX J.

4.7 Discussion

The study found that informal public transport stops along the corridor create traffic conflicts and unsafe conditions for road users. None of the observed stops fall under the low-severity category, which highlights how unmanaged passenger boarding and alighting directly affect traffic movement in dense urban areas. Higher severity was observed at locations with increased pedestrian activity, high traffic volume, longer dwell times, poor road geometry, and proximity to busy intersections. These findings are consistent with previous research showing that frequent stopping behavior and pedestrian exposure significantly increase conflict risk around public transport stops (Singleton et al., 2024; Yendra et al., 2024).

An important contribution of this study is the use of traffic conflicts as a surrogate safety measure in the absence of reliable crash data. Since crash records rarely provide stop-level detail and are often underreported, near-miss observations offer a practical approach to assess safety within short observation periods. This aligns with earlier studies which demonstrate that traffic conflict indicators can effectively represent safety conditions and support proactive identification of hazardous locations (Gettman & Head, 2003; Zheng et al., 2014). Systematic reviews further confirm that surrogate safety measures provide meaningful insights, particularly in complex and data-limited urban environments (Astarita et al., 2020; Mahmud et al., 2017). In this study, the application of conflict-based indicators within the CSI framework enabled a more detailed understanding of safety conditions at informal stops.

Since CSI values depend on local traffic conditions and AHP-based weighting, validation of results was necessary. Spearman's rank correlation, sensitivity analysis, and confidence interval testing were applied to assess the stability of the results. The findings showed only minor variations in CSI values and rankings, mainly among lower-priority stops, while the overall severity classification remained unchanged. This indicates that the framework is reasonably stable and consistent under variations in expert judgment, which is also supported by previous studies using similar validation approaches (Astarita et al., 2020; Zheng et al., 2014).

Spatial mapping using GIS provided additional insight by visually representing how severity varies along the corridor. The results show that higher-severity stops are concentrated around intersections and commercial areas where pedestrian activity is high and road space is limited. This pattern supports existing research which indicates that safety risks are not randomly distributed but tend to cluster in high-activity zones (Al-Aamri et al., 2021; Anderson, 2009; Xie & Yan, 2008). In the Kathmandu context, corridor-based transport studies also highlight that mobility pressure and safety impacts are concentrated in specific sections of the network (Asian Transport Observatory, 2023). In this study, GIS mapping was primarily used as a visualization tool to represent the spatial distribution of CSI-based severity classes rather than to perform advanced spatial statistical analysis.

Compared to previous studies in Nepal, which mainly focused on formal bus stops or general road safety indicators, this study provides a more detailed and stop-specific assessment of informal stopping behavior. Earlier research in Nepal has largely examined unsafe acts, accessibility, or general safety conditions, with limited use of validation techniques such as repeated field observations or statistical testing (Pandey & Acharya, 2020; Panthi et al., 2023). In addition, studies specifically addressing informal stops remain limited and often focus on location characteristics rather than conflict severity (Behal et al., 2020). While international studies have applied multi-criteria approaches, many rely on checklist-based scoring without validating severity classification (Tubis et al., 2021). In contrast, this study integrates AHP-based weighting, traffic conflict indicators, CSI computation, and multiple validation methods including rank correlation, sensitivity analysis, confidence intervals, and GIS-based visualization, providing a more robust and systematic framework for prioritizing informal public transport stops.

Overall, the analysis confirms that informal stops create localized safety risks within Kathmandu's road network, particularly in areas with high pedestrian activity and complex traffic conditions. The combined AHP-CSI framework, supported by GIS visualization, offers a practical and evidence-based approach to identify high-risk locations and support targeted safety improvements in data-limited urban environments.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study develops and applies a Conflict Severity Index framework to assess and prioritize informal public transport stops along the Sundhara-Kirtipur Gate corridor in the Kathmandu Valley. Field-based traffic conflict observations were combined with pedestrian and traffic exposure indicators, Analytic Hierarchy Process weighting, and GIS spatial analysis to create a structured method for identifying high-risk informal stopping locations in a data-limited urban environment.

The findings from this study indicate that all identified informal stops fall within medium to high severity levels, highlighting the safety and operational challenges created by unmanaged boarding and alighting in dense urban corridors. Stops located near major intersections and high-activity land-use areas recorded the highest severity due to increased pedestrian exposure, heavy traffic volumes, longer dwell times, and limited roadway space. These results suggest that conflict severity at informal stops arises from the combined effects of safety, accessibility, operational conditions, passenger demand, and surrounding land use rather than from any single factor.

Validation tests, including Spearman's rank correlation, AHP sensitivity analysis, and confidence interval assessment, confirmed that the CSI framework produces stable rankings and consistent severity classifications under reasonable uncertainty. GIS mapping also helped strengthen the analysis by revealing clusters of higher-risk stops around key junctions and commercial areas, supporting corridor-level prioritization and clear visualization of safety patterns.

Earlier studies in Nepal mainly focused on formal bus stops or general road safety indicators, whereas this research improves informal stop assessment by combining traffic conflict measures with multi-criteria analysis and statistical validation. The proposed CSI and AHP framework provides a practical decision-support tool for transport planners to identify priority locations and guide targeted safety and operational improvements, even when detailed crash data are not available.

The analysis indicates that informal public transport stops create localized risk conditions within Kathmandu’s road network, especially where pedestrian activity overlaps with complex traffic movements near intersections. The integrated approach developed in this study offers an evidence-based foundation for improving stop management, pedestrian facilities, and enforcement strategies, thereby contributing to safer and more efficient urban public transport systems in the Kathmandu Valley.

5.2 Recommendations

Based on field observations, CSI results, expert input, and validation outcomes, the following recommendations are proposed to improve safety and operational performance at informal public transport stops in the Kathmandu Valley:

i. The AHP weights developed in this study represent local traffic conditions and may serve as a reference for future informal stop safety assessments in Kathmandu and other cities with similar urban characteristics.

ii. Informal stopping should be strictly controlled by following Nepal Urban Road Standards (NURS 2076), particularly regarding stop spacing and minimum clearance from intersections.

iii. High-severity informal stops, especially Stop 6 and Stop 5, should be addressed as a matter of urgency. Stop 6 should be shifted to a nearby formal stop through strong enforcement, whereas Stop 5 should be relocated to a safer, standard-compliant location.

iv. Medium-severity stops should be managed based on site conditions. Stops close to intersections or bridges should be relocated to safer mid-block positions, and stops with adequate space should be upgraded with designated waiting areas and controlled boarding zones.

v. Pedestrian infrastructure should be improved at all stop locations through continuous sidewalks, safe crossing points, and refuge areas where required, to reduce unsafe pedestrian movement and conflicts with traffic.

vi. Strong enforcement is required to control informal stopping, excessive dwell time, roadside encroachment, informal vending, and unauthorized pick-and-drop activities. Public transport vehicles should only operate at designated stopping locations.

vii. Informal brokers and intermediaries should be strictly prohibited from entering traffic lanes to attract passengers, as this behavior significantly increases the risk of conflict and disrupts traffic flow.

viii. Traffic signals at signalized intersections should operate continuously and be monitored regularly to avoid failures. At unsignalized locations, basic traffic control such as warning signs or manual control during peak hours should be provided to reduce conflicts.

Improving safety at informal public transport stops requires coordinated enforcement, standard-based infrastructure, and disciplined practice. Implementing these measures will help reduce conflict severity, enhance pedestrian safety, and support safer and more efficient urban mobility in the Kathmandu Valley.

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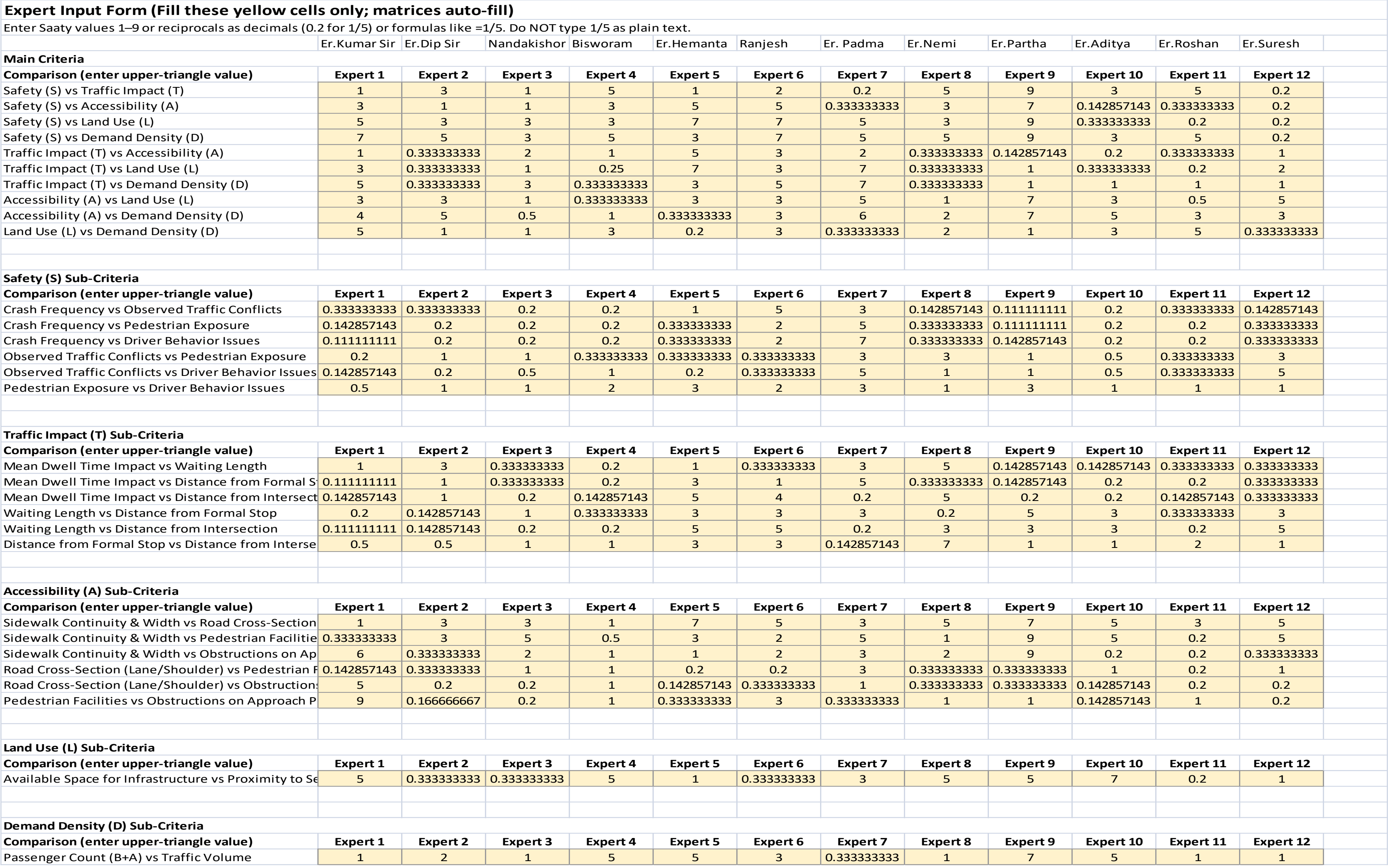
APPENDIX A: Format of Field Data Collection Sheet.

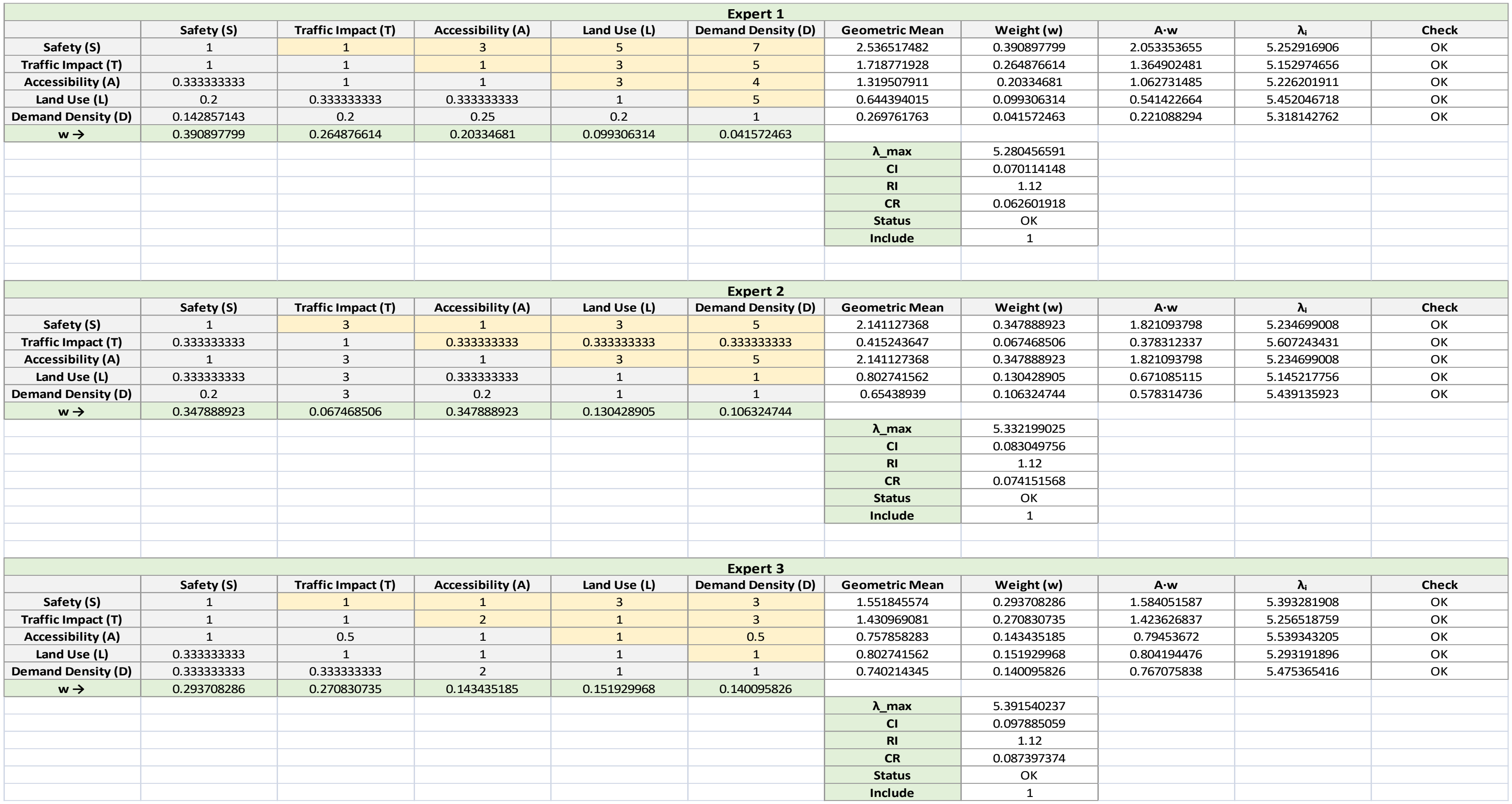
Peak/Offpeak Time													
S.N	Main Criteria	Sub Criteria		Stop 1	Stop 2	Stop 1	Stop 2	Stop 1	Stop 2	Stop 1	Stop 2	Stop 1	Stop 2
1	Safey(Conflict Score)[S]	Crash Frequency	No. of Crash Observed										
		Observed Traffic Conflict	Near Miss(V-V & V-P)										
			Sudden Braking										
		Pedistrian Exposure	Boarding + Alighting										
		Driverf Behvaiour Issue	Sudden Lane Change										
			Horn Usage										
2	Traffic Imapact(Disruption Severity)[T]	Mean Dwell Time											
		Waiting Length											
		Stop Distance from Formal Stop											
		Stop Distance from Intersection											
3	Accessibility(Walkability & Pedistrian Facilities)[A]	Side Walk Width											
		Road Cross-section											
		Pedistrian Facilities	Crosswalks										
		Obstruction On Approach Path	Presence of obstruction(parked vehicles,street vendors)										
4	Land Use Suitability[L]	Available Space for infracture Development											
		Proximity to sensitivity land use	School and Hospitals										
5	Demand Density[D]	Passenger count	Boarding + Alighting										
		Traffic Count	Veh/30min										

APPENDIX B: Valid AHP Weightage provided by all Experts.



Expert Input Form (Fill these yellow cells only; matrices auto-fill)												
Enter Saaty values 1–9 or reciprocals as decimals (0.2 for 1/5) or formulas like =1/5. Do NOT type 1/5 as plain text.												
	Er.Kumar Sir	Er.Dip Sir	Nandakishor	Bisworam	Er.Hemanta	Ranjesh	Er. Padma	Er.Nemi	Er.Partha	Er.Aditya	Er.Roshan	Er.Suresh
Main Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Safety (S) vs Traffic Impact (T)	1	3	1	5	1	2	0.2	5	9	3	5	0.2
Safety (S) vs Accessibility (A)	3	1	1	3	5	5	0.333333333	3	7	0.142857143	0.333333333	0.2
Safety (S) vs Land Use (L)	5	3	3	3	7	7	5	3	9	0.333333333	0.2	0.2
Safety (S) vs Demand Density (D)	7	5	3	5	3	7	5	5	9	3	5	0.2
Traffic Impact (T) vs Accessibility (A)	1	0.333333333	2	1	5	3	2	0.333333333	0.142857143	0.2	0.333333333	1
Traffic Impact (T) vs Land Use (L)	3	0.333333333	1	0.25	7	3	7	0.333333333	1	0.333333333	0.2	2
Traffic Impact (T) vs Demand Density (D)	5	0.333333333	3	0.333333333	3	5	7	0.333333333	1	1	1	1
Accessibility (A) vs Land Use (L)	3	3	1	0.333333333	3	3	5	1	7	3	0.5	5
Accessibility (A) vs Demand Density (D)	4	5	0.5	1	0.333333333	3	6	2	7	5	3	3
Land Use (L) vs Demand Density (D)	5	1	1	3	0.2	3	0.333333333	2	1	3	5	0.333333333
Safety (S) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Crash Frequency vs Observed Traffic Conflicts	0.333333333	0.333333333	0.2	0.2	1	5	3	0.142857143	0.111111111	0.2	0.333333333	0.142857143
Crash Frequency vs Pedestrian Exposure	0.142857143	0.2	0.2	0.2	0.333333333	2	5	0.333333333	0.111111111	0.2	0.2	0.333333333
Crash Frequency vs Driver Behavior Issues	0.111111111	0.2	0.2	0.2	0.333333333	2	7	0.333333333	0.142857143	0.2	0.2	0.333333333
Observed Traffic Conflicts vs Pedestrian Exposure	0.2	1	1	0.333333333	0.333333333	0.333333333	3	3	1	0.5	0.333333333	3
Observed Traffic Conflicts vs Driver Behavior Issues	0.142857143	0.2	0.5	1	0.2	0.333333333	5	1	1	0.5	0.333333333	5
Pedestrian Exposure vs Driver Behavior Issues	0.5	1	1	2	3	2	3	1	3	1	1	1
Traffic Impact (T) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Mean Dwell Time Impact vs Waiting Length	1	3	0.333333333	0.2	1	0.333333333	3	5	0.142857143	0.142857143	0.333333333	0.333333333
Mean Dwell Time Impact vs Distance from Formal S	0.111111111	1	0.333333333	0.2	3	1	5	0.333333333	0.142857143	0.2	0.2	0.333333333
Mean Dwell Time Impact vs Distance from Intersect	0.142857143	1	0.2	0.142857143	5	4	0.2	5	0.2	0.2	0.142857143	0.333333333
Waiting Length vs Distance from Formal Stop	0.2	0.142857143	1	0.333333333	3	3	3	0.2	5	3	0.333333333	3
Waiting Length vs Distance from Intersection	0.111111111	0.142857143	0.2	0.2	5	5	0.2	3	3	3	0.2	5
Distance from Formal Stop vs Distance from Interse	0.5	0.5	1	1	3	3	0.142857143	7	1	1	2	1
Accessibility (A) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Sidewalk Continuity & Width vs Road Cross-Section	1	3	3	1	7	5	3	5	7	5	3	5
Sidewalk Continuity & Width vs Pedestrian Facilitie	0.333333333	3	5	0.5	3	2	5	1	9	5	0.2	5
Sidewalk Continuity & Width vs Obstructions on Ap	6	0.333333333	2	1	1	2	3	2	9	0.2	0.2	0.333333333
Road Cross-Section (Lane/Shoulder) vs Pedestrian F	0.142857143	0.333333333	1	1	0.2	0.2	3	0.333333333	0.333333333	1	0.2	1
Road Cross-Section (Lane/Shoulder) vs Obstruction	5	0.2	0.2	1	0.142857143	0.333333333	1	0.333333333	0.333333333	0.142857143	0.2	0.2
Pedestrian Facilities vs Obstructions on Approach P	9	0.166666667	0.2	1	0.333333333	3	0.333333333	1	1	0.142857143	1	0.2
Land Use (L) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Available Space for Infrastructure vs Proximity to Se	5	0.333333333	0.333333333	5	1	0.333333333	3	5	5	7	0.2	1
Demand Density (D) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Passenger Count (B+A) vs Traffic Volume	1	2	1	5	5	3	0.333333333	1	7	5	1	1

APPENDIX C: Computation of comparison matrix, Eigen vector (priority vector), Eigen value, consistency index (CI), consistency ratio (CR), and random index (RI).



Expert 1

	Safety (S)	Traffic Impact (T)	Accessibility (A)	Land Use (L)	Demand Density (D)	Geometric Mean	Weight (w)	A·w	λ_i	Check
Safety (S)	1	1	3	5	7	2.536517482	0.390897799	2.053353655	5.252916906	OK
Traffic Impact (T)	1	1	1	3	5	1.718771928	0.264876614	1.364902481	5.152974656	OK
Accessibility (A)	0.333333333	1	1	3	4	1.319507911	0.20334681	1.062731485	5.226201911	OK
Land Use (L)	0.2	0.333333333	0.333333333	1	5	0.644394015	0.099306314	0.541422664	5.452046718	OK
Demand Density (D)	0.142857143	0.2	0.25	0.2	1	0.269761763	0.041572463	0.221088294	5.318142762	OK
w →	0.390897799	0.264876614	0.20334681	0.099306314	0.041572463					

λ_max	5.280456591
CI	0.070114148
RI	1.12
CR	0.062601918
Status	OK
Include	1

Expert 2

	Safety (S)	Traffic Impact (T)	Accessibility (A)	Land Use (L)	Demand Density (D)	Geometric Mean	Weight (w)	A·w	λ_i	Check
Safety (S)	1	3	1	3	5	2.141127368	0.347888923	1.821093798	5.234699008	OK
Traffic Impact (T)	0.333333333	1	0.333333333	0.333333333	0.333333333	0.415243647	0.067468506	0.378312337	5.607243431	OK
Accessibility (A)	1	3	1	3	5	2.141127368	0.347888923	1.821093798	5.234699008	OK
Land Use (L)	0.333333333	3	0.333333333	1	1	0.802741562	0.130428905	0.671085115	5.145217756	OK
Demand Density (D)	0.2	3	0.2	1	1	0.65438939	0.106324744	0.578314736	5.439135923	OK
w →	0.347888923	0.067468506	0.347888923	0.130428905	0.106324744					

λ_max	5.332199025
CI	0.083049756
RI	1.12
CR	0.074151568
Status	OK
Include	1

Expert 3

	Safety (S)	Traffic Impact (T)	Accessibility (A)	Land Use (L)	Demand Density (D)	Geometric Mean	Weight (w)	A·w	λ_i	Check
Safety (S)	1	1	1	3	3	1.551845574	0.293708286	1.584051587	5.393281908	OK
Traffic Impact (T)	1	1	2	1	3	1.430969081	0.270830735	1.423626837	5.256518759	OK
Accessibility (A)	1	0.5	1	1	0.5	0.757858283	0.143435185	0.79453672	5.539343205	OK
Land Use (L)	0.333333333	1	1	1	1	0.802741562	0.151929968	0.804194476	5.293191896	OK
Demand Density (D)	0.333333333	0.333333333	2	1	1	0.740214345	0.140095826	0.767075838	5.475365416	OK
w →	0.293708286	0.270830735	0.143435185	0.151929968	0.140095826					

λ_max	5.391540237
CI	0.097885059
RI	1.12
CR	0.087397374
Status	OK
Include	1

APPENDIX D: Aggregated Weights of all Valid Experts.

Aggregated Weights (Valid Experts Only)

Item	E1 w	E2 w	E3 w	E4 w	E5 w	E6 w	E7 w	E8 w	E9 w	E10 w	E11 w	E12 w	Included Experts	Avg Weight (valid)
Safety (S)	0.390897799	0.347888923	0.293708286	0.461011538	0.363760164	0.487603396	0.149394053	0.468118613	0.612594388	0.123594476	0.166527379	0.04372573	12	0.325735395
Traffic Impact (T)	0.264876614	0.067468506	0.270830735	0.068808967	0.363760164	0.263307973	0.465589069	0.059409056	0.048499782	0.068383593	0.0634021	0.251138369	12	0.187956244
Accessibility (A)	0.20334681	0.347888923	0.143435185	0.100560353	0.075333696	0.127543331	0.288805901	0.182022638	0.241906265	0.512420242	0.253036196	0.375772785	12	0.237672694
Land Use (L)	0.099306314	0.130428905	0.151929968	0.256514276	0.038310676	0.076839344	0.038541774	0.182022638	0.048499782	0.227218097	0.453632225	0.110734467	12	0.151164872
Demand Density (D)	0.041572463	0.106324744	0.140095826	0.113104866	0.1588353	0.044705957	0.057669203	0.108427054	0.048499782	0.068383593	0.0634021	0.218628649	12	0.097470795

Item	E1 w	E2 w	E3 w	E4 w	E5 w	E6 w	E7 w	E8 w	E9 w	E10 w	E11 w	E12 w	Included Experts	Avg Weight (valid)
Crash Frequency	0.043455047	0.068629711	0.06191752	0.059420943	0.118788069	0.445441634	0.563812769	0.073767449	0.037585045	0.060873146	0.067480983	0.065294075	12	0.138872199
Observed Traffic Conflicts	0.087180424	0.177752327	0.260331103	0.225750764	0.104546774	0.081326144	0.263378357	0.44489213	0.317666539	0.215219071	0.150892065	0.58885211	12	0.243148984
Pedestrian Exposure	0.329545349	0.302009069	0.3095876	0.464994005	0.469001673	0.277213018	0.117786382	0.20782601	0.418072677	0.361953891	0.390813476	0.183953862	12	0.319396418
Driver Behavior Issues	0.53981918	0.451608893	0.368163777	0.249834288	0.307663483	0.196019205	0.055022492	0.273514411	0.226675739	0.361953891	0.390813476	0.161899953	12	0.298582399

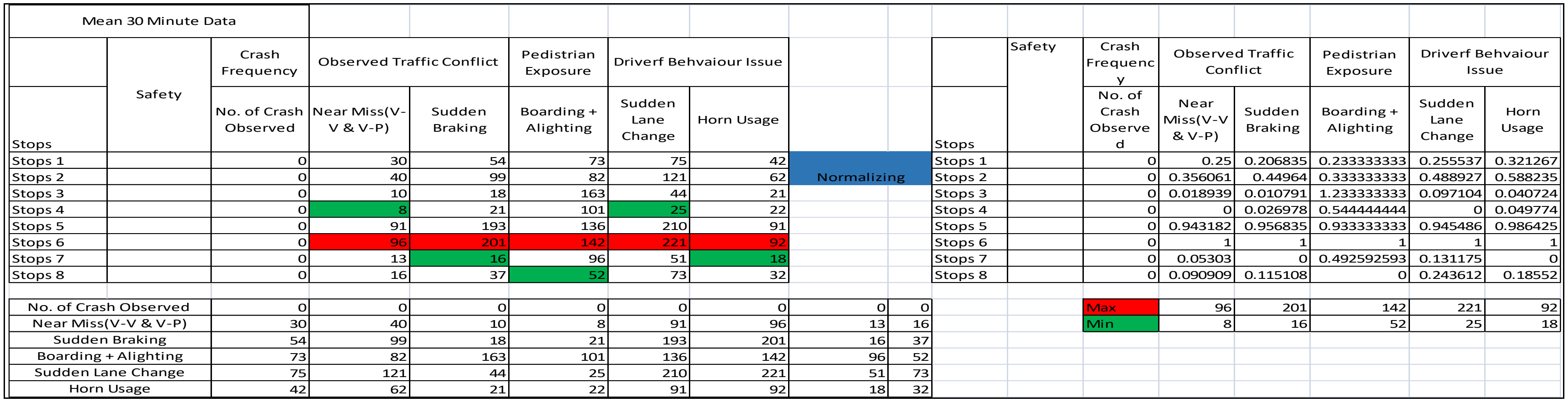
Item	E1 w	E2 w	E3 w	E4 w	E5 w	E6 w	E7 w	E8 w	E9 w	E10 w	E11 w	E12 w	Included Experts	Avg Weight (valid)
Mean Dwell Time Impact	0.056616385	0.268291756	0.080130606	0.050586618	0.390813476	0.213891835	0.221772448	0.292883606	0.044517079	0.0512502	0.058208687	0.089367925	12	0.151527552
Waiting Length	0.061584886	0.058546061	0.182658282	0.13980247	0.390813476	0.515540338	0.112689843	0.101457857	0.563787579	0.525158277	0.124607053	0.52762546	12	0.275355965
Distance from Formal Stop	0.347394471	0.278832906	0.273137839	0.362091202	0.150892065	0.199048781	0.052641706	0.551807627	0.191580008	0.211795762	0.436079268	0.203714816	12	0.271584704
Distance from Intersection	0.534404257	0.394329277	0.464073273	0.447519711	0.067480983	0.071519046	0.612896003	0.05385091	0.200115333	0.211795762	0.381104993	0.1792918	12	0.301531779

Item	E1 w	E2 w	E3 w	E4 w	E5 w	E6 w	E7 w	E8 w	E9 w	E10 w	E11 w	E12 w	Included Experts	Avg Weight (valid)
Sidewalk Continuity & Width	0.196141153	0.242765016	0.452154074	0.2086538	0.396609348	0.427192815	0.520490138	0.387666874	0.722457422	0.23834297	0.108983426	0.306891518	12	0.350695713
Road Cross-Section (Lane/Shoulder)	0.151627933	0.071220113	0.098171024	0.248132583	0.046829185	0.06864377	0.200959887	0.084169658	0.052551045	0.065530402	0.06292161	0.08077839	12	0.102627967
Pedestrian Facilities	0.611542544	0.117860418	0.08640147	0.295081034	0.159952118	0.334296444	0.077590089	0.286905587	0.112495766	0.065530402	0.414047482	0.08077839	12	0.220206812
Obstructions on Approach Path	0.040688369	0.568154454	0.363273433	0.248132583	0.396609348	0.169866971	0.200959887	0.24125788	0.112495766	0.630596225	0.414047482	0.531551701	12	0.326469508

Item	E1 w	E2 w	E3 w	E4 w	E5 w	E6 w	E7 w	E8 w	E9 w	E10 w	E11 w	E12 w	Included Experts	Avg Weight (valid)
Available Space for Infrastructure	0.833333333	0.25	0.25	0.833333333	0.5	0.25	0.75	0.833333333	0.833333333	0.875	0.166666667	0.5	12	0.572916667
Proximity to Sensitive Land Uses	0.166666667	0.75	0.75	0.166666667	0.5	0.75	0.25	0.166666667	0.166666667	0.125	0.833333333	0.5	12	0.427083333

Item	E1 w	E2 w	E3 w	E4 w	E5 w	E6 w	E7 w	E8 w	E9 w	E10 w	E11 w	E12 w	Included Experts	Avg Weight (valid)
Passenger Count (B+A)	0.5	0.666666667	0.5	0.833333333	0.833333333	0.75	0.25	0.5	0.875	0.833333333	0.5	0.5	12	0.628472222
Traffic Volume	0.5	0.333333333	0.5	0.166666667	0.166666667	0.25	0.75	0.5	0.125	0.166666667	0.5	0.5	12	0.371527778

APPENDIX E: Complete Field Data Collected of all Criteria along with their Normalized Values.



Mean 30 Minute Data

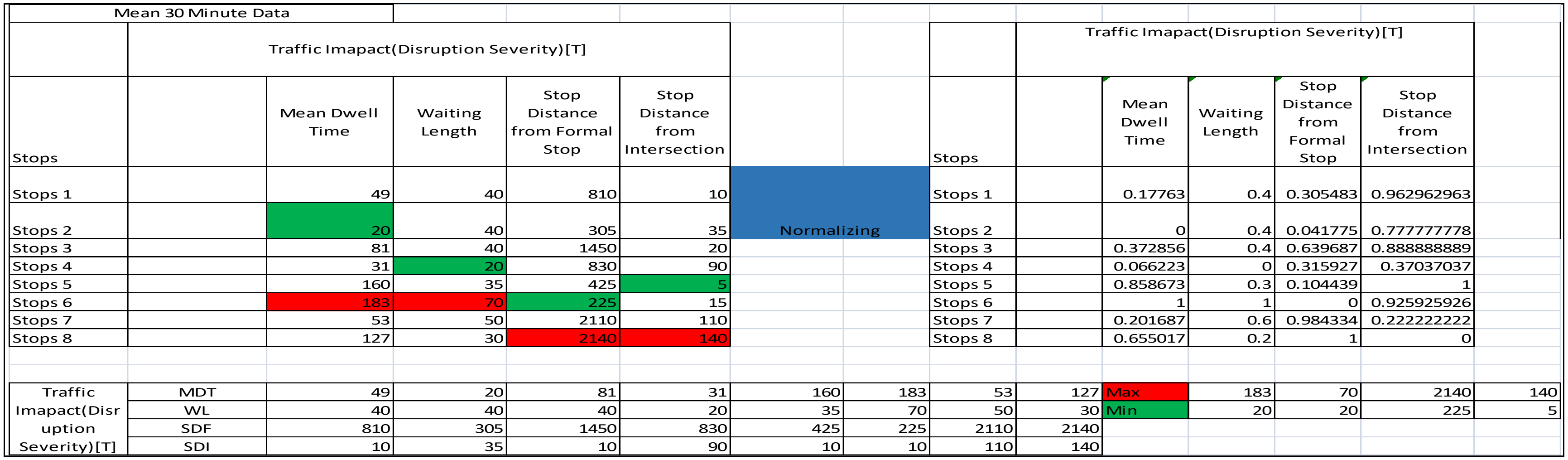
	Safety	Crash Frequency	Observed Traffic Conflict		Pedistrian Exposure	Driverf Behvaiour Issue	
Stops		No. of Crash Observed	Near Miss(V-V & V-P)	Sudden Braking	Boarding + Alighting	Sudden Lane Change	Horn Usage
Stops 1		0	30	54	73	75	42
Stops 2		0	40	99	82	121	62
Stops 3		0	10	18	163	44	21
Stops 4		0	8	21	101	25	22
Stops 5		0	91	193	136	210	91
Stops 6		0	96	201	142	221	92
Stops 7		0	13	16	96	51	18
Stops 8		0	16	37	52	73	32

Normalizing

	Safety	Crash Frequency	Observed Traffic Conflict		Pedistrian Exposure	Driverf Behvaiour Issue	
Stops		No. of Crash Observed	Near Miss(V-V & V-P)	Sudden Braking	Boarding + Alighting	Sudden Lane Change	Horn Usage
Stops 1		0	0.25	0.206835	0.233333333	0.255537	0.321267
Stops 2		0	0.356061	0.44964	0.333333333	0.488927	0.588235
Stops 3		0	0.018939	0.010791	1.233333333	0.097104	0.040724
Stops 4		0	0	0.026978	0.544444444	0	0.049774
Stops 5		0	0.943182	0.956835	0.933333333	0.945486	0.986425
Stops 6		0	1	1	1	1	1
Stops 7		0	0.05303	0	0.492592593	0.131175	0
Stops 8		0	0.090909	0.115108	0	0.243612	0.18552

No. of Crash Observed	0	0	0	0	0	0	0	0
Near Miss(V-V & V-P)	30	40	10	8	91	96	13	16
Sudden Braking	54	99	18	21	193	201	16	37
Boarding + Alighting	73	82	163	101	136	142	96	52
Sudden Lane Change	75	121	44	25	210	221	51	73
Horn Usage	42	62	21	22	91	92	18	32

Max	96	201	142	221	92
Min	8	16	52	25	18



Mean 30 Minute Data

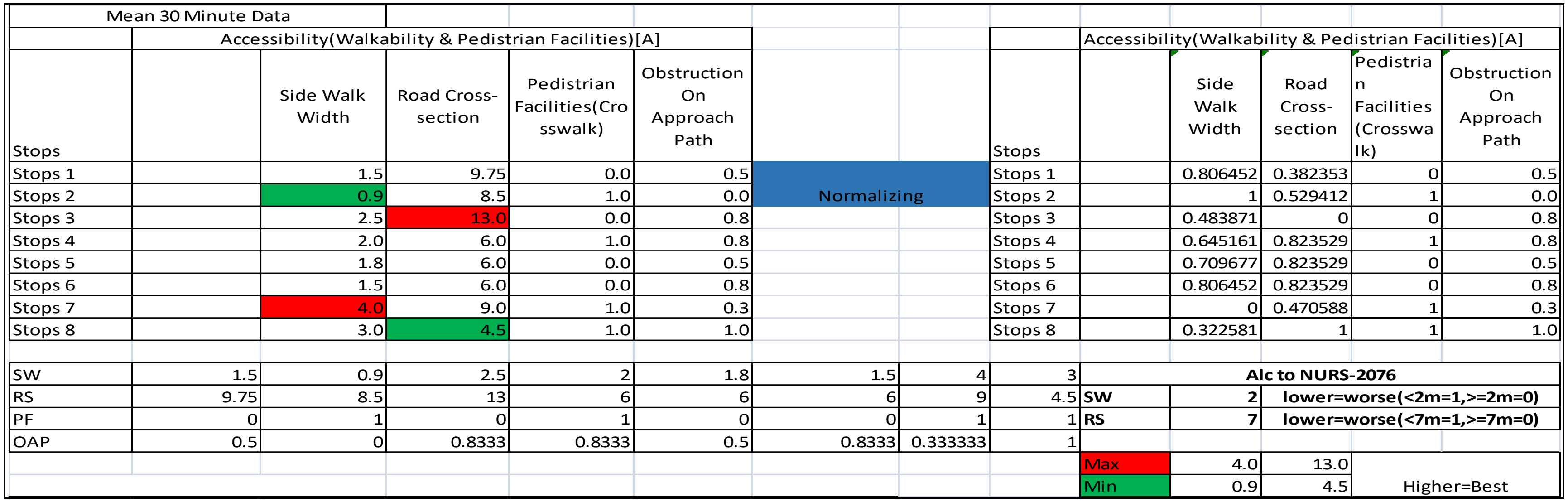
		Traffic Imapact(Disruption Severity)[T]			
Stops		Mean Dwell Time	Waiting Length	Stop Distance from Formal Stop	Stop Distance from Intersection
Stops 1		49	40	810	10
Stops 2		20	40	305	35
Stops 3		81	40	1450	20
Stops 4		31	20	830	90
Stops 5		160	35	425	5
Stops 6		183	70	225	15
Stops 7		53	50	2110	110
Stops 8		127	30	2140	140

Normalizing

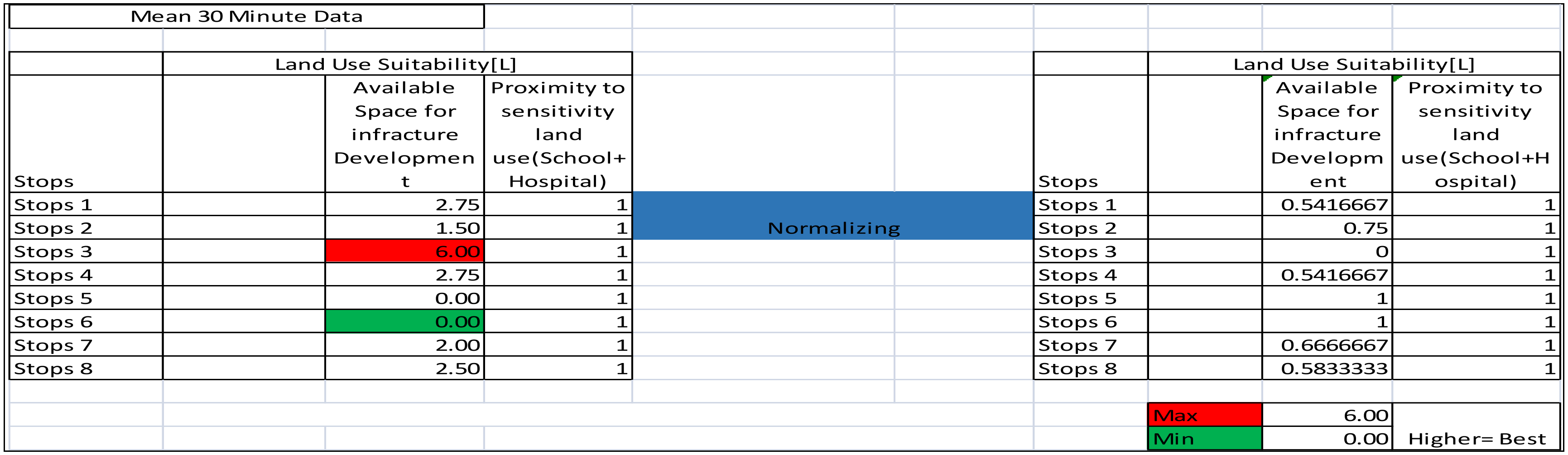
		Traffic Imapact(Disruption Severity)[T]			
Stops		Mean Dwell Time	Waiting Length	Stop Distance from Formal Stop	Stop Distance from Intersection
Stops 1		0.17763	0.4	0.305483	0.962962963
Stops 2		0	0.4	0.041775	0.777777778
Stops 3		0.372856	0.4	0.639687	0.888888889
Stops 4		0.066223	0	0.315927	0.37037037
Stops 5		0.858673	0.3	0.104439	1
Stops 6		1	1	0	0.925925926
Stops 7		0.201687	0.6	0.984334	0.222222222
Stops 8		0.655017	0.2	1	0

Traffic Imapact(Disruption Severity)[T]	MDT	49	20	81	31	160	183	53	127
	WL	40	40	40	20	35	70	50	30
	SDF	810	305	1450	830	425	225	2110	2140
	SDI	10	35	10	90	10	10	110	140

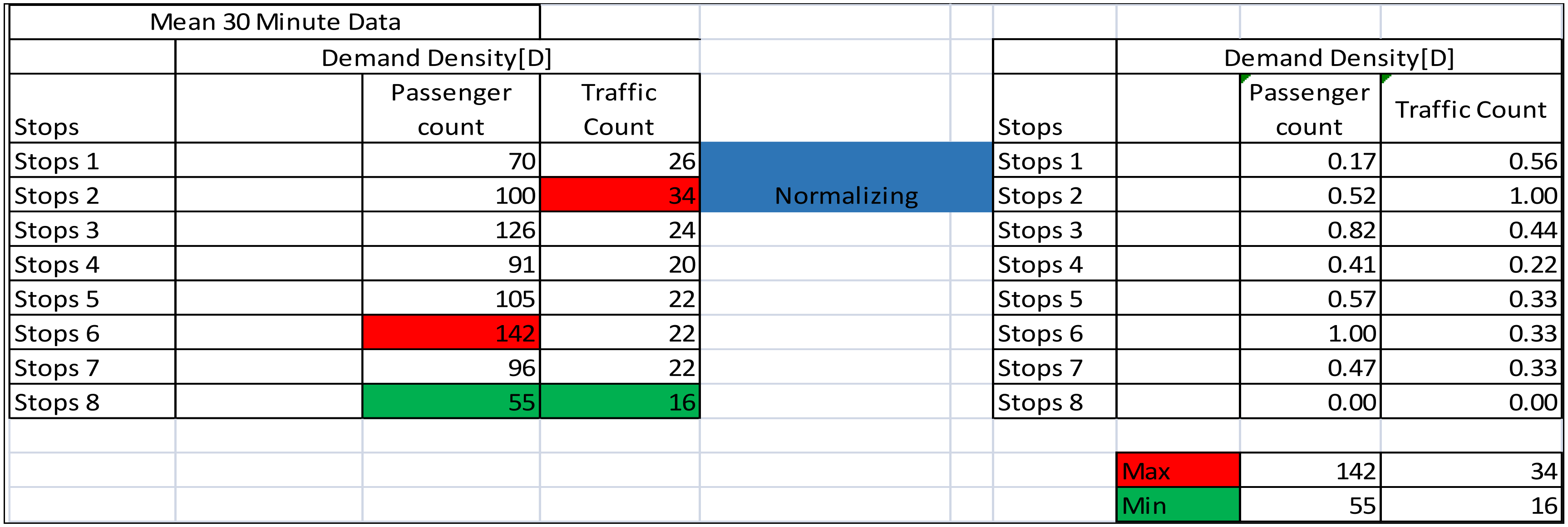
Max	183	70	2140	140
Min	20	20	225	5



Mean 30 Minute Data													
	Accessibility(Walkability & Pedistrian Facilities)[A]								Accessibility(Walkability & Pedistrian Facilities)[A]				
Stops		Side Walk Width	Road Cross-section	Pedestrian Facilities(Crosswalk)	Obstruction On Approach Path			Stops		Side Walk Width	Road Cross-section	Pedestrian Facilities (Crosswalk)	Obstruction On Approach Path
Stops 1		1.5	9.75	0.0	0.5			Stops 1		0.806452	0.382353	0	0.5
Stops 2		0.9	8.5	1.0	0.0	Normalizing		Stops 2		1	0.529412	1	0.0
Stops 3		2.5	13.0	0.0	0.8			Stops 3		0.483871	0	0	0.8
Stops 4		2.0	6.0	1.0	0.8			Stops 4		0.645161	0.823529	1	0.8
Stops 5		1.8	6.0	0.0	0.5			Stops 5		0.709677	0.823529	0	0.5
Stops 6		1.5	6.0	0.0	0.8			Stops 6		0.806452	0.823529	0	0.8
Stops 7		4.0	9.0	1.0	0.3			Stops 7		0	0.470588	1	0.3
Stops 8		3.0	4.5	1.0	1.0			Stops 8		0.322581	1	1	1.0
SW	1.5	0.9	2.5	2	1.8	1.5	4	3	**Alc to NURS-2076**				
RS	9.75	8.5	13	6	6	6	9	4.5	**SW**	**2**	**lower=worse(<2m=1,>=2m=0)**		
PF	0	1	0	1	0	0	1	1	**RS**	**7**	**lower=worse(<7m=1,>=7m=0)**		
OAP	0.5	0	0.8333	0.8333	0.5	0.8333	0.333333	1					
									Max	4.0	13.0		
									Min	0.9	4.5	Higher=Best	



Mean 30 Minute Data									
	Land Use Suitability[L]						Land Use Suitability[L]		
Stops		Available Space for infracture Development	Proximity to sensitivity land use(School+Hospital)			Stops		Available Space for infracture Development	Proximity to sensitivity land use(School+Hospital)
Stops 1		2.75	1			Stops 1		0.5416667	1
Stops 2		1.50	1	Normalizing		Stops 2		0.75	1
Stops 3		6.00	1			Stops 3		0	1
Stops 4		2.75	1			Stops 4		0.5416667	1
Stops 5		0.00	1			Stops 5		1	1
Stops 6		0.00	1			Stops 6		1	1
Stops 7		2.00	1			Stops 7		0.6666667	1
Stops 8		2.50	1			Stops 8		0.5833333	1
							Max	6.00	
							Min	0.00	Higher= Best



Mean 30 Minute Data

Stops	Demand Density[D]		
		Passenger count	Traffic Count
Stops 1		70	26
Stops 2		100	34
Stops 3		126	24
Stops 4		91	20
Stops 5		105	22
Stops 6		142	22
Stops 7		96	22
Stops 8		55	16

Normalizing

Stops	Demand Density[D]		
		Passenger count	Traffic Count
Stops 1		0.17	0.56
Stops 2		0.52	1.00
Stops 3		0.82	0.44
Stops 4		0.41	0.22
Stops 5		0.57	0.33
Stops 6		1.00	0.33
Stops 7		0.47	0.33
Stops 8		0.00	0.00
	Max	142	34
	Min	55	16

APPENDIX F: Conflict Severity Index (CSI) of all Criteria.

Conflict Severity Index(CSI)								
	Crash Frequency	Observed Traffic Conflict		Pedistrian Exposure	Driverf Behvaiour Issue		Total	**Safety(S)**
Local Weight	**0.13887220**	**0.243148984**		**0.31939642**	**0.298582399**			**0.325735395**
Stops	No. of Crash Observed	Near Miss(V-V & V-P)	Sudden Braking	Boarding + Alighting	Sudden Lane Change	Horn Usage		
Stops 1	0	0.060787246	0.050291606	0.074525831	0.076298739	0.0959247	0.357828084	**0.116557273**
Stops 2	0	0.086575775	0.109329579	0.106465473	0.145984921	0.1756367	0.623992452	**0.203256428**
Stops 3	0	0.004605094	0.00262391	0.393922249	0.028993521	0.0121595	0.442304238	**0.144074146**
Stops 4	0	0	0.006559775	0.173893605	0	0.0148616	0.195314947	**0.063620992**
Stops 5	0	0.229333701	0.232653344	0.298103323	0.282305335	0.2945292	1.336924948	**0.435483776**
Stops 6	0	0.243148984	0.243148984	0.319396418	0.298582399	0.2985824	1.402859184	**0.456960891**
Stops 7	0	0.012894264	0	0.157332309	0.039166686	0	0.20939326	**0.068206796**
Stops 8	0	0.022104453	0.027988372	0	0.072738131	0.0553931	0.178224071	**0.058053888**

	Mean Dwell Time	Waiting Length	Stop Distance from Formal Stop	Stop Distance from Intersection	Total	**Traffic Impact(T)**
Local Weight	**0.15152755**	**0.27535597**	**0.27158470**	**0.30153178**		**0.187956244**
Stops						
Stops 1	0.026915794	0.110142386	0.082964518	0.290363935	0.510386633	**0.095930355**
Stops 2	0	0.110142386	0.011345575	0.234524717	0.356012678	**0.066914806**
Stops 3	0.056497942	0.110142386	0.173729119	0.268028248	0.608397694	**0.114352146**
Stops 4	0.010034661	0	0.085800912	0.111678437	0.20751401	**0.039003554**
Stops 5	0.130112649	0.08260679	0.028363938	0.301531779	0.542615155	**0.101987907**
Stops 6	0.151527552	0.275355965	0	0.279196092	0.706079609	**0.132712071**
Stops 7	0.030561125	0.165213579	0.267330113	0.067007062	0.530111879	**0.099637838**
Stops 8	0.09925311	0.055071193	0.271584704	0	0.425909007	**0.080052257**

	Side Walk Width	Road Cross-section	Pedistrian Facilities(Crosswalk)	Obstruction On Approach Path	Total	**Accessibility(A)**
Local Weight	**0.35069571**	**0.10262797**	**0.22020681**	**0.32646951**		**0.237672694**
Stops						
Stops 1	0.282819123	0.039240105	0	0.163234754	0.485293982	**0.115341128**
Stops 2	0.350695713	0.054332453	0.220206812	0	0.625234978	**0.148601281**
Stops 3	0.169691474	0	0	0.272047041	0.441738515	**0.104989183**
Stops 4	0.226255299	0.084517149	0.220206812	0.272047041	0.803026301	**0.190857424**
Stops 5	0.248880828	0.084517149	0	0.163234754	0.496632732	**0.118036039**
Stops 6	0.282819123	0.084517149	0	0.272047041	0.639383314	**0.151963954**
Stops 7	0	0.048295514	0.220206812	0.108823169	0.377325495	**0.089679967**
Stops 8	0.113127649	0.102627967	0.220206812	0.326469508	0.762431936	**0.181209252**

	Available Space for infracture Development	Proximity to sensitivity land use(School+Hospital)	Total	**Land Use Suitability[L]**
Local Weight	**0.57291667**	**0.42708333**		**0.151164872**
Stops				
Stops 1	0.310329861	0.427083333	0.737413194	**0.111470971**
Stops 2	0.429687500	0.427083333	0.856770833	**0.129513653**
Stops 3	0.000000000	0.427083333	0.427083333	**0.064559997**
Stops 4	0.310329861	0.427083333	0.737413194	**0.111470971**
Stops 5	0.572916667	0.427083333	1.000000000	**0.151164872**
Stops 6	0.572916667	0.427083333	1.000000000	**0.151164872**
Stops 7	0.381944444	0.427083333	0.809027778	**0.122296581**
Stops 8	0.334201389	0.427083333	0.761284722	**0.115079508**

	Passenger count	Traffic Count	Total	**Demand Density[D]**
Local Weight	**0.62847222**	**0.37152778**		**0.097470795**
Stops				
Stops 1	0.108357280	0.206404321	0.314761601	**0.030680063**
Stops 2	0.325071839	0.371527778	0.696599617	**0.067898118**
Stops 3	0.512891124	0.165123457	0.678014581	**0.06608662**
Stops 4	0.260057471	0.082561728	0.342619200	**0.033395366**
Stops 5	0.361190932	0.123842593	0.485033525	**0.047276603**
Stops 6	0.628472222	0.123842593	0.752314815	**0.073328723**
Stops 7	0.296176564	0.123842593	0.420019157	**0.040939601**
Stops 8	0.000000000	0.000000000	0.000000000	**0.000000000**

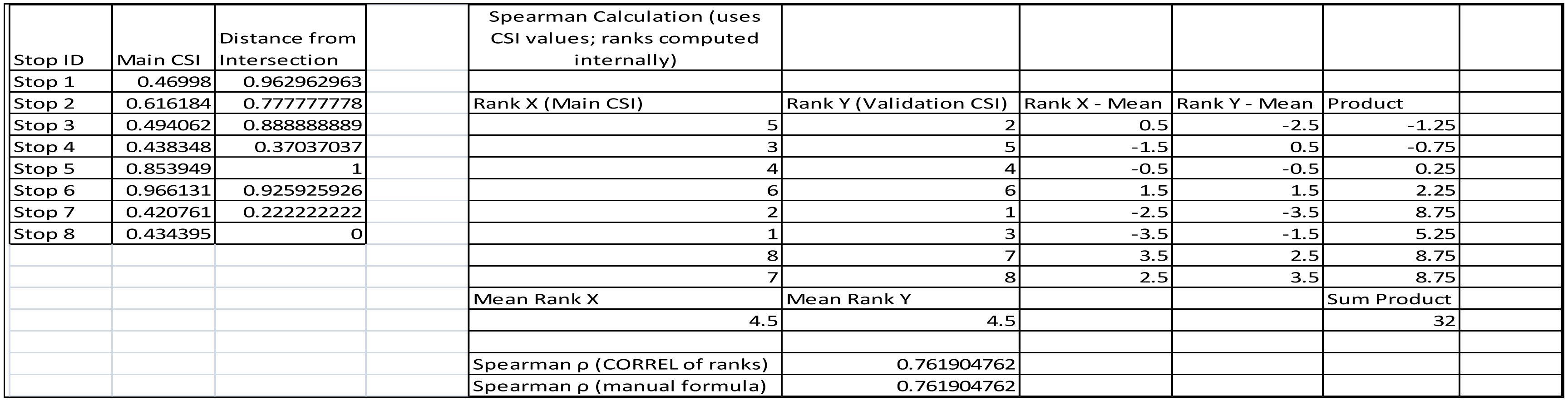
APPENDIX G: Complete Field Data Collection for Validation.

				P.mrng	offpeak	P.nght	Mean	P.mrng	offpeak	P.nght	Mean	P.mrng	offpeak	P.nght	Mean	P.mrng	offpeak	P.nght	Mean	P.mrng	offpeak	P.nght	Mean	P.mrng	offpeak	P.nght	Mean	P.mrng	offpeak	P.nght	Mean	P.mrng	offpeak	P.nght	Mean	Remarks
				10:24	1:04	4:36		10:07	12:36	4:07		9:19	1:46	5:33		9:42	2:19	5:07		10:09	2:50	6:03		10:37	3:16	6:42		10:57	2:10	6:08		10:36	2:31	5:46		
S.N	Main Criteria	Sub Criteria		Teku Pipalbot(Stop 1)				Teku Showroom(Stop 2)				Kalimati Chowk(Stop 3)				Kalimati Market(Stop 4)				Balkhu Wari(Stop 5)				Balkhu Pari(Stop 6)				Kritipur Trees(Stop 7)				Kritipur Gates(Stop 8)				
1	Safey(Conflict Score)[S]	Crash Frequency	No. of Crash Observed	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	0	0	0	**0**	
		Observed Traffic Conflict	Near Miss(V-V & V-P)	28	7	24	**20**	35	14	30	**26**	3	2	15	**7**	6	2	8	**5**	44	55	75	**58**	46	61	81	**63**	6	3	16	**8**	23	1	9	**11**	
			Sudden Braking	35	24	52	**37**	84	37	76	**66**	10	5	22	**12**	13	8	21	**14**	104	110	162	**125**	67	145	182	**131**	6	4	22	**11**	50	3	21	**25**	
		Pedistrian Exposure	Boarding + Alighting	64	25	57	**49**	66	37	60	**54**	76	73	187	**112**	79	54	73	**69**	109	69	90	**89**	91	68	130	**96**	55	46	96	**66**	57	22	23	**34**	
		Driverf Behvaiour Issue	Sudden Lane Change	48	34	69	**50**	89	64	84	**79**	14	11	62	**29**	18	12	20	**17**	113	121	185	**140**	71	165	198	**145**	7	18	77	**34**	91	17	34	**47**	
			Horn Usage	27	16	39	**27**	34	26	63	**41**	11	6	24	**14**	15	8	22	**15**	42	66	70	**59**	47	64	68	**60**	12	6	19	**12**	40	5	18	**21**	
2	Traffic Imapact(Disruption Severity)[T]	Dwell Time		1462	281	1011		480	342	510		1865	665	1380		550	315	370		1950	2700	2080		2100	2320	3435		415	495	1390		1807	1045	1395		
		Mean Dweel Time		73	23	48	**48**	17	16	26	**19**	124	51	63	**79**	39	26	26	**31**	115	225	139	**159**	162	193	181	**179**	30	41	87	**53**	129	95	155	**126**	
		Waiting Length		40				40				40				20				35				70				50				30				
		Stop Distance from Formal Stop		810				305				1450				830				425				225				2110				2140				
		Stop Distance from Intersection		10				35				20				90				5				15				110				140				
3	Accessibility(Walkability & Pedistrian Facilities)[A]	Side Walk Width		1.5				0.9				2.5				2				1.8				1.5				4				3				
		Road Cross-section		9.75				8.5				13				6				6				6				9				4.5				
		Pedistrian Facilities	Crosswalks & Signals	0				1				0				1				0				0				1				1				
		Obstruction On Approach Path	Presence of obstruction (parked vehicles,street vendors)	0.5	0.5	0.5	**0.5**	0	0	0	**0**	0.5	1	1	**0.83333**	0.5	1	1	**0.83333**	0	1	0.5	**0.500**	0.5	1	1	**0.83**	0	0.5	1	**0.50**	1	1	1	**1.00**	
4	Land Use Suitability[L]	Available Space for infracture Development		2.75				1.5				6				2.75				0				0				2				2.5				
		Proximity to sensitivity land use	School and Hospitals	1				1				1				1				1				1				1				1				
5	Demand Density[D]	Passenger count	Boarding + Alighting	64	25	57	**49**	66	37	60	**54**	76	73	187	**112**	79	54	73	**69**	109	69	90	**89**	91	68	130	**96**	55	46	96	**66**	57	22	23	**34**	
		Traffic Count	Veh/30min	20	12	21	**18**	28	22	20	**23**	15	13	22	**17**	14	12	14	**13**	17	12	15	**15**	13	12	19	**15**	14	12	16	**14**	14	11	9	**11**	

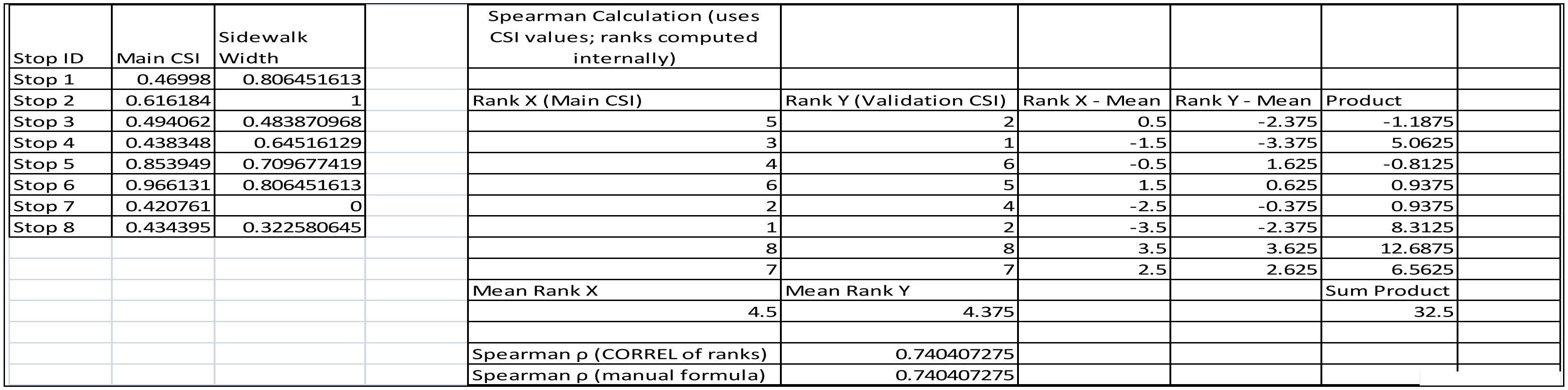
APPENDIX H: Variation of Field Data between Main and Validation taken at given specific period.

			Main	Valid	**% difference**	Main	Valid	**% differen**	Main	Valid	**% difference**	Main	Valid	**% difference**	Main	Valid	**% difference**	Main	Valid	**% difference**	Main	Valid	**% difference**	Main	Valid	**% difference**
			Stop 1	Stop 1		Stop 2	Stop 2		Stop 3	Stop 3		Stop 4	Stop 4		Stop 5	Stop 5		Stop 6	Stop 6		Stop 7	Stop 7		Stop 8	Stop 8	
S.N	Main Criteria	Sub -criteria	Mean			Mean			Mean			Mean			Mean			Mean			Mean			Mean		
1	Safey(Conflict Score)[S]	No. of Crash Observed	0	0		0	0		0	0		0	0		0	0		0	0		0	0		0	0	
		Near Miss(V-V & V-P)	30	20	**35.2%**	40	26	**33.6%**	10	7	**33.3%**	8	5	**36.0%**	91	58	**36.5%**	96	63	**34.9%**	13	8	**35.9%**	16	11	**32.7%**
		Sudden Braking	54	37	**31.9%**	99	66	**33.9%**	18	12	**31.5%**	21	14	**33.3%**	193	125	**35.2%**	201	131	**34.8%**	16	11	**33.3%**	37	25	**33.9%**
		Boarding + Alighting	73	49	**33.3%**	82	54	**33.7%**	163	112	**31.3%**	101	69	**32.0%**	136	89	**34.3%**	142	96	**32.2%**	96	66	**31.8%**	52	34	**34.6%**
		Sudden Lane Change	75	50	**33.2%**	121	79	**34.7%**	44	29	**34.6%**	25	17	**34.2%**	210	140	**33.6%**	221	145	**34.5%**	51	34	**33.3%**	73	47	**35.2%**
		Horn Usage	42	27	**34.9%**	62	41	**33.5%**	21	14	**35.9%**	22	15	**31.8%**	91	59	**34.8%**	92	60	**35.1%**	18	12	**32.7%**	32	21	**34.4%**
2	Traffic Imapact(Disruption Severity)[T]	Mean Dweel Time	49	48	**2.1%**	20	19	**4.7%**	81	79	**2.1%**	31	31	**1.5%**	160	159	**0.5%**	183	179	**2.5%**	53	53	**1.1%**	127	126	**0.5%**
		Waiting Length	49	40		40	40		40	40		20	20		35	35		70	70		50	50		30	30	
		Stop Distance from Formal Stop	810	810		305	305		1450	1450		830	830		425	425		225	225		2110	2110		2140	2140	
		Stop Distance from Intersection	10	10		35	35		20	20		90	90		5	5		15	15		110	110		140	140	
3	Accessibility(Walkability & Pedistrian Facilities)[A]	Side Walk Width	1.5	1.5		0.9	0.9		2.5	2.5		2	2		1.8	1.8		1.5	1.5		4	4		3	3	
		Road Cross-section	9.75	9.75		8.5	8.5		13	13		6	6		6	6		6	6		9	9		4.5	4.5	
		Pedistrian Facilities (Crosswalks / Signals)	0	0		1	1		0	0		1	1		0	0		0	0		1	1		1	1	
		Presence of obstruction(parked vehicles,street vendors)	0.5	0.5	**0.0%**	0	0	**0.0%**	0.83	0.83	**0.0%**	0.83	0.83	**0.0%**	0.5	0.5	**0.0%**	0.83	0.83	**0.0%**	0.5	0.333	**33.4%**	1	1	**0.0%**
4	Land Use Suitability[L]	Available Space for infracture Development	2.75	2.75		1.5	1.5		6	6		2.75	2.75		0	0		0	0		2	2		2.5	2.5	
		Proximity to sensitivity land use(School and Hospitals)	1	1		1	1		1	1		1	1		1	1		1	1		1	1		1	1	
5	Demand Density[D]	Passenger count(B+A)	73	49	**33.3%**	82	54	**33.7%**	163	112	**31.3%**	101	69	**32.0%**	136	89	**34.3%**	142	96	**32.2%**	96	66	**31.8%**	52	34	**34.6%**
		Traffic Count(Veh/rec time)	26	18	**32.9%**	34	23	**31.4%**	25	17	**32.4%**	20	13	**33.3%**	22	15	**32.3%**	22	15	**33.3%**	21	14	**34.4%**	17	11	**33.3%**

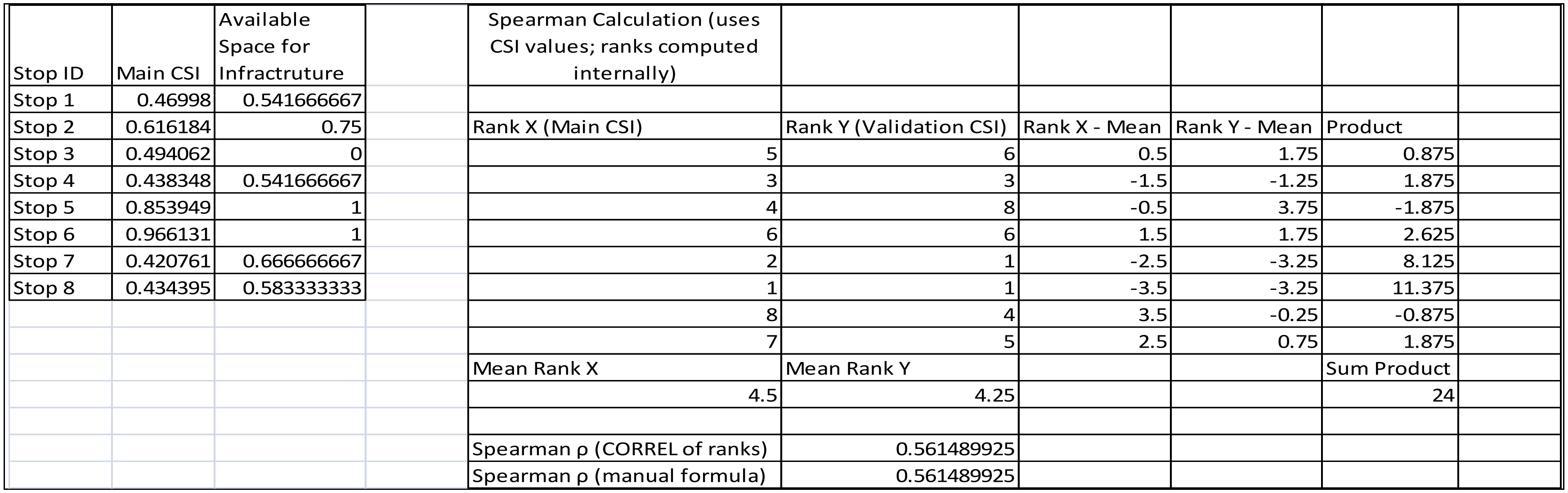
APPENDIX I: Spearman Correlation was performed between final CSI values and selected raw field data (Pedestrian Exposure, Distance from Intersection, Available Space for Infrastructure and Sidewalk Width).



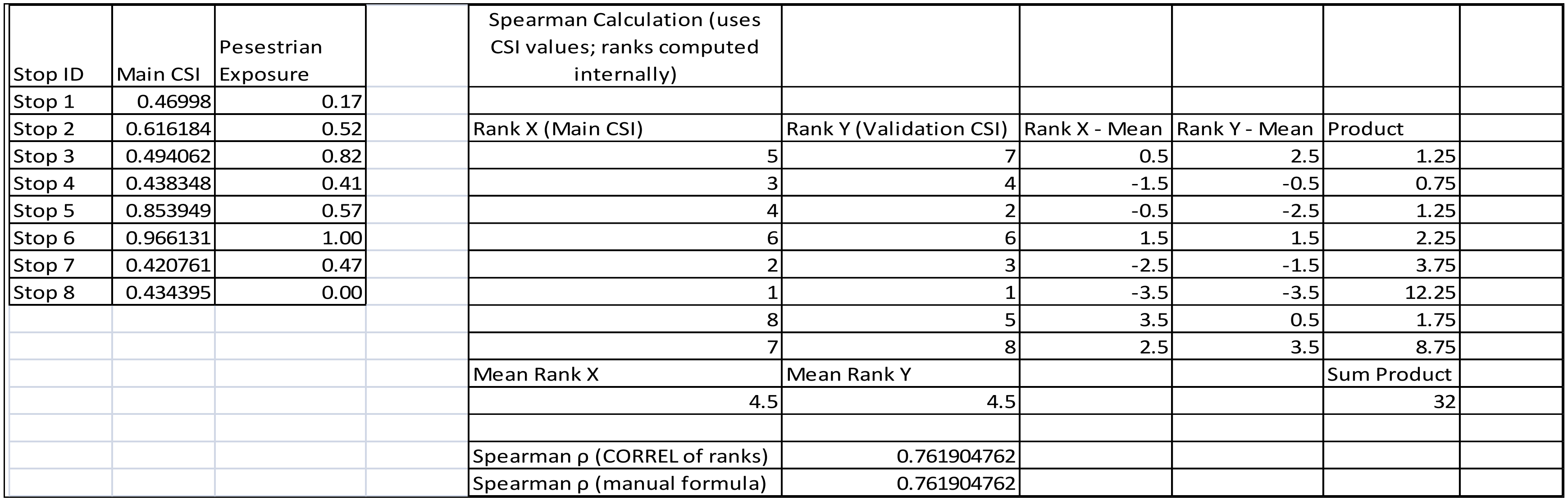
Stop ID	Main CSI	Distance from Intersection		Spearman Calculation (uses CSI values; ranks computed internally)					
Stop 1	0.46998	0.962962963							
Stop 2	0.616184	0.777777778		Rank X (Main CSI)	Rank Y (Validation CSI)	Rank X - Mean	Rank Y - Mean	Product	
Stop 3	0.494062	0.888888889		5	2	0.5	-2.5	-1.25	
Stop 4	0.438348	0.37037037		3	5	-1.5	0.5	-0.75	
Stop 5	0.853949	1		4	4	-0.5	-0.5	0.25	
Stop 6	0.966131	0.925925926		6	6	1.5	1.5	2.25	
Stop 7	0.420761	0.222222222		2	1	-2.5	-3.5	8.75	
Stop 8	0.434395	0		1	3	-3.5	-1.5	5.25	
				8	7	3.5	2.5	8.75	
				7	8	2.5	3.5	8.75	
				Mean Rank X	Mean Rank Y			Sum Product	
				4.5	4.5			32	
				Spearman ρ (CORREL of ranks)	0.761904762				
				Spearman ρ (manual formula)	0.761904762				



Stop ID	Main CSI	Sidewalk Width		Spearman Calculation (uses CSI values; ranks computed internally)					
Stop 1	0.46998	0.806451613							
Stop 2	0.616184	1		Rank X (Main CSI)	Rank Y (Validation CSI)	Rank X - Mean	Rank Y - Mean	Product	
Stop 3	0.494062	0.483870968		5	2	0.5	-2.375	-1.1875	
Stop 4	0.438348	0.64516129		3	1	-1.5	-3.375	5.0625	
Stop 5	0.853949	0.709677419		4	6	-0.5	1.625	-0.8125	
Stop 6	0.966131	0.806451613		6	5	1.5	0.625	0.9375	
Stop 7	0.420761	0		2	4	-2.5	-0.375	0.9375	
Stop 8	0.434395	0.322580645		1	2	-3.5	-2.375	8.3125	
				8	8	3.5	3.625	12.6875	
				7	7	2.5	2.625	6.5625	
				Mean Rank X	Mean Rank Y			Sum Product	
				4.5	4.375			32.5	
				Spearman ρ (CORREL of ranks)	0.740407275				
				Spearman ρ (manual formula)	0.740407275				

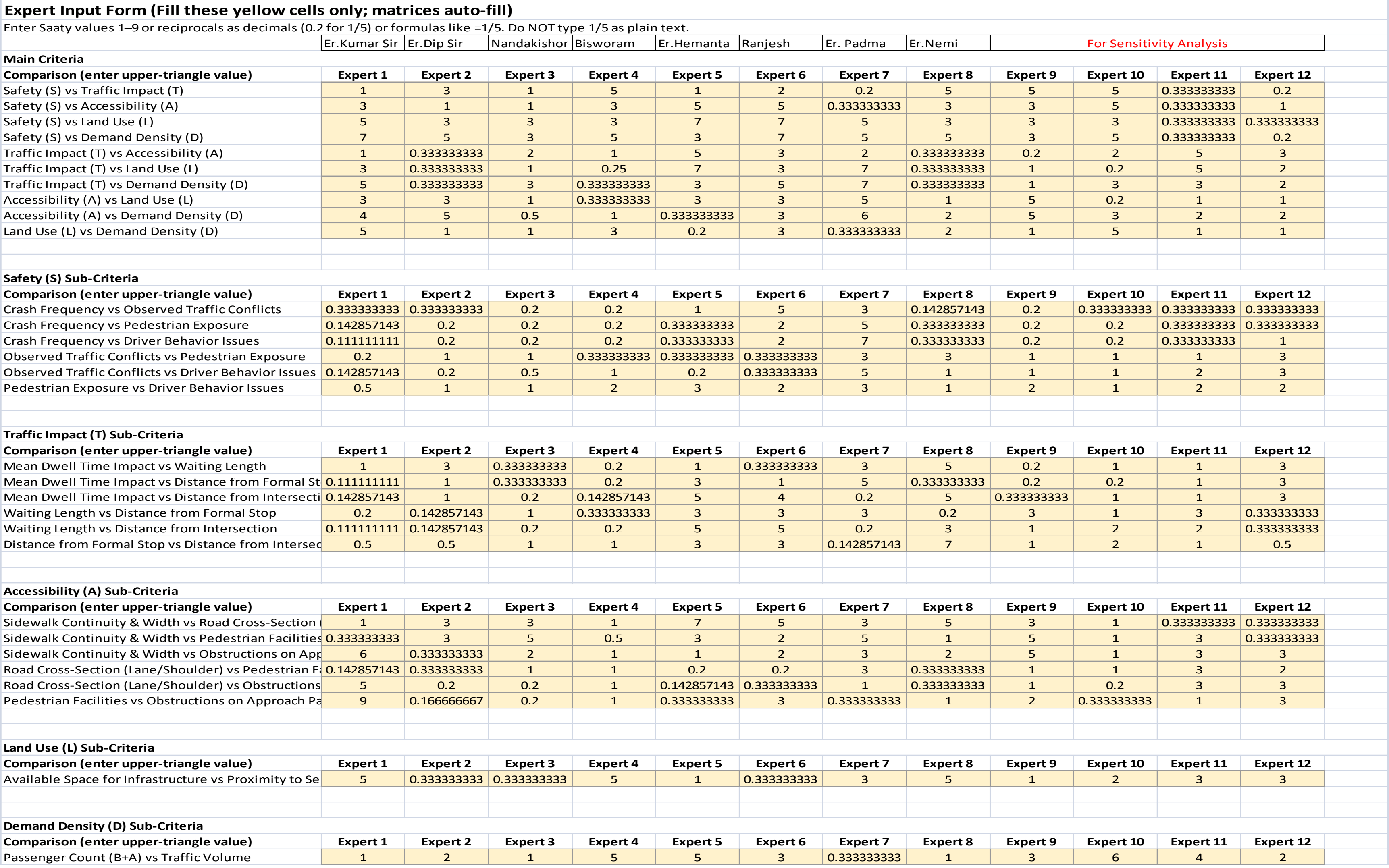


Stop ID	Main CSI	Available Space for Infractruture		Spearman Calculation (uses CSI values; ranks computed internally)					
Stop 1	0.46998	0.541666667							
Stop 2	0.616184	0.75		Rank X (Main CSI)	Rank Y (Validation CSI)	Rank X - Mean	Rank Y - Mean	Product	
Stop 3	0.494062	0		5	6	0.5	1.75	0.875	
Stop 4	0.438348	0.541666667		3	3	-1.5	-1.25	1.875	
Stop 5	0.853949	1		4	8	-0.5	3.75	-1.875	
Stop 6	0.966131	1		6	6	1.5	1.75	2.625	
Stop 7	0.420761	0.666666667		2	1	-2.5	-3.25	8.125	
Stop 8	0.434395	0.583333333		1	1	-3.5	-3.25	11.375	
				8	4	3.5	-0.25	-0.875	
				7	5	2.5	0.75	1.875	
				Mean Rank X	Mean Rank Y			Sum Product	
				4.5	4.25			24	
				Spearman ρ (CORREL of ranks)	0.561489925				
				Spearman ρ (manual formula)	0.561489925				



Stop ID	Main CSI	Pesestrian Exposure		Spearman Calculation (uses CSI values; ranks computed internally)					
Stop 1	0.46998	0.17							
Stop 2	0.616184	0.52		Rank X (Main CSI)	Rank Y (Validation CSI)	Rank X - Mean	Rank Y - Mean	Product	
Stop 3	0.494062	0.82		5	7	0.5	2.5	1.25	
Stop 4	0.438348	0.41		3	4	-1.5	-0.5	0.75	
Stop 5	0.853949	0.57		4	2	-0.5	-2.5	1.25	
Stop 6	0.966131	1.00		6	6	1.5	1.5	2.25	
Stop 7	0.420761	0.47		2	3	-2.5	-1.5	3.75	
Stop 8	0.434395	0.00		1	1	-3.5	-3.5	12.25	
				8	5	3.5	0.5	1.75	
				7	8	2.5	3.5	8.75	
				Mean Rank X	Mean Rank Y			Sum Product	
				4.5	4.5			32	
				Spearman ρ (CORREL of ranks)	0.761904762				
				Spearman ρ (manual formula)	0.761904762				

APPENDIX J: Expert Review inputs and AHP calculation outputs.



Expert Input Form (Fill these yellow cells only; matrices auto-fill)

Enter Saaty values 1–9 or reciprocals as decimals (0.2 for 1/5) or formulas like =1/5. Do NOT type 1/5 as plain text.

	Er.Kumar Sir	Er.Dip Sir	Nandakishor	Bisworam	Er.Hemanta	Ranjesh	Er. Padma	Er.Nemi	For Sensitivity Analysis			
Main Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Safety (S) vs Traffic Impact (T)	1	3	1	5	1	2	0.2	5	5	5	0.333333333	0.2
Safety (S) vs Accessibility (A)	3	1	1	3	5	5	0.333333333	3	3	5	0.333333333	1
Safety (S) vs Land Use (L)	5	3	3	3	7	7	5	3	3	3	0.333333333	0.333333333
Safety (S) vs Demand Density (D)	7	5	3	5	3	7	5	5	3	5	0.333333333	0.2
Traffic Impact (T) vs Accessibility (A)	1	0.333333333	2	1	5	3	2	0.333333333	0.2	2	5	3
Traffic Impact (T) vs Land Use (L)	3	0.333333333	1	0.25	7	3	7	0.333333333	1	0.2	5	2
Traffic Impact (T) vs Demand Density (D)	5	0.333333333	3	0.333333333	3	5	7	0.333333333	1	3	3	2
Accessibility (A) vs Land Use (L)	3	3	1	0.333333333	3	3	5	1	5	0.2	1	1
Accessibility (A) vs Demand Density (D)	4	5	0.5	1	0.333333333	3	6	2	5	3	2	2
Land Use (L) vs Demand Density (D)	5	1	1	3	0.2	3	0.333333333	2	1	5	1	1
Safety (S) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Crash Frequency vs Observed Traffic Conflicts	0.333333333	0.333333333	0.2	0.2	1	5	3	0.142857143	0.2	0.333333333	0.333333333	0.333333333
Crash Frequency vs Pedestrian Exposure	0.142857143	0.2	0.2	0.2	0.333333333	2	5	0.333333333	0.2	0.2	0.333333333	0.333333333
Crash Frequency vs Driver Behavior Issues	0.111111111	0.2	0.2	0.2	0.333333333	2	7	0.333333333	0.2	0.2	0.333333333	1
Observed Traffic Conflicts vs Pedestrian Exposure	0.2	1	1	0.333333333	0.333333333	0.333333333	3	3	1	1	1	3
Observed Traffic Conflicts vs Driver Behavior Issues	0.142857143	0.2	0.5	1	0.2	0.333333333	5	1	1	1	2	3
Pedestrian Exposure vs Driver Behavior Issues	0.5	1	1	2	3	2	3	1	2	1	2	2
Traffic Impact (T) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Mean Dwell Time Impact vs Waiting Length	1	3	0.333333333	0.2	1	0.333333333	3	5	0.2	1	1	3
Mean Dwell Time Impact vs Distance from Formal St	0.111111111	1	0.333333333	0.2	3	1	5	0.333333333	0.2	0.2	1	3
Mean Dwell Time Impact vs Distance from Intersecti	0.142857143	1	0.2	0.142857143	5	4	0.2	5	0.333333333	1	1	3
Waiting Length vs Distance from Formal Stop	0.2	0.142857143	1	0.333333333	3	3	3	0.2	3	1	3	0.333333333
Waiting Length vs Distance from Intersection	0.111111111	0.142857143	0.2	0.2	5	5	0.2	3	1	2	2	0.333333333
Distance from Formal Stop vs Distance from Intersec	0.5	0.5	1	1	3	3	0.142857143	7	1	2	1	0.5
Accessibility (A) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Sidewalk Continuity & Width vs Road Cross-Section (	1	3	3	1	7	5	3	5	3	1	0.333333333	0.333333333
Sidewalk Continuity & Width vs Pedestrian Facilities	0.333333333	3	5	0.5	3	2	5	1	5	1	3	0.333333333
Sidewalk Continuity & Width vs Obstructions on App	6	0.333333333	2	1	1	2	3	2	5	1	3	3
Road Cross-Section (Lane/Shoulder) vs Pedestrian Fa	0.142857143	0.333333333	1	1	0.2	0.2	3	0.333333333	1	1	3	2
Road Cross-Section (Lane/Shoulder) vs Obstructions	5	0.2	0.2	1	0.142857143	0.333333333	1	0.333333333	1	0.2	3	3
Pedestrian Facilities vs Obstructions on Approach Pa	9	0.166666667	0.2	1	0.333333333	3	0.333333333	1	2	0.333333333	1	3
Land Use (L) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Available Space for Infrastructure vs Proximity to Se	5	0.333333333	0.333333333	5	1	0.333333333	3	5	1	2	3	3
Demand Density (D) Sub-Criteria												
Comparison (enter upper-triangle value)	**Expert 1**	**Expert 2**	**Expert 3**	**Expert 4**	**Expert 5**	**Expert 6**	**Expert 7**	**Expert 8**	**Expert 9**	**Expert 10**	**Expert 11**	**Expert 12**
Passenger Count (B+A) vs Traffic Volume	1	2	1	5	5	3	0.333333333	1	3	6	4	2

Global Weights (Main × Sub-criteria)

Pulls averaged valid-expert weights from each AHP sheet and computes global weights.

Main Criterion	Main Weight	Sub-Criterion	Local Weight
Safety (S)	0.331696565	Crash Frequency	0.149251145
Safety (S)	0.331696565	Observed Traffic Conflicts	0.256031003
Safety (S)	0.331696565	Pedestrian Exposure	0.314134526
Safety (S)	0.331696565	Driver Behavior Issues	0.280583326
Traffic Impact (T)	0.240423982	Mean Dwell Time Impact	0.210038328
Traffic Impact (T)	0.240423982	Waiting Length	0.226534585
Traffic Impact (T)	0.240423982	Distance from Formal Stop	0.268621896
Traffic Impact (T)	0.240423982	Distance from Intersection	0.29480519
Accessibility (A)	0.18370157	Sidewalk Continuity & Width	0.339907592
Accessibility (A)	0.18370157	Road Cross-Section (Lane/Shoulder)	0.18239662
Accessibility (A)	0.18370157	Pedestrian Facilities	0.227505986
Accessibility (A)	0.18370157	Obstructions on Approach Path	0.250189802
Land Use (L)	0.14152865	Available Space for Infrastructure	0.597222222
Land Use (L)	0.14152865	Proximity to Sensitive Land Uses	0.402777778
Demand Density (D)	0.102649233	Passenger Count (B+A)	0.658928571
Demand Density (D)	0.102649233	Traffic Volume	0.341071429