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Comprehensive Safety Assessment and Improvement Strategies for the Satdobato-Budhanilkantha Corridor in Kathmandu Valley, Nepal

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Abstract

This study evaluates road safety conditions along Kathmandu's critical 17.7 km Satdobato-Budhanilkantha corridor, where infrastructure deficiencies contribute to high accident rates. Using GIS mapping and field surveys, we have identified severe shortcomings: only 47% of footpaths have tactile paving, 1 of 53 zebra crossings remains visible, and just 12 of 32 bus stops have proper laybys. Our findings reveal how inadequate signage, hazardous parking, and poor pedestrian facilities elevate crash risks. We propose targeted interventions including signal upgrades, crossing improvements, and optimised signage to enhance safety in this vital urban artery.

Keywords: Road safety, Crash, GIS mapping

1. Background

Nepal's transportation system remains overwhelmingly dependent on road networks, due to limited air and rail alternatives this heavy reliance has exacerbated road safety challenges, particularly along critical corridors like the Satdobato-Budhanilkantha route connecting Kathmandu and Lalitpur districts, which experiences severe mixed-traffic conflicts, inadequate pedestrian infrastructure (meeting only 12% of WHO safety standards; WHO, 2022), and dangerous traffic conditions. The corridor's safety deficiencies mirror national trends where road crashes consume 1.85% of GDP annually (Tiwari & Rizal, 2023), compounded by insufficient parking and poor traffic management, resulting in pedestrians comprising 42% of fatalities (Nepal Police, 2023). This study investigates these systemic failures through engineering assessments of this high-risk urban artery.

2. Literature Review

Road safety remains a critical challenge in Nepal, with recent data highlighting the severity of the issue. According to the Nepal Demographic and Health Survey (NDHS, 2022), the country records approximately 4,000 road fatalities annually, equivalent to 14 deaths per 100,000 population. Further data from the Nepal Police (2023) reveals 5,960 reported traffic accidents in the fiscal year 2022–23, though under reporting suggests the actual figures may be higher. These alarming statistics are exacerbated by inadequate infrastructure, with only 25% of Nepal's 100,000 km road network meeting basic safety standards (Department of Roads, 2023).

Studies specific to the Kathmandu Valley have identified numerous infrastructural deficiencies contributing to road accidents. Shrestha et al. (2021) documented poor pedestrian infrastructure, including faded zebra crossings and missing tactile paving, alongside malfunctioning traffic signals and insufficient signage.

Three critical factors significantly influence road user safety: (1) traffic sign visibility, (2) parking management, and (3) zebra crossing adequacy. Poorly planned roadside parking creates hazardous conditions and disrupts traffic flow, exacerbating existing transportation system challenges (Persia et al., 2016). The persistent demand for parking spaces remains a fundamental challenge for urban transportation networks, as adequate parking facilities constitute essential component of effective traffic system design (Singh, 2017). Traditional parking planning approaches that prioritize abundant, free parking at all destinations - aiming to maximize supply while minimizing

cost - have proven ineffective in modern urban contexts (ADB, 2020). Research demonstrates that roads with higher Annual Average Daily Traffic (AADT) volumes experience greater accident frequency and severity per kilometer, particularly when combined with inadequate signage (International Road Federation [IRF], 2006). The IRF (2006) study provides compelling evidence that proper traffic sign implementation can reduce accidents by 41%, as demonstrated in UK road networks.

Additionally, unregulated parking and roadside encroachments further compromise safety. The International Road Federation (2006) demonstrated that proper signage implementation can reduce accidents by 41%, a finding particularly relevant to Nepal, where Marasini (2004) linked poor traffic management to congestion and heightened risks.

The economic impact of road crashes adds another layer of urgency. Research by Tiwari and Rizal (2023) found that crash costs in Kathmandu Valley nearly offset transportation sector profits, underscoring the need for targeted infrastructure investments. While Nepal's Road Safety Audit Manual (2016) and Traffic Sign Manual (2016) provide theoretical guidelines, inconsistent implementation remains a barrier to progress.

Recent studies offer potential solutions. Dhakal and Tiwari (2023) demonstrated the effectiveness of intersection optimization, while Tiwari (2023) outlined systemic reforms, including legal measures and capacity building, to enhance safety. However, gaps persist in localized assessments of high-risk corridors, GIS-based spatial analysis, and studies on pedestrian-vehicle interactions. This study addresses these gaps by employing geospatial methods to evaluate the Satdobato-Budhanilkantha route, aligning with WHO (2022) recommendations for urban road safety assessments.

3. Objectives

This study aims to assess road safety conditions along Kathmandu's Satdobato-Budhanilkantha corridor through field surveys and geospatial analysis, identifying critical gaps in pedestrian infrastructure, traffic signage, and parking management. By evaluating compliance with national and international safety standards, it proposes targeted interventions—such as improved crossings, optimized signage, and better parking enforcement—to reduce accidents. The findings will provide a practical framework for enhancing urban road safety in similar developing contexts while supporting data-driven infrastructure upgrades.

4. Study Area

The study route spans a total length of 17.7 km, with 5.7 km passing through Lalitpur district (inside the Ring Road) and the remaining 12 km through Kathmandu district (outside the Ring Road). The route traverses key business centers, including Sundhara and Ratnapark, and accommodates all modes of transportation available in the Kathmandu Valley. The study covers six distinct sections: Satdobato to Lagankhel, Lagankhel to Pulchowk, Pulchowk to Sundhara, Sundhara to Ranipokhari (a one-way segment), Ranipokhari to Maharajgunj, and Maharajgunj to Budhanilkantha. Each segment varies in infrastructure and traffic characteristics, influencing overall route functionality.

Figure 1. Study map

5. Methodology

The study area was selected on the basis of the fact that the route connects the inside as well as the outside of the ring road and also connects major commercial areas. The route is divided into 6 segments based on key factors such as cycle lane availability, parking spaces, one-way road sections, speed limits, and carriageway width.

Field surveys were conducted along the study route to collect safety-related data using SW Maps from 2081/09/12 to 2081/10/01, a mobile mapping application that recorded precise geographic coordinates (latitude and longitude) along with dimensional attributes such as length and width of various infrastructure elements. The survey specifically documented bridge dimensions (length and width), footpath characteristics (including width, surface condition, and type), cycle lane conditions, bus stop locations with details about layby availability, and observed parking spaces. All collected spatial data was subsequently processed and mapped using ArcGIS software for comprehensive analysis and visualization of the route's safety features.

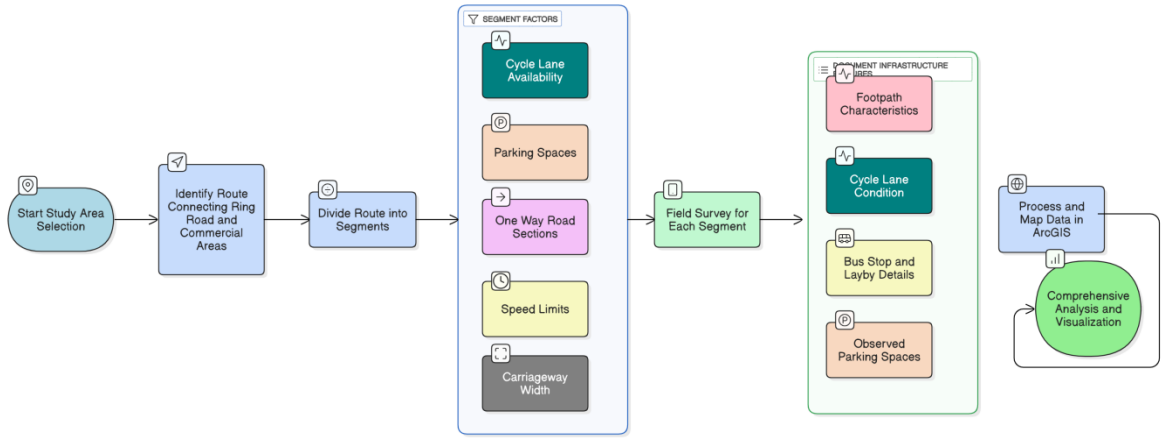


Figure 2. Flowchart of the methodology

6. Findings

6.1 Satdobato to Lagankhel

The Satdobato intersection experiences significant traffic congestion, an average daily traffic of **65723** (Department of Roads, 2022/2023) relying entirely on traffic police due to malfunctioning pedestrian countdown signals and traffic lights. Although tactile paving exists, footpath conditions are poor with noticeable potholes, creating accessibility challenges for visually impaired pedestrians. Zebra crossings require repainting as most have faded. All the information, regulatory and warning signs are adequately placed in appropriate numbers throughout this section.

6.2 Lagankhel to Pulchowk

During the period of survey, this section lacked proper intersection signage and functional pedestrian countdown signals. While footpaths are adequately wide for pedestrian, the width was measured to be 3.5m comfort, zebra crossings are poorly maintained. Street lighting is evenly spaced, but parking management is problematic. Kumaripati has designated taxi parking but no dedicated motorcycle spaces, leading to frequent violations in no-parking zones.

6.3 Pulchowk to Sundhara

Thapathali intersection is well-equipped with functioning signals and traffic police presence. The section features adequate footpaths and painted cycle lanes, though zebra crossing quality is inferior to other sections. Other intersections lack essential safety elements. All regulatory, informative and mandatory traffic signs are inadequate and improperly placed according to standards, particularly near schools and hospitals. Footpath width varies significantly, exceeding 2.5m at locations like Alka Hospital.

6.4 Sundhara to Ranipokhari (One-way Section)

This section contains traffic signs but lacks traffic signals or presence of police personals. No formal intersections exist. Footpaths are of adequate width but lack tactile paving and show poor maintenance. Signage is inadequate and non-compliant with standard Traffic Sign Manual issued by the Government of Nepal, especially near critical areas like schools and hospitals.

6.5 Ranipokhari to Maharajgunj

Ongoing footpath construction on the left side showed no progress over a 15-day observation period from 2081/09/12 to 2081/10/01. Zebra crossings exist but are not properly visible. Street lighting spacing is appropriate for nighttime visibility, but footpaths lack tactile paving. Traffic signage remains insufficient and improperly placed according to regulatory standards.

6.6 Maharajgunj to Budhanilka ntha

Zebra crossings are nearly obliterated, and footpaths contain hazardous potholes without tactile paving. Traffic signage is both inadequate and non-compliant with placement standards, particularly near schools, hospitals, and crossings.

6.7 Overall Findings

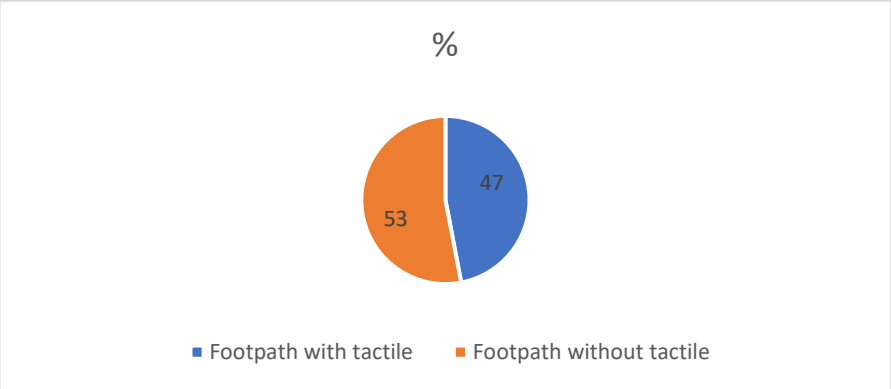
The comprehensive survey of the 17.7 km Satdobato-Budhanilkantha route revealed multiple critical infrastructure deficiencies compromising road safety. Traffic control measures proved inadequate, with only 84 signs observed along the entire corridor, including a severe shortage of diversion (6) and speed limit signs, while some sections lacked even these basic requirements. Pedestrian infrastructure was particularly deficient, with poorly maintained footpaths and dangerously inadequate crossings - of 53 zebra crossings documented, only the Thapathali intersection crossing remained fully visible, while 6 were deteriorated beyond functionality. This situation creates exceptional hazards near schools and hospitals where pedestrian crossings are scarcest. Bridge crossings presented additional challenges, with average crossing times of 2.25 minutes recorded at three major bridges (Satdobato, Labim Mall, and Ratnapark) regardless of pedestrian demographics or carried loads. Public transport infrastructure showed similar shortcomings, with only 12 of 32 observed bus stops featuring proper laybys. 14 Bus stops were observed in Lalitpur district other 18 in Kathmandu district along the study route.

Figure 3. Map of designated parking areas along the route

Parking management was equally problematic, with just 4 designated parking areas (Lagankhel, Ratnapark, Bir Hospital vicinity, and Kumaripati) contrasted against 11 unauthorized parking zones. While most basic traffic elements were physically present, their poor maintenance and uneven distribution significantly undermine functionality, particularly regarding nighttime safety due to inconsistent street lighting spacing. These systemic

deficiencies directly contribute to elevated crash risks along the corridor, with variation in infrastructure quality between sections creating unpredictable traffic conditions. The findings underscore an urgent need for comprehensive infrastructure upgrades to address these multilayered safety challenges in Kathmandu's critical transport artery.

The assessment revealed significant gaps in accessible infrastructure, with tactile paving present on only 47% of footpaths, leaving 53% without this critical feature for visually impaired pedestrians.



Intersection safety measures proved equally inadequate - among the 26 intersections along the route only Thapathali featured properly functioning pedestrian countdown signals, clearly visible crossings, and consistent traffic police presence. Field observations identified particularly dangerous pedestrian behaviors such as not using crossings and footpaths for locomotion stemming from poor infrastructure design. Numerous instances were documented of pedestrians crossing immediately in front of stopped buses after disembarking, creating blind spots where approaching vehicles in the same direction became invisible. This hazardous behavior appears directly linked to two design flaws:

- Placement of crosswalks on the far-side of bus loading zones
- Location of bus stops at the nearside of intersections

These conditions force pedestrians to make unsafe crossing decisions and significantly increase collision risks, particularly during peak hours when traffic volumes are highest. The findings underscore the urgent need for pedestrian infrastructure redesign that incorporates universal accessibility features and follows established safety principles for transit stop placement relative to crossings.

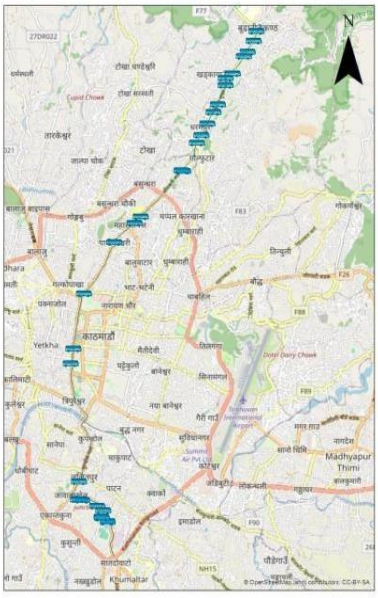


Figure 4. Bus Stops located in the study route

Figure 5. Traffic Signs Along the study route

7. Recommended Safety Measures

Based on the field findings and in accordance with Nepal's Traffic Sign Manual and Road Safety Audit Manual (Department of Roads, 2016), this study proposes the following evidence-based interventions to improve road safety.

- Installation of three-phase traffic signals with dedicated U-turn phases at major intersections to improve traffic flow and reduce congestion
- Immediate repainting of all zebra crossings using high-visibility, durable thermoplastic materials meeting WHO (2022) standards
- Complete restoration of tactile paving along all footpaths, particularly near schools and hospitals in all the sections,

7.1 Traffic Control Measures:

To enhance road safety and compliance with traffic regulations, a strategic installation of 72 standardized signs in accordance with the Traffic Sign Manual. This includes 9 regulatory signs (such as stop, yield, and priority signs), 41 warning signs (for curves, pedestrian crossings, and school zones), and 22 informational signs (providing directions and distances). These upgrades will improve clarity, enforce traffic rules, and ensure safer navigation for all road users.

7.2 Policy Recommendations

To improve road infrastructure and ensure safer transportation, several key measures should be implemented. First, regular maintenance programs must be established to keep roads in optimal condition. Second, proper parking zones should be designated and enforced to prevent congestion and hazards. Bus stops should be relocated to safer locations with adequate laybys to enhance passenger safety and traffic flow. Lastly, adequate street lighting should be installed at uniform intervals to improve visibility and security for all road users. These steps will collectively enhance road safety, efficiency, and overall infrastructure quality. These recommendations incorporate global best practices (IRF, 2018) and align with Nepal's road safety commitments. When implemented, these measures can significantly enhance pedestrian safety and traffic management along the corridor.

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