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Performance Evaluation of Exclusive Bus Lane System with Signal Priority using Simulation-based Analysis - A Case Study of a Section in Kathmandu-Bhaktapur Route

by

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The undersigned certify that they have read, and recommended to the Institute of Engineering for acceptance, a thesis entitled "**Performance Evaluation of Exclusive Bus Lane System with Signal Priority using Simulation-based Analysis - A Case Study of a Section in Kathmandu-Bhaktapur Route**" submitted by Mr. **Samrat Acharya** in partial fulfillment of the requirements for the degree of Master in Transportation Engineering.

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ABSTRACT

In developing cities with heterogeneous traffic and limited road space, such as Kathmandu, urban roads are becoming highly congested, especially the major corridors like the Kathmandu-Bhaktapur Road. This study aims to examine whether exclusive bus lanes and signal priority system can be effectively implemented in such an environment. To achieve this, a microsimulation model in PTV VISSIM was developed replicating existing traffic conditions on which various scenarios involving exclusive bus lanes and signal priority were simulated and performance indicators like queue length and travel time were analyzed. Introduction of exclusive bus lanes prioritizes public transport by providing separate lane, thereby reducing queues and travel time significantly, but it heavily penalizes general traffic by amplifying the queues and travel time in the normal lanes. Signal priority when used with exclusive bus lanes delivers the most consistent results across every approach. It preserves the major improvements for public transportation by eliminating queues to minimal level while also softening the negative impact on normal lanes. Travel time for public transport follows similar pattern and delivers the greatest improvement in both directions when exclusive bus lane is used in conjunction with signal priority, resulting a reduction of 20-32%. In contrast, travel time for other vehicles in normal lanes remains relatively stable across both approaches during evening peak hour. However, during morning peak hour, travel time drops by 13% in Tinkune-Lokanthali approach and increases by 67% in Lokanthali-Tinkune approach.

Hence, this study highlights the effectiveness of exclusive bus lane system with signal priority for the Kathmandu-Bhaktapur Road. It offers a comparatively improved balance between public transport priority and general traffic performance delivering the greatest travel time savings and lowest queue length for public transport while imposing less severe adverse impacts on other vehicles during both morning and evening peak hours.

Keywords: Exclusive Bus Lane, Signal Priority, Public Transportation Priority, Kathmandu-Bhaktapur Route, Simulation, VISSIM

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LIST OF ABBREVIATIONS

BRT	Bus Rapid Transit
BSP	Bus Signal Priority
EBL	Exclusive Bus Lane
GE	Green Extension
GEH	Geoffrey E. Havers
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
Km	Kilometer
KSUTP	Kathmandu Sustainable Urban Transport Project
m	Meter
MRT	Mass Rapid Transit
NRS	Nepal Road Standard
ODOT	Oregon Department of Transportation
PCU	Passenger Car Unit
PT	Public Transportation
RBC	Ring Barrier Controller
RMSNE	Root Mean Squared Normalized Error
RT	Red Truncation
s	Seconds
TSP	Transit Signal Priority
w.r.t	with respect to

CHAPTER 1: INTRODUCTION

1.1 Background

The rapid growth of urban populations worldwide has led to a surge in private vehicle ownership, presenting significant challenges for cities trying to maintain efficient and sustainable transportation systems. This increasing reliance on private vehicles stresses existing road infrastructure, creating chronic traffic congestion, especially at peak hours. This congestion results in longer commute times, reduced productivity, and increased delay and queue length in intersection, and higher fuel consumption, negatively impacting both the economy and the environment. Overdependence on private vehicles also disadvantages those who cannot afford or are unable to drive, limiting their access to employment, education, and essential services.

Public transport plays a crucial role in addressing urban mobility challenges, such as traffic congestion, air pollution, and energy consumption. They can transport a large number of passengers efficiently, reducing the overall number of vehicles on the roads and the associated environmental and economic costs.

The road traffic in Kathmandu valley has increased at a very steep rate in the recent past, from 1.4 million vehicles plying on the roads of valley to 1.75 million in just a span of year, according to Kathmandu valley Traffic Police Office (Kandel et al., 2023). Chronic congestion resulting in long, unpleasant, oppressive traffic jam in Kathmandu valley affects the residents in all aspects of life. Since the condition of traffic congestion in Kathmandu valley is being bad day by day, there is discussion over safe, sustainable and reliable transportation systems.

However, urban transportation systems in Kathmandu face significant challenges in providing efficient and reliable public transportation services. Rapid urbanization, growing private vehicle ownership, and lack of dedicated infrastructure for public transportation have contributed to persistent traffic congestion, excessive commute times, and a decline in the overall attractiveness of public transportation services. Addressing these issues is crucial for promoting sustainable and equitable mobility in Kathmandu valley.

By focusing on infrastructure upgrades like introduction of Mass Rapid Transit (MRT), Bus Rapid Transit (BRT), integration of multimodal transportation system, intelligent transportation system, the policy makers can create a more efficient, reliable, and sustainable public transport system. Nevertheless, these enhancements are expensive, and there is a need for finding alternative solutions to the problem. One approach is to make better use of existing road space by increasing its passenger-carrying capacity rather than its vehicle capacity. This can be achieved by dedicating lanes exclusively for buses, enabling them to operate more efficiently (Arasan & Vedagiri, 2009). In turn, this allows more people to be transported using fewer vehicles, which helps to ease the traffic congestion.

Many cities in the world have implemented the provision of exclusive bus lanes to prioritize bus movements and improve the performance and service reliability of public transportation systems. Additionally, signal priority measures, which give priority to public transport vehicles at traffic signals, can further enhance bus operations by reducing delays at intersections (Dumbliauskas et al., 2017). The integration of these two strategies has shown potential benefits in alleviating urban traffic congestion and enhancing transit service (Furth & Halawani, 2018). Exclusive bus lanes allow buses to bypass general traffic, while signal priority ensures that buses receive preferential treatment at signalized intersections, reducing delays and improving travel times. However, the implementation of these measures requires a thorough understanding of the local transportation dynamics, challenges, and potential impacts.

1.2 Problem Statement

One of the prevalent complaints among Kathmandu's residents is increased traffic congestion. Chronic congestion affects people residing in every nook and corner of Kathmndu valley on a daily basis. The long, unpleasant, oppressive traffic jam in Kathmandu affects people on every aspect of life.

Under heterogeneous traffic conditions, buses experience difficulty maneuvering through mixed traffic due to their relatively larger size. Frequent acceleration and deceleration reduce operating speeds and passenger comfort, leading to increased delay and travel time, which ultimately decreases the attractiveness of public transport (Arasan

& Vedagiri, 2009). Since traffic conditions in Kathmandu are also highly heterogeneous, buses operating within the valley experience similar operational difficulties.

The Kathmandu-Bhaktapur route is around 13 Km in length and is used by more than 68000 passengers on normal days and more than 56000 passengers on public holidays; but the service offered is not reliable and systematic and needs to be upgraded (Kandel et al., 2023).

In this context, with the aim to improve the reliability of this route and promote the use of public transport, a pilot project, Express Bus Service was officially inaugurated in September 21, 2023 A.D. Under the service, 25 regular buses with over 40 seats were operated on a separate red-marked lane in the peak hours from 9am to 11am, and 4pm to 6pm, while ambulances, police vans, fire brigades and other emergency vehicles were allowed to use this express lane, with access restricted for private vehicles. To support the operation of this express bus, Department of Roads painted red patches every 200 meters on road sections at a cost of over Rs 10 million (*Public Buses Get Fast Lane on Ratnapark-Suryabinayak Road*, n.d.).

However, the project was halted within a month before any significant changes was observed. The limited buses operating on this lane, multiple intersection of this lane with the other traffic lanes, lack of awareness among people, inaugurated in a hurry without the proper infrastructures and lack of prior studies and research might be some of the reasons behind its failure.

While the study on the various solutions to promote urban mobility in context of Kathmandu valley have been carried out previously, the performance evaluation of exclusive bus lanes and signal priority has received less attention.

With these backgrounds and problems stated, it is imperative that there is a need to understand the combined effects of these two strategies on bus operations, general traffic, and overall system performance and move one step forward towards achieving the solution of congestion, and increasing the attractiveness of public transportation in Kathmandu valley and hence reducing the dependency on private vehicles.

1.3 Objective of Study

The main objective of the study is to evaluate the performance of an exclusive bus lane with signal priority using simulation-based analysis. Specifically, this study aims to:

1. Develop a simulation model that accurately represents the characteristics of the study area including lane configuration, signal control, and mixed traffic conditions.
2. Assess the impacts of the exclusive bus lane and signal priority on travel time and queue length.

1.4 Scope of Study

This study aimed to conduct a detail analysis of performance of exclusive bus lane system within 1.75 km section of Kathmandu-Bhaktapur route from Tinkune to Lokanthali. Simulation-based technique was used for the study using simulation software, PTV VISSIM, which enabled us to model and test the various scenarios and evaluate the results.

1.5 Significance of Study

The findings of this study would contribute to the understanding of the potential benefits of implementing exclusive bus lanes with signal priority, particularly in the context of Kathmandu-Bhaktapur route. The results can inform policymakers and urban planners, providing evidence-based recommendations in developing effective public transport strategies that prioritize bus operations while minimizing the impact on general traffic. Similarly, enhancing bus systems through EBLs and BSP can lead to better urban mobility, increased attractiveness towards public transport hence reducing the impact of congestion and improved quality of life for residents of Kathmandu valley. Moreover, the simulation-based approach can be applied to other case studies, providing a framework for evaluating similar transportation interventions.

1.6 Organization of Thesis

This thesis consists of following chapters:

CHAPTER 1: **Introduction** describes about the background, problem statement, objectives, scope and significance of the study.

CHAPTER 2: **Literature Review** discusses the available literature in the study area regarding the performance evaluation of exclusive bus lanes with bus signal priority and simulation techniques in transportation studies.

CHAPTER 3: **Research Methodology** provides a detailed description of the overall research approach and methodology adopted in this study. This chapter explains the selection of study area, data collections procedures, data processing, model formation and analysis procedures to address the research objectives.

CHAPTER 4: **Result and Analysis** provides a detailed analysis of collected data, outcomes of the study and their interpretations.

CHAPTER 5: **Conclusion and Recommendation** provides summary of the whole study, its limitations and recommendation for further works.

Finally, the **References** and **APPENDIX** are also attached at the end of this thesis.

CHAPTER 2: LITERATURE REVIEW

2.1 General

Existing studies indicate potential interventions that may enhance service quality within urban transport systems, including exclusive bus lanes (EBLs) and bus signal priority (BSP). Due to the complex interactions between buses and general traffic in various situations, simulation-based analyses play an important role. This review thus focuses on studies that examined the influence of EBLs and BSP systems on travel times, general traffic flow and the balance between bus and general traffic performance. This review also evaluates the strengths and weaknesses of simulation models and data collection methods used for such studies previously and eventually help to define the methodology for a case study on the Kathmandu-Bhaktapur corridor.

2.2 Heterogenous Traffic and its Charactersists

Heterogeneous traffic refers to a traffic stream composed of vehicles with diverse characteristics, unlike homogeneous traffic which assumes similar vehicle types and behaviors. These characteristics include:

- **Static Characteristics:** These are time-invariant properties such as vehicle size (length, width, height), weight, engine power, and acceleration/deceleration capabilities. The presence of a wide range of vehicle types, from motorcycles and bicycles to large buses and trucks, significantly impacts traffic flow dynamics.

- **Dynamic Characteristics:** These are time-varying properties such as speed, maneuverability, and driver behavior. In heterogeneous traffic, vehicles exhibit diverse speeds and acceleration/deceleration patterns, leading to complex interactions and weaving maneuvers. The lack of strict lane discipline, common in many developing countries like ours, further complicates the flow dynamics.

2.3 Concept of Exclusive Bus Lane (EBL) and its Significance

Exclusive bus lanes (EBLs), also known as dedicated bus lanes or bus-only lanes, are sections of roadways reserved solely for the use of buses and, sometimes, other high-occupancy vehicles (HOVs) like taxis or carpools. The core concept is to provide buses with a dedicated right-of-way, separating them from general traffic improving the efficiency and reliability of the public bus service by minimizing delays caused by mixed traffic. By reducing delays and improving efficiency, EBLs aim to make bus travel more attractive to commuters, potentially leading to a modal shift from private vehicles to public transport.

2.3.1 Types of Exclusive Bus Lanes

There are several types of exclusive bus lanes, primarily differentiated by their location within the roadway.

a. Curbside Bus Lanes:

These are the most common type of EBL, typically located on either side of the roadway adjacent to the curb which allows buses to conveniently enter and exit the lane at bus stops, but it can sometimes interfere with general traffic turning left or accessing side streets (Zhu et al., 2012). This study also highlights that curbside lane, while improving bus speeds, can create bottlenecks if not carefully designed, particularly at intersections where cars merge into and out of the bus lane. The effectiveness of curbside lanes is also influenced by the type of lane markings (solid or dashed lines), with solid lines indicating strict bus-only access and dashed lines allowing other vehicles to enter under certain conditions (Kim, 2003).

b. Median Bus Lanes:

These lanes are located in the median or center of the roadway, separating bus traffic from traffic in both directions. This configuration minimizes interference with general traffic, but it requires dedicated access and exit points for buses, often involving ramps or special signal phasing (Zhu et al., 2012). This study states that median bus lanes can significantly improve bus speeds and reduce overall travel times, but they may require more complex infrastructure and careful planning to avoid creating congestion at access points.

c. Contra-flow Bus Lanes:

Contra-flow bus lanes are another type of EBL. These lanes operate in the opposite direction of general traffic, often implemented on freeways or multi-lane roads during off-peak hours to provide faster bus transit. The feasibility of contra-flow lanes depends on factors like traffic volume, road geometry, and safety considerations.

d. Dynamically Activated Exclusive Bus Lanes:

Dynamically activated exclusive bus lanes are not always physically separated but are designated as bus-only lanes during certain times or under specific traffic conditions using technology like sensors and adaptive traffic signal control (Khakimov & Tanaka, 2024). This type of lane offers flexibility in allocating road space based on real-time traffic demands.

2.3.2 Criteria for Setting up Exclusive Bus Lanes

The conditions of setting an exclusive bus lane includes:

a. Geometric conditions on the road

There should be at least two lanes in each direction on the road, and it is better if there are three or four lanes (Lu, 2003). Considering the needed space for bus vehicles, the width of a bus lane usually equals 3.5 meters, which can be appropriately reduced but should be at least 3 meters (Lu, 2003; Yang, 2003).

b. Traffic saturation level on the road

It is necessary to deploy an exclusive bus lane when the volume-to-capacity ratio on a road arrives at or exceeds the value of 0.8 (Zhang et al., 2003).

c. Bus volume on the road section

It is suggested to build an exclusive bus lane if bus volume on a road section in peak hours is higher than 150 vehicles per hour (Yang, 2003).

d. Public transit passenger volume on the road section

The Highway Capacity Manual (Council & others, 2000) suggests that passenger volume on a bus lane should be 50 percent higher than that on other lanes, and this value should be more than 3,000 person-trips per hour on the bus lane (Lin et al., 2015).

2.3.3 Case Studies of Exclusive Bus Lane in Different Cities

The study in the various cities about the impact of exclusive bus lane includes:

- **Chennai, India:** A study by Arasan & Vedagiri (2009) focused on the impact of EBLs under highly heterogeneous traffic conditions using a simulation model called HETEROSIM. This study analyzed the effects on bus speeds, travel times, and modal shift, considering different road widths and traffic volumes. Their findings indicated that the introduction of EBLs could lead to a reduction in the speed of other motor vehicles due to the consequent reduction in road space, but ultimately improved overall traffic flow by facilitating faster bus movement.

- **Tashkent, Uzbekistan:** A study by Khakimov & Tanaka (2024) used PTV VISSIM to simulate the impact of EBLs on a broader traffic network, incorporating a binary logistic model to predict modal shift from cars to buses. The simulation showed a 37% reduction in bus travel time on designated streets but no improvement on other roads. A modal shift analysis of this study suggested that approximately 33% of car users might switch to buses. The study also highlighted the impact of EBLs on intersection permeability and resulting congestion.

- **Beijing, China:** A study by Zhu et al. (2012) simulated the impact of EBLs on an expressway using VISSIM, comparing curbside and median bus lane scenarios, considering factors like bus stop design, ramp control, and bus route adjustments. Results of this study indicated improved bus speeds and travel times but also highlighted potential congestion in certain areas.

- **Seoul, Korea:** A study reviewed the performance of EBLs in Seoul, focusing on bus speeds, trip circulation rates, and modal share changes (Kim, 2003). This study found positive impacts on bus speeds but also discussed challenges in warranting EBLs based on bus volume and the need for improved enforcement and lane markings.

2.3.4 Benefits of Exclusive Bus Lanes

- **Improved Bus Speeds and Reliability:** EBLs significantly reduce bus travel times and improve service reliability by separating buses from general traffic congestion.
- **Increased Bus Ridership:** Improved bus service reliability and reduced travel times can lead to increased ridership, potentially shifting commuters from private vehicles to public transport.
- **Reduced Congestion (in some cases):** While some studies show potential for increased congestion in certain areas, others suggest that EBLs can improve overall network efficiency and reduce congestion, particularly during peak hours.
- **Environmental Benefits:** Increased bus ridership and reduced travel times can lead to lower fuel consumption and reduced emissions.

2.3.5 Challenges in Enforcement and Public Acceptance

- **Enforcement:** Illegal use of EBLs by unauthorized vehicles is a major challenge. Effective enforcement mechanisms, including clear signage, markings, and penalties for violations, are crucial for the success of EBLs. The Seoul study highlights the importance of solid lane markings to deter illegal use (Kim, 2003).
- **Public Acceptance:** Introducing EBLs can lead to reduced road space for general traffic, potentially causing frustration among drivers. Public awareness campaigns and clear communication about the benefits of EBLs are essential for gaining public acceptance. The Tashkent study showed that while EBLs improved bus travel times, they also led to increased congestion for other vehicles in some areas (Khakimov & Tanaka, 2024), highlighting the need for careful planning and public engagement.
- **Intersection Management:** The interaction between EBLs and intersections can create congestion if not properly managed. The Beijing study explored different scenarios, including median bus lanes requiring dedicated ramps, which can impact traffic flow (Zhu et al., 2012). The Tashkent study also highlighted the

impact of EBLs on intersection permeability and the resulting congestion (Khakimov & Tanaka, 2024).

- **Bus Stop Design:** Efficient bus stop design is crucial to minimize dwell times and avoid queue spillback into general traffic. The Chennai study considered bus stop spacing and dwell times in its analysis (Arasan & Vedagiri, 2009).

2.3.6 Implications in Context of Nepal

While EBLs offer significant benefits for bus transit and potentially overall traffic efficiency. The effectiveness of EBLs is highly context-dependent and requires tailored solutions for specific urban environments.

Jha (2023) argues that implementing a BRT system, which includes EBLs, can significantly alleviate traffic congestion in Kathmandu valley. The study emphasizes that BRT can serve city to establish rapid, safe, comfortable, equitable, efficient, sustainable, economical, and efficient modern mass transit system that can ensure carry of a high number of passengers.

Similarly, the implementation of EBLs has been recognized as a practical strategy to improve bus operations, particularly in urban areas with high congestion levels. According to Lin et al. (2015), EBLs can effectively reduce bus travel time at local arterials without significantly negatively impacting the overall traffic network. This is particularly relevant for Kathmandu valley, where traffic congestion is a major challenge, and the introduction of EBLs could lead to improved public transport efficiency.

2.4 Concept of Bus Signal Priority and its Significance

Bus Signal Priority (BSP), also known as Transit Signal Priority (TSP), is a traffic management strategy aimed at reducing bus delays at signalized intersections. The core concept is to adjust the normal traffic signal timing to give buses preferential treatment, allowing them to proceed through intersections more quickly than other vehicles, thereby reducing delays and improving service reliability. This preferential treatment can involve various techniques, as detailed below. The ultimate goal is to improve bus speed and reliability, making bus transit a more attractive and efficient mode of transportation, potentially leading to a modal shift from private vehicles to public transport. BSP is particularly relevant in heterogeneous traffic conditions, where buses often experience significant delays due to interactions with slower-moving vehicles.

2.4.1 Bus Signal Priority Strategies

There are mainly two Strategies through which the Bus signal priority is given,

a. Passive Priority

This approach uses pre-timed signal plans optimized to favor buses based on predicted or scheduled bus arrivals. It doesn't involve real-time detection of buses. One example is area-wide signal timing plans designed to facilitate bus progression along an arterial. However, passive priority may not be effective under highly variable traffic conditions or when bus schedules are not strictly adhered to.

b. Active Priority

This approach uses real-time detection of approaching buses to dynamically adjust signal timings. When a bus is detected approaching an intersection, the signal controller implements one or more of the following strategies:

- **Green Extension (GE)**: The green light for the bus's approach is extended, allowing the bus to pass through the intersection before the light turns red.
- **Red Truncation (RT)**: The red light for the cross-street is shortened, allowing the bus to proceed sooner.
- **Phase Insertion**: An additional phase is inserted into the signal cycle specifically for buses.
- **Conditional Priority**: Priority is granted only under certain conditions, such as when a bus is significantly behind schedule or when the intersection is not heavily congested. This approach aims to minimize negative impacts on general traffic.
- **Unconditional Priority**: Priority is always given to the bus, regardless of traffic conditions. This can lead to significant delays for other vehicles.

The choice of BSP strategy depends on various factors, including traffic volume, bus frequency, intersection geometry, and the desired balance between bus priority and general traffic flow. The studies show that simulation models like PTV VISSIM are frequently used to evaluate the effectiveness of different BSP strategies under various scenarios. Studies also mention the use of VisVAP (Visual Vehicle Actuated Programming) and Ring Barrier Controller (RBC) within VISSIM for simulating active priority strategies with Green Extension and Red Truncation (Lin et al., 2015).

2.4.2 Technologies Used in Conjunction with BSP

Implementing BSP systems requires several technologies:

- **Bus Detection Systems:** These systems detect the presence and location of approaching buses. Common technologies include inductive loop detectors embedded in the roadway, video image processing, and GPS tracking of buses.
- **Communication Networks:** These networks transmit real-time bus location data from detection systems to the traffic signal controllers. Wireless communication technologies are often used.
- **Advanced Traffic Signal Controllers:** These controllers receive bus location data and adjust signal timings based on pre-programmed algorithms or real-time optimization strategies. The controllers may incorporate sophisticated logic to handle multiple bus arrivals and prioritize buses based on various criteria.

2.4.3 Effectiveness of BSP in Improving Bus Efficiency

The effectiveness of BSP in improving bus efficiency varies depending on several factors, including the specific strategy employed, traffic conditions, and the quality of implementation. However, studies consistently show that BSP can lead to:

a. Reduced Bus Travel Times

By reducing delays at intersections, BSP significantly improves bus travel times. Studies using simulation models often report reductions in bus travel time ranging from 19% to over 20%. The study by Syed et al. (2016) evaluated various bus priority strategies using VISSIM simulation and found that implementing BSP significantly reduced delays for buses, especially during peak traffic hours. This aligns with the study by Dumbliauskas et al. (2017), who emphasizes that active bus priority measures, such as green time extension and stage skipping, can significantly reduce public transport delays by up to 60% without causing substantial adverse impacts on general traffic delays.

b. Improved Bus Reliability

Reduced delays lead to more predictable and reliable bus schedules, making bus transit more attractive to commuters. Lin et al. (2015) provided a comprehensive review of TSP controls, categorizing them into passive and active priority methods. Active TSP systems utilize bus detection technologies to adjust signal timings dynamically, allowing for green time extensions or red truncations when buses approach intersections. This flexibility can significantly enhance bus travel times and reliability, as demonstrated in various studies across different cities.

c. Potential for Modal Shift

Improved bus service reliability and reduced travel times can encourage a modal shift from private vehicles to public transport. However, it's crucial to note that BSP can also have negative impacts on general traffic if not carefully implemented. Poorly designed BSP strategies can lead to increased delays for other vehicles, particularly on cross-streets. Therefore, careful planning, optimization, and consideration of the trade-offs between bus priority and general traffic flow are essential for successful BSP implementation. The use of simulation models helps to mitigate these risks by allowing for the evaluation of different strategies before implementation.

2.5 Exclusive Bus Lane System with Bus Signal Priority

There have been various studies suggesting that the bus signal priority when used in combination with EBLs, can be effective measures in enhancing the operational performance of public transportation. For instance, one of the studies demonstrated that the introduction of bus signal priority (BSP) in conjunction with EBLs led to a reduction in bus travel time by approximately 19% and average delays by 38% at signalized intersections (Rahmat et al., 2013). This aligns with findings from Khakimov & Tanaka (2024), who noted that exclusive bus lanes combined with signal priority could lead to a modal shift, encouraging more commuters to use public transport.

Similarly, Baalaganapathy et al. (2023) evaluated the effectiveness of bus signal priority (BSP) and dedicated bus lanes (DBL) in Chennai, India, using VISSIM simulation. Their study found that the combination of BSP and DBL resulted in a significant reduction in bus travel time and delays at signalized intersections, whereas the use of

DBL only resulted in reduction of travel time of buses in expense of increment in travel time of other modes.

Further, Chen et al. (2007) emphasized that exclusive bus lanes and transit signal priority (TSP) should be implemented simultaneously to effectively enhance the operational performance of BRT systems. This study highlighted that after the application of signal priority, the traffic flow status at intersections along the BRT route improved significantly, indicating the importance of integrating signal priority with EBLs for optimal performance.

The effectiveness of both EBLs and BSP is significantly influenced by the heterogeneity of the traffic. In highly heterogeneous traffic conditions (common in many developing countries), the challenges of implementing and enforcing both measures are greater, and the potential for negative impacts on general traffic is higher. The study by Baalaganapathy et al. (2023) emphasizes the need to account for this heterogeneity in simulation models and implementation strategies.

2.6 Simulation-Based Analysis in Transportation Studies

Simulation modeling is a powerful tool for evaluating the performance of transportation systems under various scenarios. These are categorized based on their level of detail and traffic characteristics modeled as shown in Table 2.1 below:

Table 2.1: Simulation Types and their Focus Area

Simulation Type	Focus Area	Best Used For	Example Software
Macroscopic	Aggregate flow (speed, volume, density)	Highway design, traffic forecasting, regional planning	PTV VISUM, TRANSCAD
Mesoscopic	Individual vehicles, but simplified interactions	Corridor analysis, congestion pricing, demand management	AIMSUN, DynusT, Dynameq
Microscopic	Individual driver behavior, detailed vehicle interactions	Signal optimization, bus lane analysis, pedestrian movement	PTV VISSIM, SUMO, AIMSUN Next, TransModeler
Hybrid (Multi-Resolution)	Combines multiple levels	Large urban networks, ITS, mixed-mode transport	AIMSUN Next, PTV VISSIM, Paramics

The significance of simulation software in transportation research lies in its ability to:

- **Model complex systems:** Simulations can accurately represent the intricate interactions between vehicles, infrastructure, and traffic control systems.
- **Test different scenarios:** Researchers can easily modify parameters and test various interventions without the cost and disruption of real-world implementation.
- **Predict outcomes:** Simulations provide quantitative predictions of the impact of different strategies on key performance indicators.
- **Optimize designs:** Simulation results can inform the design and optimization of transportation systems.

2.6.1 Simulation-Based Analysis using PTV VISSIM

PTV VISSIM, a widely used microscopic traffic simulation software, allows researchers to model complex traffic interactions and assess the impacts of different traffic management strategies.

Lin et al. (2015) emphasize the importance of simulation in evaluating TSP systems, noting that simulation tests can provide insights into the effectiveness of various priority strategies before their implementation in real-world settings.

Baalaganapathy et al. (2023) utilized VISSIM to compare the effectiveness of BSP and dedicated bus lanes, finding that the combination of both strategies yielded the best results in terms of reducing bus delays and improving overall traffic flow.

Similarly, Syed et al. (2016) utilized VISSIM to analyze various bus priority strategies and found that implementing BSP significantly reduced delays for buses, especially during peak traffic hours. This approach is particularly relevant for Kathmandu, where simulation can help predict the outcomes of proposed EBLs and signal priority systems before their implementation.

2.7 Current Scenario and Need for the Study

While there is a growing body of literature on EBLs and bus priority systems globally, research specific to Kathmandu valley remains limited. Kandel et al. (2023) highlighted the inefficiencies of the current public transport system in Kathmandu, characterized by severe congestion and delays. This study emphasizes the need for systematic upgrades to the public transport system to improve reliability and efficiency. The introduction of EBLs and BSP in Kathmandu could address these issues, as evidenced by successful implementations in other cities. For example, Arasan & Vedagiri (2010) demonstrated that EBLs could significantly improve bus service levels in heterogeneous traffic conditions. Similarly, the study by Sakamoto et al. (2007) on the effectiveness of bus priority lanes in Shizuoka City, Japan, showed that the implementation of bus priority systems led to improved travel times for buses and reduced congestion in general traffic lanes. Further, studies in cities like Guangzhou have shown that the combination of exclusive bus lanes and TSP can significantly improve bus travel speeds and reduce delays. (Lin et al., 2015)

2.8 Summary of Literature Review

Despite the promising findings from global studies, there is a notable lack of localized research focusing on the specific conditions and challenges faced by transport system in Kathmandu. Most existing studies have been conducted in improving the service quality and reliability of public transport. This research proposal aims to fill this gap by providing a simulation-based analysis of EBLs and BSP in a section Kathmandu-Bhaktapur route, contributing valuable insights for urban transport planning.

In conclusion, the literature review highlights the potential benefits of exclusive bus lanes and signal priority systems in improving public transport efficiency. The use of simulation modeling, particularly VISSIM, provides a robust framework for evaluating these strategies in the context of Kathmandu valley. By addressing the existing research gaps and focusing on localized conditions, this study aims to contribute valuable insights that can guide the implementation of effective public transport solutions in Kathmandu.

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Research Design

Taking into consideration from the above-mentioned context, the proposed research design for this study is shown in the Figure 3.1.

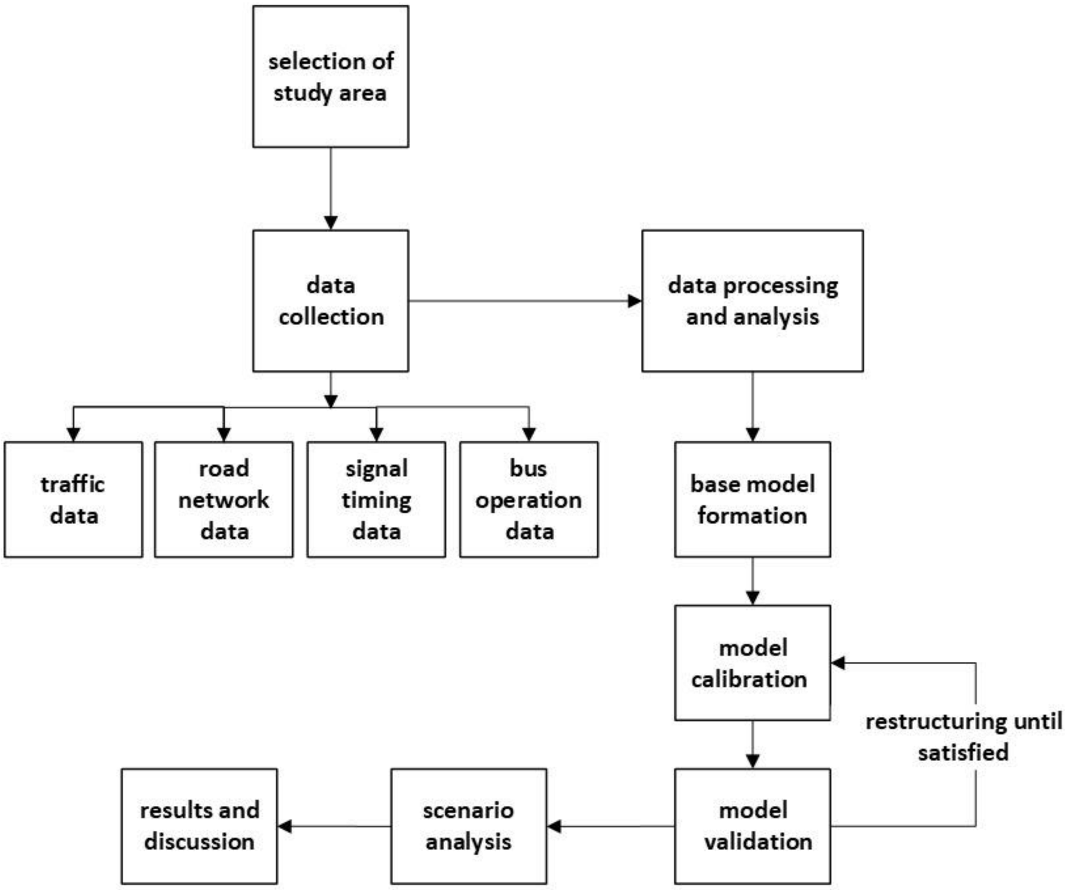


Figure 3.1: Research Methodology

This research adopts a quantitative approach, employing a simulation-based analysis to evaluate the performance of an exclusive bus lane system with signal priority in the section of Kathmandu-Bhaktapur route.

The major data required for the study are road network data, traffic data, signal timing data and public transport operational data.

3.2 Study Area Selection

One of the most vital and trafficked stretches of road in the Kathmandu valley, the Kathmandu-Bhaktapur Road, a section of Arniko Highway (NH34) (also a section of Asian Highway (AH42)) has served as an important artery connecting Kathmandu, Bhaktapur and the eastern parts of Nepal. The research aims to evaluate the performance of exclusive bus lanes with bus signal priority system in this stretch of road. This section of road consists of mixed traffic, has potential for improvement (as bus lane was previously implemented) and most importantly meets the general requirement for setting up an exclusive bus lane:

- **Geometric conditions on the road**: This section of road has 3 or more lanes in each direction with widths of 3.5 meters. Accordingly, the geometric structure of the Kathmandu-Bhaktapur route meets the physical requirements of deploying exclusive bus lanes as mentioned in Section 2.3.2 (a).
- **Traffic saturation level on the road:** According to the study by JICA (2024), in one of the major intersections of this section, Koteshwor intersection, the critical flow ratio is 2.938 and the critical v/c ratio is greater than 0.9 which exceeds the given threshold value mentioned in Section 2.3.2 (b).
- **Bus volume on the road section:** The data obtained from the traffic count shows the average public transportation volumes of 191 and 231 vehicles per hour during morning and evening peak hour respectively in both approaches as shown in Section 4.4. This indicate that the public transportation volume in the peak hours on this route is more than threshold limit of 150 vehicles per hour as mentioned in Section 2.3.2 (c).
- **Public transit passenger volume on the road section:** The route serves over 68,000 passengers on normal days and over 56,000 on holidays (Kandel et al., 2023). This high demand necessitates improvements to the system's efficiency and meets the general requirement mentioned in Section 2.3.2 (d).

So, for this study, about 1.75km stretch of Kathmandu-Bhaktapur route (i.e Ratnapark-Suryabinayak), between Tinkune and Lokanthali was considered which is the most congested section of the corridor where vehicle conflicts and intersection delays are most significant. Also, these intersections already have signal control system in place, with potential to support bus signal priority. The selected road section consists of 6 lanes, each with a lane width of 3.5m, split into a combination of at 3 and 3 lanes separated by a median. Figure 3.2 shows the general overview of the study area.

Figure 3.2: Study Area Location

Similarly, Figure 3.3 shows the general layout of study area that is modeled in VISSIM. The bus stops along the routes are indicated by red markers.

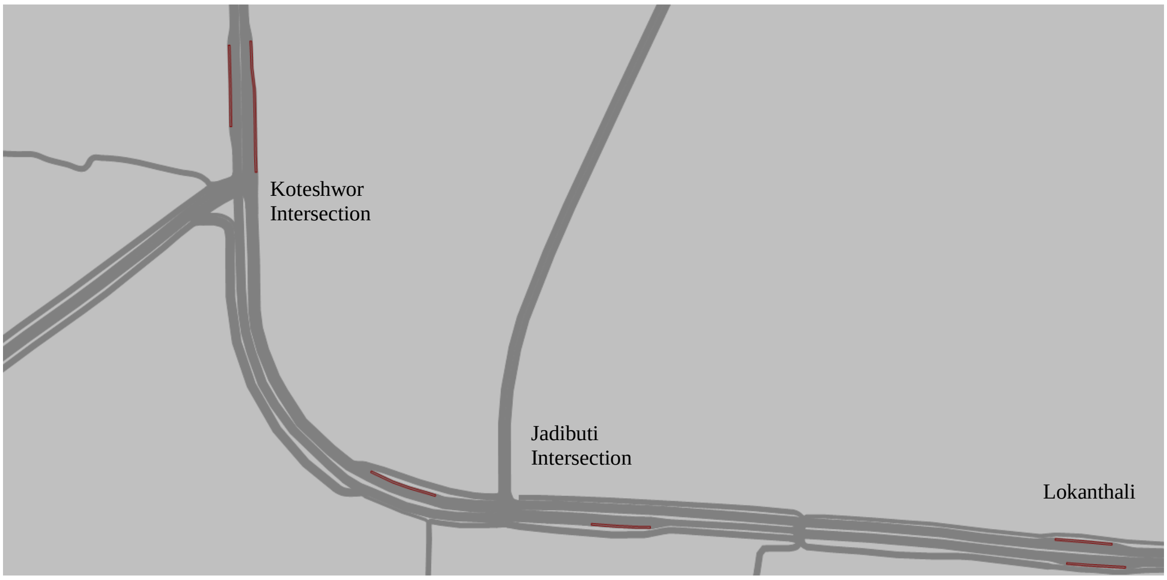


Figure 3.3: Study Area Model in VISSIM

3.3 Data Collection

Various data were collected during the study for the comprehensive development of simulation model.

3.3.1 Primary Data Collection

Primary data serves as the main source for this study. The following data were collected during this study.

3.3.1.1 Road Network Data

The detailed road geometry data of the selected section was collected. This includes road configuration, no. of lanes, lane width, intersection layout, bus stop location and layout. These data are required for setting up the model in simulation software. The general layout of the study area along with bus stop is shown in the Figure 3.4 below.

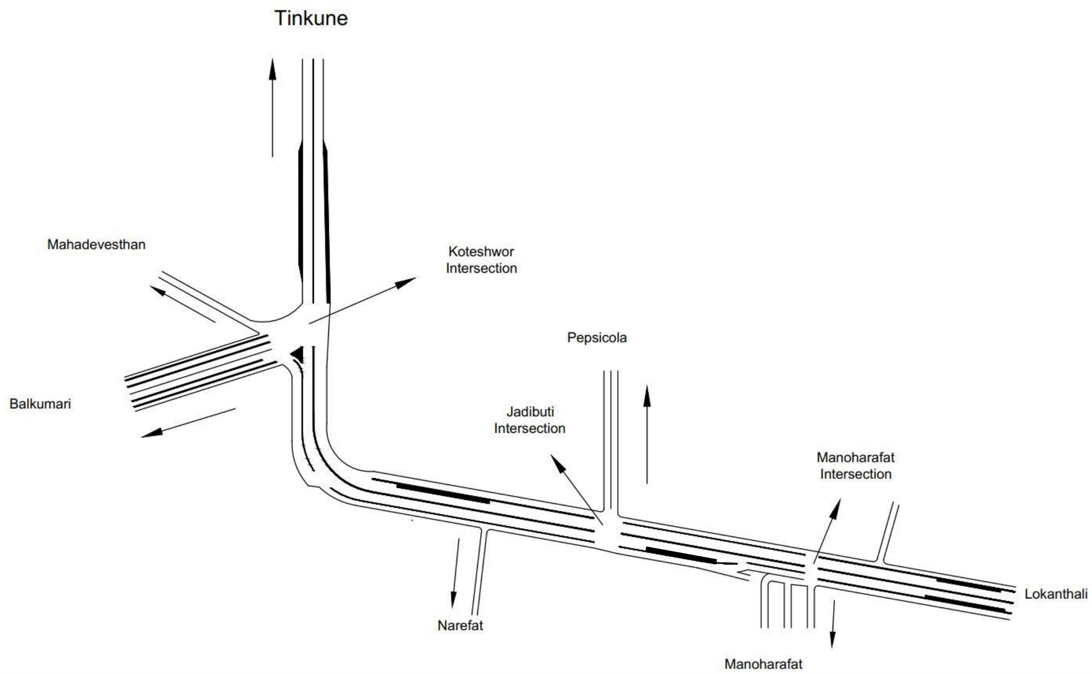


Figure 3.4: Study Area Road Network Layout

This road section consists of two major signalized intersection i.e. Koteshwor intersection and Jadibuti intersection as well as one minor unsignalized intersection i.e. Manoharafat intersection whose details are briefly explained below.

3.3.1.1.1 Koteshwor Intersection

Koteswor intersection is the major signalized intersection in this road section. Kathmandu-Bhaktapur route intersects with ring-road at this intersection. It has three major approaches, Tinkune, Balkumari and Jadibuti approach and one minor approach towards Mahadevsthan. The detailed layout of Koteshwor intersection along with the lane configuration is shown in the Figure 3.5 below.

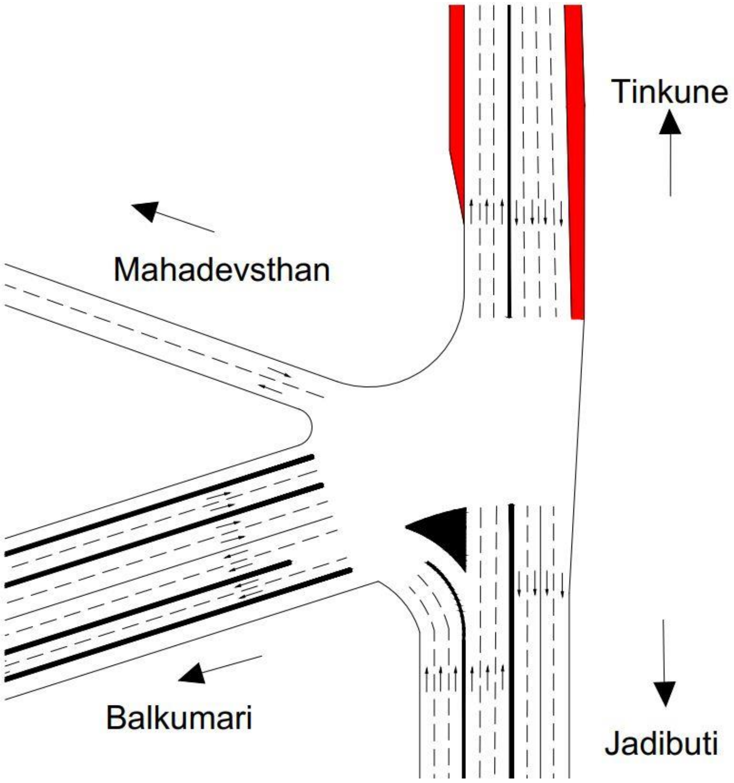


Figure 3.5: General Layout of Koteshwor intersection

3.3.1.1.2 Jadibuti Intersection

Jadibuti intersection is also a signalized intersection which has three major and one minor approach. Lokanthali and Koteshwor approach lie in Arniko highway whereas Pepsicola approach deviates perpendicular from the highway. The minor approach is towards the Narefat. The detailed layout of Jadibuti intersection with lane configuration is shown in the Figure 3.6 below.

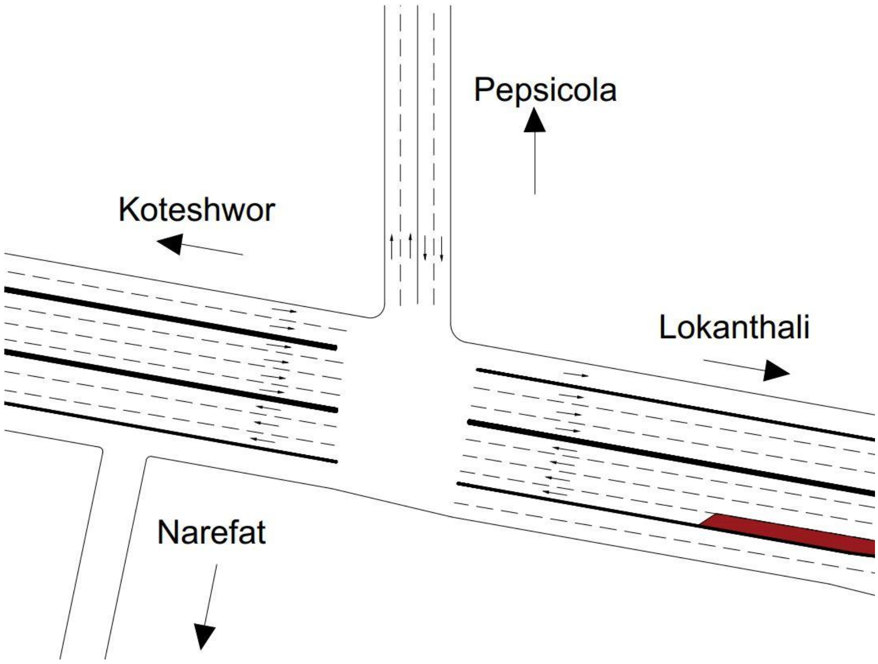


Figure 3.6: General Layout of Jadibuti intersection

3.3.1.1.3 Manoharafat Intersection

Manoharafat intersection is the minor unsignalized intersection in this study area. It consists of two main approaches and two minor approaches. Lokanthali and Jadibuti approach are the major approach whereas Manoharafat and Siddhartha petrol pump approaches are minor ones. The detailed layout of Manoharafat intersection with lane configuration is shown in the Figure 3.7 below.

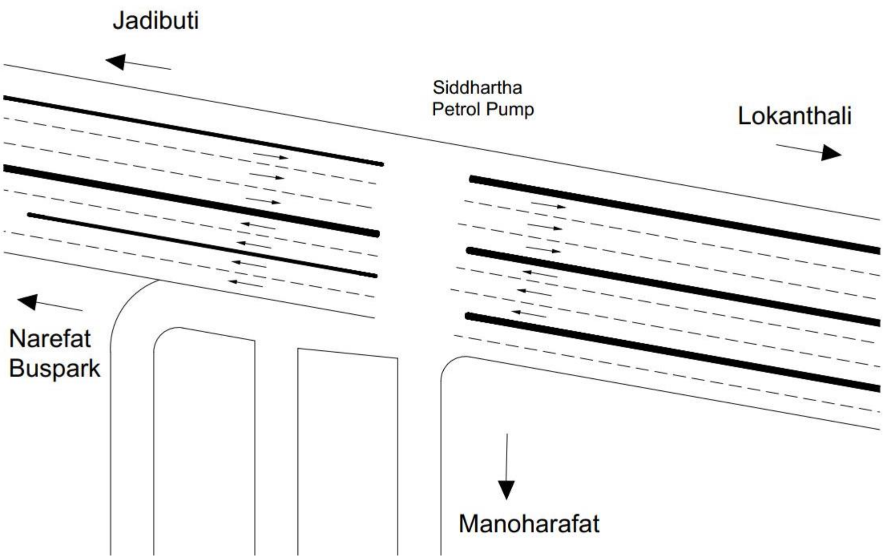


Figure 3.7: General Layout of Manoharafat intersection

This section consists of three bus stops on each approach. The details of stops are tabulated in Table 3.1 and the location of bus stop can be seen as the shaded region in Figure 3.3 and Figure 3.4 above.

Table 3.1: Bus Stops in study area and their types

Approach	Bus Stops	Type
Koteshwor-Lokanthali	Koteshwor Bus-stop	Near-side Bus-stop
	Jadibuti Bus-stop	Near-side Bus-stop
	Lokanthali Bus-stop	Near-side Bus-stop
Lokanthali-Koteshwor	Lokanthali Bus-stop	Far-side Bus-stop
	Jadibuti Bus-stop	Near-side Bus-stop
	Koteshwor Bus-stop	Far-side Bus-stop

3.3.1.2 Traffic Volume Data

The traffic flow data was obtained through the footage of 11 CCTV cameras installed at various locations along the study area. The access to the video recordings was provided at Kathmandu valley Police Office, Ranipokhari. Appropriate CCTV camera location capturing the required traffic flow and directional movement at intersection was selected based on location, camera angle and the clarity of the video. The traffic movement as listed in Table 3.2 were considered and traffic data were recorded accordingly.

Table 3.2: Traffic Movements in the study area

Movement No.	Traffic Movements	Movement No.	Traffic Movements
1	Lokanthali to Jadibuti (Total Entry)	16	Tinkune to Koteswor to Jadibuti (Through)
2	Lokanthali to Jadibuti Lane (Through)	17	Tinkune to Koteswor to Balkumari (Right Turn)
3	Lokanthali to Buspark Lane (Left Turn)	18	Jadibuti to Koteswor to Tinkune (Through)
4	Siddhartha Petrolpump to Jadibuti Lane (Total)	19	Jadibuti to Narefat Petrolpump to Balkumari (Left Turn)
5	Manoharafat to Jadibuti Lane (Left Turn)	20	Balkumari to Tinkune (Left Turn)
6	Manoharafat to Buspark Lane (Left Turn)	21	Balkumari to Jadibuti (Right Turn)
7	Manoharafat to Lokanthali (Through)	22	Mahadevsthan to Tinkune (Left Turn)
8	Lokanthali to Jadibuti to Koteswor (Through)	23	Mahadevsthan to Jadibuti (Through)
9	Lokanthali to Pepsicola (Right Turn)	24	Mahadevsthan to Balkumari (Right Turn)

Movement No.	Traffic Movements	Movement No.	Traffic Movements
10	Pepsicola to Lokanthali (Left Turn)	25	Jadibuti to Lokanthali (Through)
11	Pepsicola to Koteshwor (Right Turn)	26	Jadibuti to Pepsicola (left Turn)
12	Narefat to Pepsicola (Through)	27	Jadibuti to Narefat (Right Turn)
13	Narefat to Lokanthali (Right turn)	28	Jadibuti to Pepsicola lane to Lokanthali (Through)
14	Narefat to Koteswor (Left Turn)	29	Jadibuti Pul to Manoharafat (Right Turn)
15	Narefat Petrolpump to Koteshwor to Tinkune	30	Jadibuti Pul to Lokanthali (Straight)

The above listed traffic movements are further clarified through sketch as shown in Figure 3.8, Figure 3.9 and Figure 3.10.

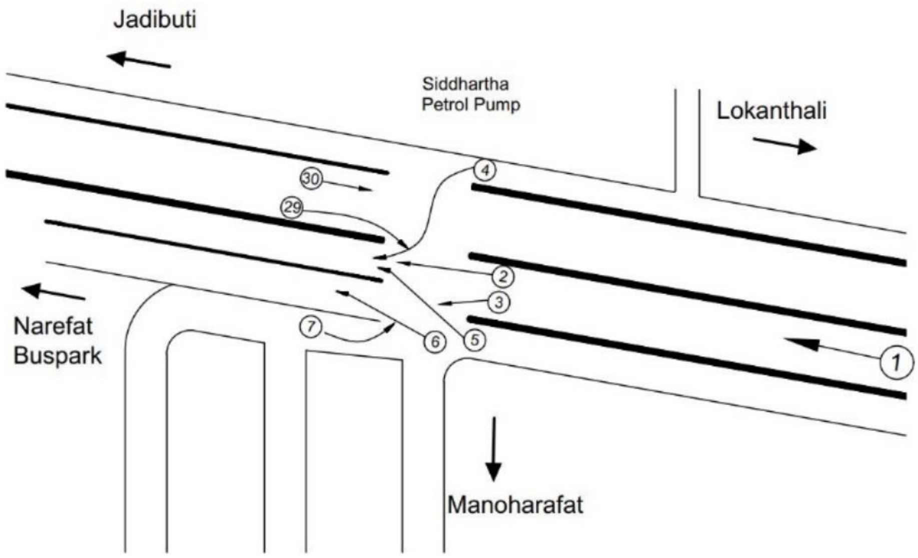


Figure 3.8: Recorded traffic movements at Manoharafat intersection

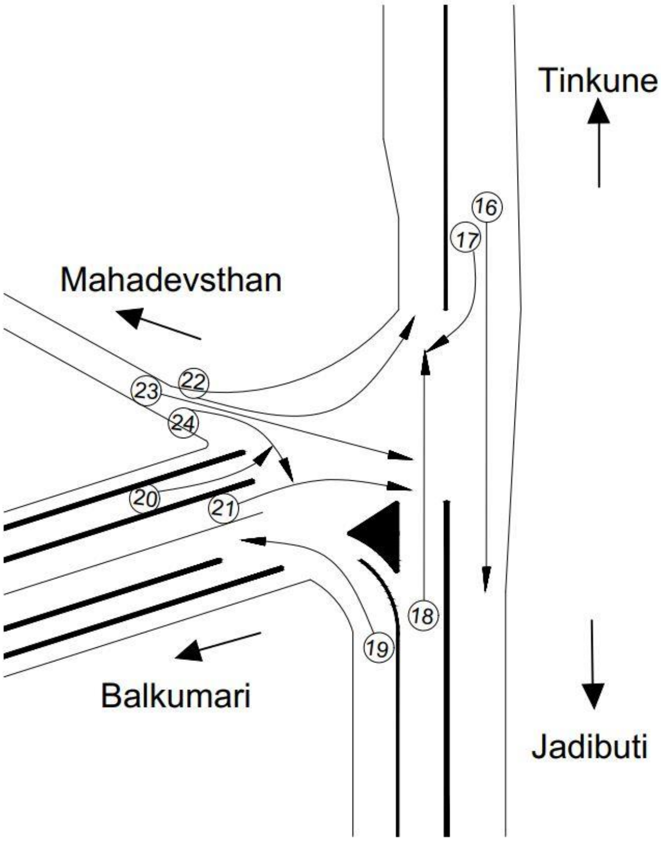


Figure 3.9: Recorded traffic movements at Koteshwor intersection

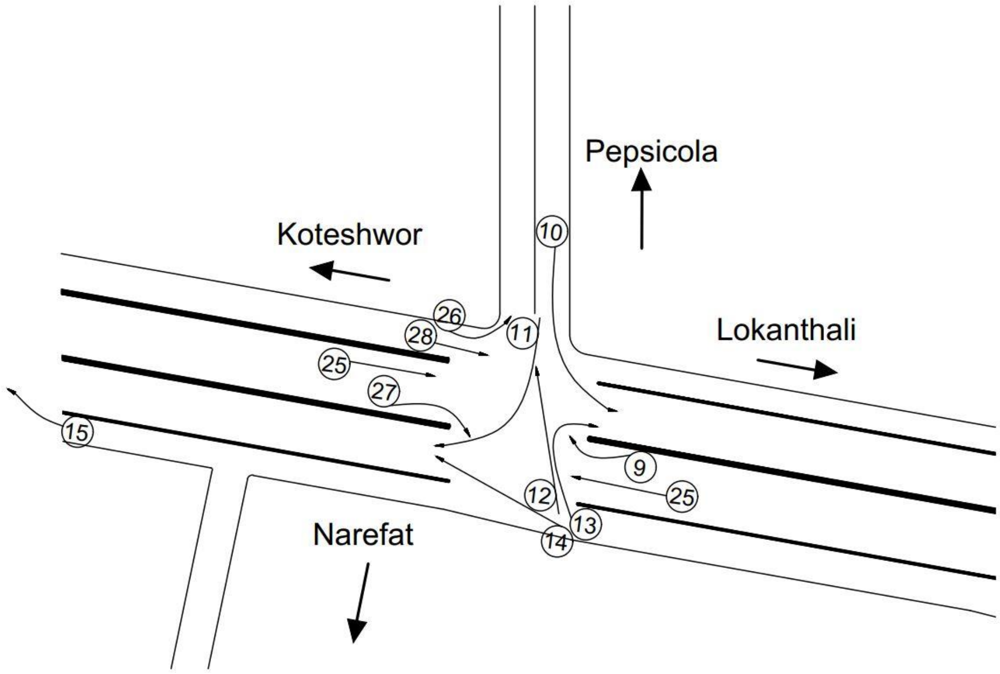


Figure 3.10: Recorded traffic movements at Jadibuti intersection

From the video recordings, classified volume count was conducted manually at 15-minute interval during morning (9:00am to 12:00pm) and evening (4:00 to 7:00pm) period. The classified traffic volume for 18 different categories as shown in Table 3.3 as well as directional volume at each leg of intersections, and entry point of the traffic into the study area was recorded at 15-minute interval which are attached in the APPENDIX B.

Table 3.3: Observed Vehicle Types during study

S.N	Types of Vehicles	S.N	Types of Vehicles
1	Motorcycle	10	Tempo
2	Cycle	11	Micro
3	Car	12	Minibus
4	Jeep	13	Large Bus
5	Van	14	Private Bus
6	Utility Pickup	15	Private Micro
7	Emergency Vehicle	16	Minitruck
8	Tractor	17	Large Truck
9	Rickshaw-Cart	18	Excavator

3.3.1.3 Signal Timing Data

The current signal phasing and timing of the two signalized intersection was also obtained from the video recordings of CCTV camera installed nearby these intersections from which green time for each phase and total cycle length was obtained. These existing signal timing data are vital for scenario analysis. Two different signal timing were observed during morning and evening period at both intersections.

3.3.1.3.1 Koteshwor Intersection

The total cycle time of 442 seconds and 402 seconds were observed during morning and evening period respectively. The amber time was 4 seconds for all phase. The phasing diagram for the Koteshwor intersection for three phases during morning and evening peak hour are shown in the Figure 3.11 and Figure 3.12 respectively.

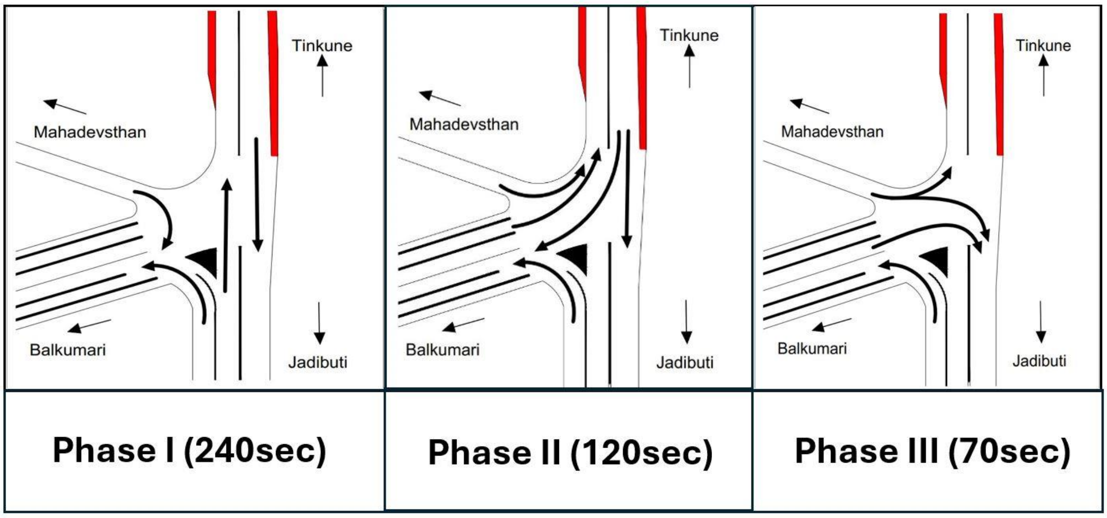


Figure 3.11: Phasing diagram and green time for morning peak hour at Koteshwor intersection

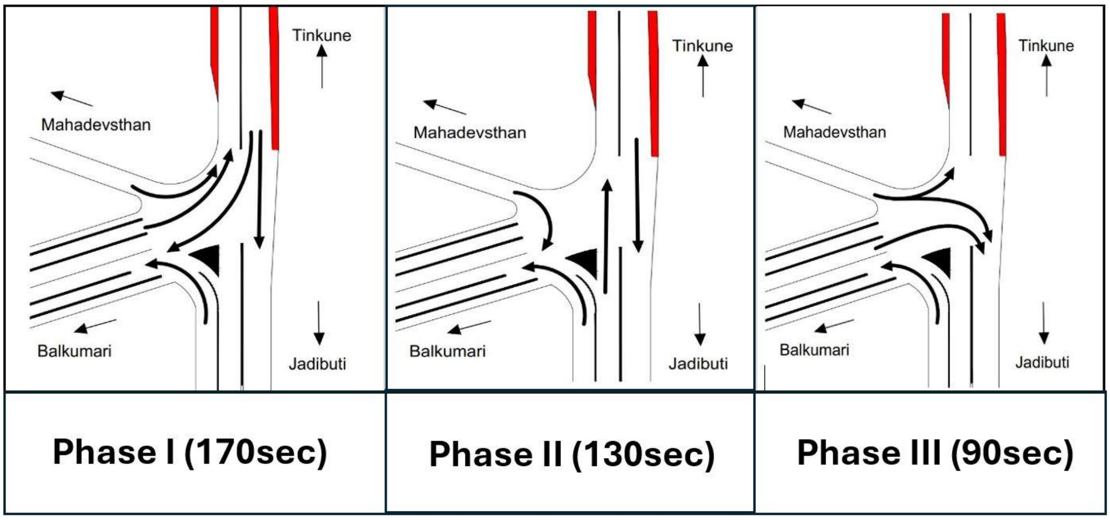


Figure 3.12: Phasing diagram and green time for evening peak hour at Koteshwor intersection

3.3.1.3.2 Jadibuti Intersection

The total cycle time of 480 seconds and 420 seconds were observed during morning and evening period respectively. The amber time was 4 seconds for all phase. The phasing diagram and green time for five phases during morning and evening peak hours at Jadibuti intersection are shown in the Figure 3.13 and Figure 3.14 respectively.

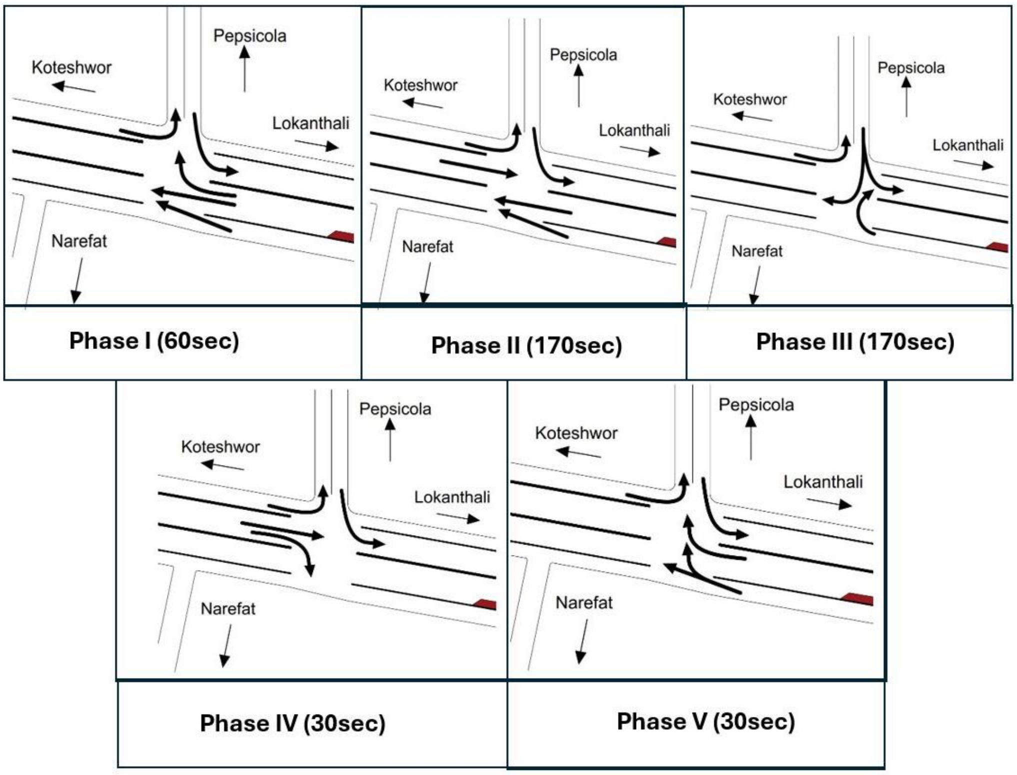


Figure 3.13: Phasing diagram and green time for morning peak hour at Jadibuti intersection

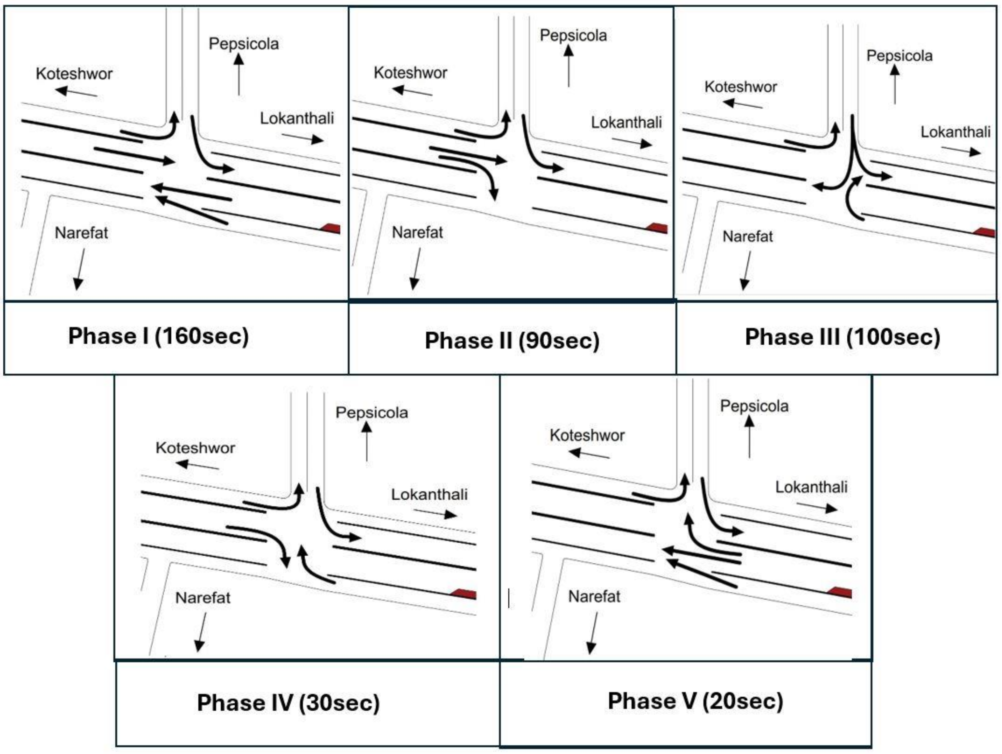


Figure 3.14: Phasing diagram and green time for evening peak hour at Jadibuti intersection

3.3.1.4 Public Transportation Operational Data

The public transportation that operates on the selected route consists of large bus, minibus and micro. The operational data such as travel time, dwell time at stops, no. of stops on this section, and delay at intersection for all public transportation were collected using onboard survey during both morning and evening period. Both the approaches Tinkune-Lokanthali and Lokanthali to Tinkune, were considered for onboard survey.

Stratified random sampling was used to ensure representation from each category of public transportation i.e. large bus, minibus and micro. The sample size for the number of onboard surveys for travel time and delay was calculated using Cochran's formula for finite population as shown in Equation (3.1).

$$n = \frac{z^2 p(1-p)}{e^2} \qquad \textbf{(3.1)}$$

where,

n = sample size

z = value at reliability level or level of confidence (1.96 for 95% level of confidence)

p = population proportion (0.5, considering maximum variability in heterogeneous population)

e= precision level (0.05)

Adjust for finite population is shown in Equation (3.2):

$$n' = \frac{n}{1 + \frac{(n-1)}{N}} \qquad \textbf{(3.2)}$$

where,

n' = adjusted sample size for finite population

N= total population size

Using Equation (3.1) and Equation (3.2), the following sample size were determined as shown in Table 3.4. The data format for onboard survey is attached in APPENDIX A and the collected data are presented on APPENDIX B.

Table 3.4: Sample Size Calculation for Onboard Survey

Approach	Time period	Total no. in peak hour	Sample size
Lokanthali-Tinkune	Morning	71	61
	Evening	108	85
Tinkune-Lokanthali	Morning	117	91
	Evening	120	93

3.3.1.5 Average Speed Data

The spot speed of all 18 category of vehicle was obtained by using speed gun. 50 sets of data were collected for each category of vehicle except excavator and rickshaw-cart. These data were then extracted and the outliers were removed and the average speed for various vehicles is obtained as in Table 3.5 below, which were used in the simulation model as well.

Table 3.5: Average speed for various vehicle category

S.N	Vehicle	Average speed (km/hr)	S.N	Vehicle	Average speed (km/hr)
1	Motorcycle	36.5	10	Private Bus	29.1
2	Car	33.5	11	Private Micro	32.3
3	Jeep	33.5	12	Minitruck	26.0
4	Van	33.5	13	Large Truck	22.7
5	Utility	33.5	14	Emergency	34.7
6	Tempo	22.0	15	Cycle	15.4
7	Micro	30.5	16	Rickshaw-cart	11.5
8	Minibus	26.0	17	Tractor	20.4
9	Large Bus	24.4	18	Excavator	13.5

3.3.2 Secondary Data Collection

Secondary data consists of those data that have been already gathered and examined in relation to this subject like books, manuals, standards, journals, research papers and thesis and dissertations. Secondary data used in this study consists of:

3.3.2.1 Equivalency Factor/Passenger Car Units (PCU)

Traffic in Kathmandu is heterogenous in nature, with different types of vehicles occupying varying amounts of road space and having distinct operational characteristics. Therefore, a standardized unit is required to relate different vehicle types. For geometric road design, the Passenger Car Unit (PCU) serves as this standard, representing a typical passenger car. This study utilized the equivalency factors from Kathmandu Sustainable Urban Transport Project (2010) as shown in Table 3.6. For motorcycle, a lower equivalency factor of **0.35** similar to that in JICA (2012) is adopted for effective calibration of the model network to the observed data.

Table 3.6: Equivalency Factor as per KSUTP (2010)

S.N	Vehicle Type	Equivalency Factor
1	Motorcycles	0.25
2	Tempo	1
3	Cars/Taxi/Utility Vehicles	1
4	Light Truck	1.5
5	Heavy Truck	3
6	Micro Bus	1.5
7	Mini Bus	2.5
8	Large Bus	3

(Source: KSUTP, 2010)

For other missing vehicle types like tractor and rickshaw-cart, although their volume is extremely low during the study period, the equivalency factor is adopted from the Nepal Road Standard (2070) as shown in Table 3.7.

Table 3.7: Equivalency Factor as per NRS (2070)

S.N	Vehicle Type	Equivalency Factor
1	Tractor with trailer	3
2	Rickshaw Cart	1.5

(Source: Nepal Road Standard, 2070)

3.4 Data Processing and Model Formation

The collected data was processed before using it as an input for developing the model.

3.4.1 Data Processing

The collected data were processed before using it as an input for developing the model. To achieve the objectives, the obtained data were arranged and thoroughly reviewed. From the classified volume count for morning (9:00 to 12:00pm) and evening (4:00 to 7:00pm), the 15minute interval traffic volume data were converted to equivalent number of passenger car by multiplying with the corresponding equivalency factor of each observed vehicle type.

At each intersection, the total PCUs entering from all approaches were calculated for every 15-minute interval during the morning and evening study periods. The hourly traffic volume was then obtained by summing four consecutive 15-minute PCU counts for both the morning and evening periods. The highest hourly PCU corresponds to the peak hour at that intersection. Thus, peak hour in the morning was observed to be at 9:30am to 10:30am at both Koteshwor and Jadibuti intersection. During the evening, the peak hour was observed at 5:00pm to 6:00pm at both the intersections.

3.4.2 Model Formation

The model formation and simulation of traffic was done using traffic simulation software, PTV VISSIM by PTV Group (2025 Version). This software was chosen because of its powerful modeling performance in replicating real-life traffic networks and its ability to accurately model exclusive bus lanes, signal priority systems, and heterogeneous traffic conditions similar to our selected section. The study area was modeled in this simulation environment.

The following data were used as inputs in VISSIM to ensure that the developed model accurately represented the existing field conditions.

- Vehicle types
- Input volume with vehicle composition
- Directional volume
- Speed of vehicles

- Route followed by vehicles
- Relative flows for static vehicle routing

First, links were created and connected with each other using connecter as per the site inspection, layout and google earth. Then all 18 different types of vehicles were defined and the corresponding speed were assigned to them. After that, the vehicle composition was defined for 10 locations from where the vehicle entered the study area. Similarly, the vehicle inputs in VISSIM were assigned for the peak hour. Then, the routes followed by vehicles were defined using static vehicle routes. Altogether 44 routes were assigned.

The next step was to assign relative volume to the particular route, this was done by using directional volume and directional split. The signal heads were installed in the models using the existing phases and signal timing data obtained from video footage. And the model was refined. Finally, node was defined to gather the results from the study area.

3.5 Model Calibration and Validation

Calibration is the process of comparing output of simulation software with the real-world data by changing various parameters so that the model realistically represents the real-world traffic environment. With calibration, the discrepancy between model results and observations from the field is minimized. The microscopic model in PTV VISSIM was calibrated according to the local condition to assure reliable outcomes. Various simulation parameters were adjusted by iterative process to fit in local conditions. These parameters include driving behavior, vehicular charactersists etc.

Calibration was iteratively done under urban (motorized) driving behaviors such as:

a. Following parameter
    - Look ahead distance
    - Look back distance
    - Behaviors during recovery from speed break down
b. Car following method parameter
    - Average standstill distance
    - Additive Part of safety distance
    - Multiplicative part of safety distance

c. Lane change parameter
    - General behaviors
    - Minimum clearance(front/rear)
    - Safety distance reduction factor

d. Lateral parameter

These several driver behaviors parameters that significantly influence the model output under heterogeneous traffic conditions cannot be directly measured in the field. Therefore, these parameters need to be calibrated to accurately replicate real-world traffic conditions.

In a study done by Maheshwary et al. (2020), several critical parameters were identified and a heuristic-based optimization using genetic algorithm was carried out to obtain a set of optimized parameter values for each mode. In this study, eight car-following parameters from the Wiedemann 99 model were found to be the most sensitive parameters for the optimization of VISSIM model for heterogenous traffic. Furthermore, ANOVA analysis was conducted by Maheshwary et al. (2020) on these eight parameters and three most optimal parameters were identified. These included CC0, CC1, and CC3.

where,
CC0 = standstill distance
CC1 = headway time
CC3 = threshold for entering following

Calibration parameters were not directly adopted from previous studies conducted in Nepal, as those studies primarily focus on isolated intersections. In contrast, this study examines a corridor comprising three consecutive intersections, where interactions between junctions significantly influence traffic behavior.

For calibration of developed model, GEH (Geoffrey E. Havers) statistics was used. The GEH formula (Oregon, D. O. T, 2011) for hourly flows is shown in Equation (3.3) as:

$$\boldsymbol{GEH} = \sqrt{\frac{\boldsymbol{2\,(m-c)^2}}{\boldsymbol{(m+c)}}} \qquad \textbf{(3.3)}$$

where,
m = output traffic volume from the simulation model (vehicle per hour)
c = input traffic volume (vehicle per hour)

The calibration was aimed for a GEH statistic value (goodness-of-fit measure) of less than 5, indicating a good fit between simulated and observed data as shown in Table 3.8.

Table 3.8: Protocol for VISSIM Simulation (OODT, 2011)

GEH Value	Remarks
<5	Acceptable fit
5 to 10	Model error or poor data
>10	Unacceptable

Similarly, for calibrating of queue length, Root Mean Squared Normalized Error (RMSNE) can be used, which measures the percentage deviation of the simulated data from field observed data using Equation (3.4). A RMSNE of less than 15% is considered acceptable for traffic model calibration (FDOT, 2014).

$$RMSNE = \sqrt{\frac{1}{N}\sum(\frac{yi,sim - yi,obs}{yi,obs})^2} \qquad \textbf{(3.4)}$$

where,
N = total number of traffic measurement observations
yi,sim = simulated data
yi,obs = observed data

The ultimate goal of simulation model validation is to determine the model's structure's validity. The model was validated by comparing simulated outputs with real-world traffic data collected during the study. This include ensuring that the model accurately reflects the traffic flow characteristics observed in the field and comparing travel times for public transportation. The model was validated for traffic volume and maximum queue lengths. Traffic volume was validated using GEH statistic and queue length was validated by calculating Root Mean Square Normalized Error (RMSNE) between observed and simulated value. The methodology for calibration and validation of network model is shown in Figure 3.15 below:

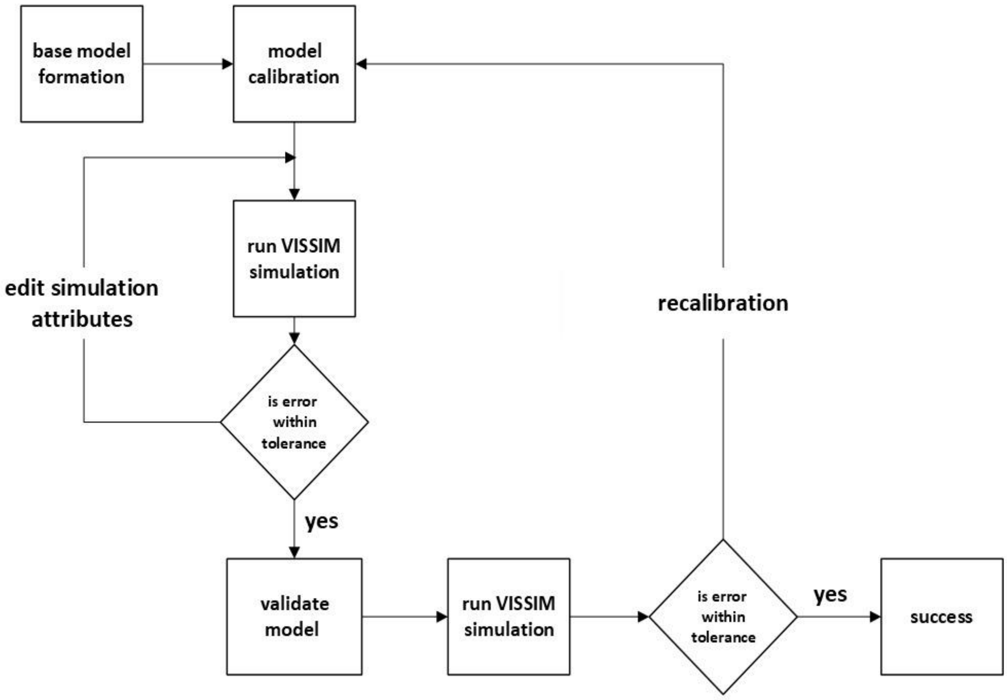


Figure 3.15: Calibration and validation of network model

3.6 Scenario Analysis

Exclusive bus lanes are then introduced in the simulation model along the selected section modifying lane configurations and restricting access to these lanes for other vehicles. Similarly, a signal priority system that grants preferential treatment to buses approaching signalized intersections is implemented. Out of various strategies mentioned in Section 2.4.1 like green extension, red truncation, or phase insertion, the simplest method of phase insertion technique was adopted in this study.

This method was selected due to its practical advantages, as it does not require significant infrastructure investment such as bus detection infrastructure, including GPS-based vehicle tracking, loop detectors, or camera-based sensors and adaptive signal controllers capable of real-time phase modification. Instead, it can be implemented using conventional signal controllers with minimal modification, making it a cost-effective and practically deployable solution. The study therefore evaluates a realistic and accessible intervention rather than an infrastructure-intensive ideal scenario.

Three major simulation scenarios were studied:

a. Scenario A: Base-case Scenario

The baseline scenario is established using the existing traffic charactersists without exclusive bus lane and existing signal timing.

b. Scenario B: Exclusive Bus Lane with Existing Signal Scenario

In this scenario, the exclusive bus lane was introduced in the simulation model keeping other parameters constant. The simulation was then run and the result was compared with base-case scenario to find out the impact of bus lane. Similarly, the bus lane layout was slightly modified and the simulation result was compared with base case scenario.

c. Scenario C: Exclusive Bus Lane with Bus Signal Priority Scenario

In this scenario, the exclusive bus lane along with signal priority was introduced in the simulation model keeping other parameters constant. Two cases of signal priority were analyzed. First, the full priority was provided for exclusive bus lane where conflict was negligible. And phase insertion technique of signal prioritization was applied at two signalized intersections. The simulation was then run for both cases and results were compared with Scenario A and B.

CHAPTER 4: RESULT AND ANALYSIS

4.1 Analysis of Traffic Volume

The classified traffic volume data collected at 15-minute intervals during the morning (9:00 AM-12:00 PM) and evening (4:00 PM-7:00 PM) periods for three consecutive days were converted into equivalent passenger car using equivalency factor from Table 3.6 and Table 3.7. From these data, hourly PCU's was calculated for two major intersections during morning and evening period.

4.1.1 Koteshwor Intersection

The hourly traffic volume and PCU's at Koteshwor intersection for three consecutive days was calculated by adding traffic volume and PCU's of each approach at given interval and tabulated in Table 4.1 shown below. From the Table 4.1, the three-days average morning peak hour traffic volume of 17755 per hour and PCU of 10203 per hour was observed during 9:30 am to 10:30am. Similarly, average evening peak hour traffic volume of 18669 per hour and PCU of 10874 per hour was observed at 5:00 to 6:00 pm. The detail data corresponding to Table 4.1, showing the total traffic volume and PCU at each approach of Koteshwor intersection is attached in APPENDIX B.

Table 4.1: Peak hourly traffic volume and PCU at Koteshwor intersection

Hourly interval	January 26, 2025 (Sunday)		January 27, 2025 (Monday)		January 28, 2025 (Tuesday)		Three-day Average		Remarks
	PCU/hr	Veh/hr	PCU/hr	Veh/hr	PCU/hr	Veh/hr	PCU/hr	Veh/hr	
9:00-10:00	9639.20	16570	9439.85	16309	9560.55	16446	9546.53	16442	
9:15-10:15	10135.85	17630	9960.00	17366	9937.40	17376	10011.08	17457	
9:30-10:30	**10234.25**	**17835**	**10198.35**	**17718**	**10176.35**	**17713**	**10202.98**	**17755**	**Morning Peak hour**
9:45-10:45	10012.95	17227	9947.60	17213	9938.00	17169	9966.18	17203	
10:00-11:00	9565.85	16288	9605.75	16416	9482.55	16202	9551.38	16302	
10:15-11:15	9129.70	15387	9216.60	15599	9147.60	15432	9164.63	15473	
10:30-11:30	8797.60	14745	8811.15	14977	8758.15	14866	8788.97	14863	
10:45-11:45	8355.10	14050	8363.65	14234	8284.25	14135	8334.33	14140	
11:00-12:00	8178.90	13699	8064.50	13765	8092.15	13878	8111.85	13781	
4:00-5:00	9826.55	16237	9691.55	16104	9632.40	16074	9716.83	16138	
4:15-5:15	10338.15	17264	10244.30	17287	10170.95	17169	10251.13	17240	
4:30-5:30	10492.20	17612	10446.20	17844	10427.95	17650	10455.45	17702	
4:45-5:45	10809.20	18266	10667.15	18291	10771.40	18275	10749.25	18277	
5:00-6:00	**10907.75**	**18608**	**10840.20**	**18777**	**10873.65**	**18622**	**10873.87**	**18669**	**Evening Peak hour**

Hourly interval	January 26, 2025 (Sunday)		January 27, 2025 (Monday)		January 28, 2025 (Tuesday)		Three-day Average		Remarks
	PCU/hr	Veh/hr	PCU/hr	Veh/hr	PCU/hr	Veh/hr	PCU/hr	Veh/hr	
5:15-6:15	10656.80	18365	10529.70	18390	10577.10	18301	10587.87	18352	
5:30-6:30	10509.15	18071	10273.55	17850	10478.60	18189	10420.43	18037	
5:45-6:45	10116.40	17343	9942.20	17215	10064.30	17393	10040.97	17317	
6:00-7:00	9652.30	16498	9450.10	16214	9559.40	16413	9553.93	16375	

4.1.2 Jadibuti Intersection

The hourly traffic volume and PCU's at another major intersection, Jadibuti intersection for three consecutive days was calculated by adding traffic volume and PCU's of each approach at given interval and tabulated in Table 4.2 shown below. From the Table 4.2, the three-days average morning peak hour traffic volume of 14246 per hour and and PCU of 7988 per hour was observed during 9:30 am to 10:30am. Similarly, average evening peak hour traffic volume of 16607 per hour and PCU of 9174 per hour was observed at 5:00 to 6:00 pm. The detail data corresponding to Table 4.2, showing the total traffic volume and PCU at each approach of Jadibuti intersection is attached in APPENDIX B.

Table 4.2: Peak hourly PCU and Volume at Jadibuti Intersection

Hourly interval	January 26, 2025 (Sunday)		January 27, 2025 (Monday)		January 28, 2025 (Tuesday)		Three-day Average		Remarks
	PCU/hr	Veh/hr	PCU/hr	Veh/hr	PCU/hr	Veh/hr	PCU/hr	Veh/hr	
9:00-10:00	7769.75	13584	7737.05	13648	7685.15	13508	7730.65	13580	
9:15-10:15	7779.25	13792	7796.70	13875	7782.90	13885	7786.28	13851	
9:30-10:30	**7946.60**	**14212**	**8022.15**	**14306**	**7996.25**	**14219**	**7988.33**	**14246**	**Morning Peak Hour**
9:45-10:45	7872.70	14036	7919.45	14209	7930.95	14165	7907.70	14137	
10:00-11:00	7671.00	13697	7843.65	14092	7741.05	13934	7751.90	13908	
10:15-11:15	7771.25	13819	7809.40	14107	7739.90	13962	7773.52	13963	
10:30-11:30	7726.75	13822	7641.70	14025	7556.00	13784	7641.48	13877	
10:45-11:45	7496.70	13383	7359.20	13425	7353.20	13352	7403.03	13387	
11:00-12:00	7417.15	13171	7125.40	12931	7196.80	12996	7246.45	13033	
4:00-5:00	8408.70	14706	8269.60	14537	8236.85	14554	8305.05	14599	
4:15-5:15	8825.50	15564	8790.20	15656	8689.30	15513	8768.33	15578	
4:30-5:30	8954.15	15851	8956.70	16150	8804.90	15828	8905.25	15943	
4:45-5:45	9184.55	16373	9085.95	16446	9051.10	16319	9107.20	16379	
5:00-6:00	**9217.85**	**16523**	**9198.45**	**16720**	**9105.50**	**16578**	**9173.93**	**16607**	**Evening Peak Hour**
5:15-6:15	9098.25	16516	9025.90	16551	8998.50	16515	9040.88	16527	
5:30-6:30	8902.15	16238	8838.25	16113	8920.70	16465	8887.03	16272	
5:45-6:45	8571.60	15673	8541.30	15615	8563.80	15822	8558.90	15703	
6:00-7:00	8229.20	15108	8164.40	14906	8200.55	15064	8198.05	15026	

From this hourly total traffic volume and PCU data from Table 4.1 and Table 4.2, three-day average highest hourly total PCUs were observed at both intersections during morning and evening period, and peak hour was identified to be:

Morning peak hour: **9:30 AM – 10:30 AM**
Evening peak hour: **5:00 PM – 6:00 PM**

The three-day average peak hourly traffic volume and PCUs at both of the major intersections are shown in the Table 4.3 below.

Table 4.3: Peak hourly PCU and Volume at Koteshwor and Jadibuti Intersection

Intersection	Morning (9:30-10:30am)		Evening (5:00-6:00pm)	
	Peak hour PCU	Peak Hour Volume	Peak hour PCU	Peak Hour Volume
Koteshwor Intersection	**10202.98**	**17755**	**10873.87**	**18669**
Jadibuti Intersection	7988.33	14246	9173.93	16607

The detailed summary of peak hourly PCUs and volumes for all the approaches during morning and evening peak hours over three days, along with their averages, is provided in APPENDIX B.

4.2 Directional Movements

Directional movements were calculated at three intersections for both morning and evening peak hour.

4.2.1 Directional Movements during Morning Peak Hour

The directional volume and the directional split were calculated for two major signalized intersections (i.e Koteshwor and Jadibuti) and one minor intersection (i.e Manoharafat intersection) during morning peak hour. This directional split was used to calculate the total volume for the defined routes in VISSIM modeling. The directional split and volume for each intersection is given below:

4.2.1.1 Koteshwor Intersection

There are 4 approaches in Koteshwor intersection, namely Tinkune Approach, Balkumari Approach, Jadibuti approach and Manadevsthan approach as shown in Figure 3.5 above. The directional volume and percentage split at Koteshwor intersection for the three-day average traffic flow during morning peak hour are shown in Table 4.4 and the schematic diagram in Figure 4.1 below.

Table 4.4: Directional volume and split at Koteshwor intersection during morning peak hour

S.N	Approach	Total Volume	Through		Left Turn		Right Turn	
			Volume	% Volume	Volume	% Volume	Volume	% Volume
1	Tinkune-Koteshwor	4067	3216	79.1%	0	0.0%	852	20.9%
2	Balkumari-Koteshwor	2204	0	0.0%	992	45.0%	1212	55.0%
3	Mahadevsthan-Koteshwor	1631	270	16.6%	1105	67.7%	252	15.5%
4	Jadibuti-Koteshwor	9856	6076	61.6%	3780	38.4%	0	0.0%

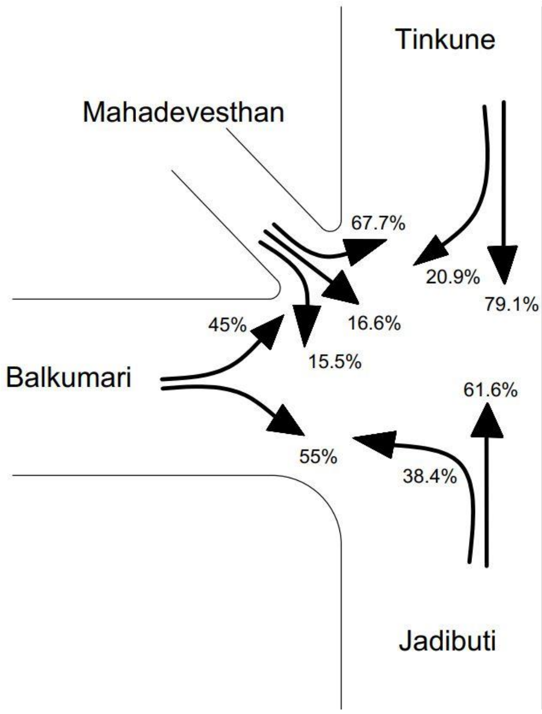


Figure 4.1: Schematic diagram of directional split at Koteshwor intersection during morning peak hour

4.2.1.2 Jadibuti Intersection

There are 5 approaches in Jadibuti intersection, namely Koteshwor main lane approach, Pepsicola approach, Lokanthali approach, Narefat approach and Koteshwor-Pepsicola lane approach as shown in Figure 3.6 above. The directional volume and percentage split at Jadibuti intersection for the three-day average traffic flow during morning peak hour are shown in the Table 4.5 and the schematic diagram in Figure 4.2 below:

Table 4.5: Directional volume and split at Jadibuti intersection during morning peak hour

S.N	Approach	Total Volume	Through		Left Turn		Right Turn	
			Volume	% Volume	Volume	% Volume	Volume	% Volume
1	Koteshwor-Jadibuti	4714	2882	61.1%	1630	34.6%	202	4.3%
2	Pepsicola-Jadibuti	4076	0	0.0%	171	4.2%	3908	95.9%
3	Narefat Buspark-Jadibuti	1441	258	17.9%	988	68.6%	197	13.7%
4	Lokanthali-Jadibuti	4009	3869	96.5%	0	0.0%	140	3.5%

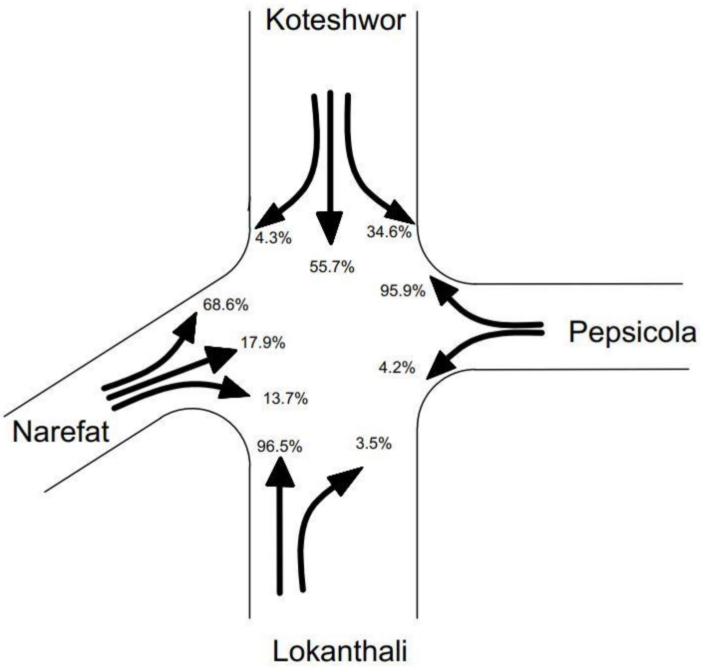


Figure 4.2: Schematic diagram of directional split at Jadibuti intersection during morning peak hour

4.2.1.3 Manoharafat Intersection

There are 4 approaches in Manoharafat intersection, namely Lokanthali approach, Jadibuti approach, Manoharafat approach, and Siddhartha petrolpump approach as shown in Figure 3.7 above. The directional volume and percentage split at Manoharafat intersection for the three-day average traffic flow during morning peak hour are shown in the Table 4.6 and the schematic diagram in Figure 4.3 below:

Table 4.6: Directional volume and split at Manoharafat intersection during morning peak hour

S. N	Approach	Total Volume	Through		Left Turn		Right Turn	
			Volume	% Volume	Volume	% Volume	Volume	% Volume
1	Lokanthali-Jadibuti Pul	4925	3339	67.8%	1587	32.2%	0	0.0%
2	Jadibuti-Jadibuti Pul	3251	3031	93.2%	0	0.0%	219	6.7%
3	Manoharafat-Jadibuti Pul	2695	112	4.2%	2235	82.9%	350	13.0%
4	Siddhartha PP-Jadibuti Pul	630	630	100.0%	0	0.0%	0	0.0%

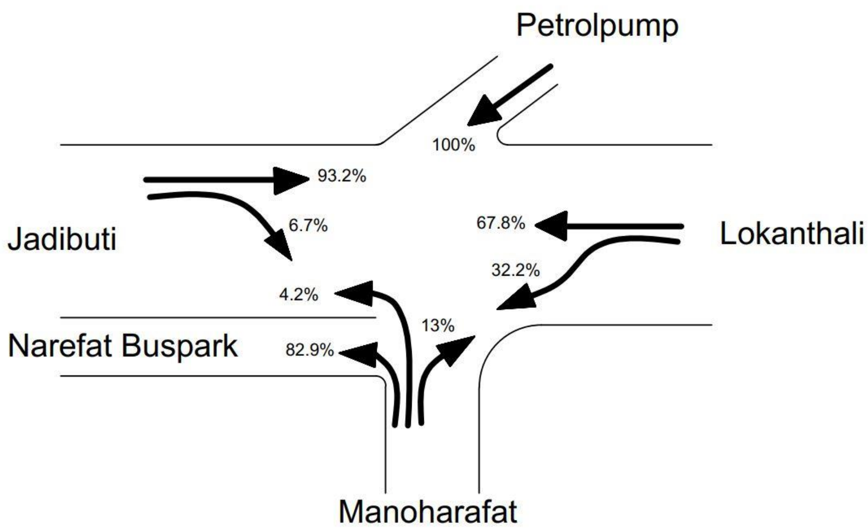


Figure 4.3: Schematic diagram of directional split at Manoharafat intersection during morning peak hour

4.2.2 Directional Movements during Evening Peak Hour

Similarly, the directional volume and the directional split were calculated for two major signalized intersections (i.e Koteshwor and Jadibuti) and one minor intersection (i.e Manoharafat intersection) during evening peak hour. This directional split was used to calculate the total volume for the defined routes in VISSIM modeling. The directional split and volume for each intersection is given below:

4.2.2.1 Koteshwor Intersection

The directional volume and percentage split at Koteshwor intersection for the three-day average traffic flow during evening peak hour are shown in the Table 4.7 and the schematic diagram in Figure 4.4 below:

Table 4.7: Directional volume and split at Koteshwor intersection during evening peak hour

S.N	Approach	Total Volume	Through		Left Turn		Right Turn	
			Volume	% Volume	Volume	% Volume	Volume	% Volume
1	Tinkune-Koteshwor	9008	7564	84.0%	0	0.0%	1445	16.0%
2	Balkumari-Koteshwor	3250	0	0.0%	1246	38.3%	2004	61.7%
3	Mahadevsthan-Koteshwor	1266	604	47.7%	342	27.0%	322	25.4%
4	Jadibuti-Koteshwor	5142	3053	59.4%	2089	40.6%	0	0.0%

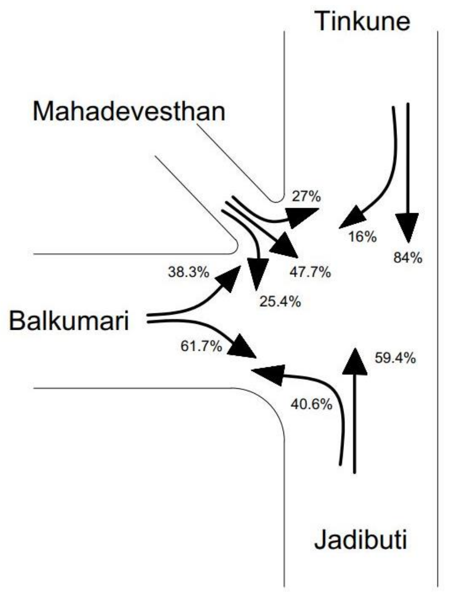


Figure 4.4: Schematic diagram of directional split at Koteshwor intersection during evening peak hour

4.2.2.2 Jadibuti Intersection

The directional volume and percentage split at Jadibuti intersection for the three-day average traffic flow during evening peak hour are shown in the Table 4.8 and the schematic diagram in Figure 4.5 below:

Table 4.8: Directional volume and split at Jadibuti intersection during evening peak hour

S.N	Approach	Total Volume	Through		Left Turn		Right Turn	
			Volume	% Volume	Volume	% Volume	Volume	% Volume
1	Koteshwor-Jadibuti	10198	6274	61.5%	3399	33.3%	525	5.1%
2	Pepsicola-Jadibuti	2486	0	0.0%	267	10.7%	2219	89.3%
3	Narefat Buspark-Jadibuti	1184	425	35.9%	535	45.2%	226	19.1%
4	Lokanthali-Jadibuti	2737	2548	93.1%	0	0.0%	189	6.9%

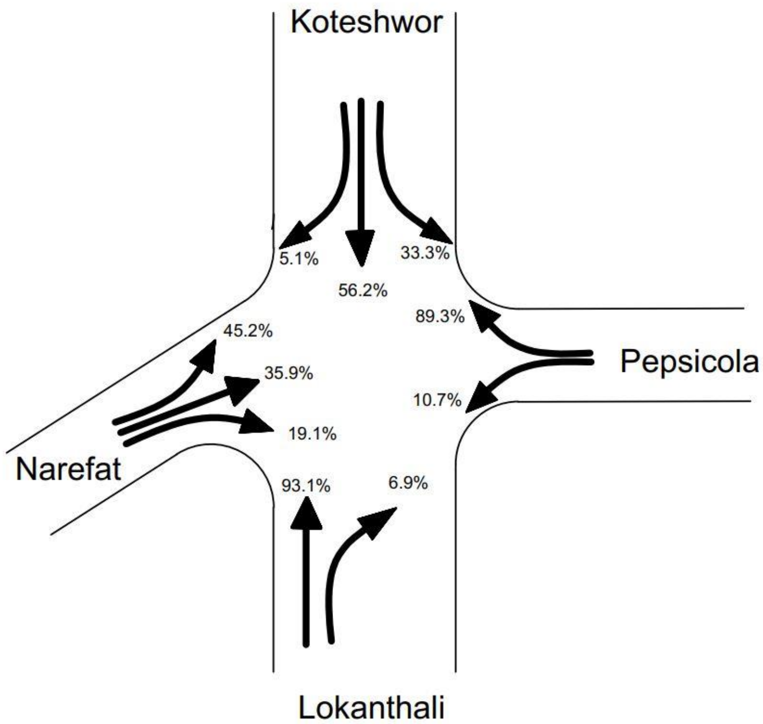


Figure 4.5: Schematic diagram of directional split at Jadibuti intersection during evening peak hour

4.2.2.3 Manoharafat Intersection

The directional volume and percentage split at Manoharafat intersection for the three-day average traffic flow during evening peak hour are shown in the Table 4.9 and the schematic diagram in Figure 4.6 below:

Table 4.9: Directional volume and split at Manoharafat intersection during evening peak hour

S. N	Approach	Total Volume	Through		Left Turn		Right Turn	
			Volume	% Volume	Volume	% Volume	Volume	% Volume
1	Lokanthali-Jadibuti Pul	3178	2476	77.9%	702	22.1%	0	0.0%
2	Jadibuti-Jadibuti Pul	6767	6184	91.4%	0	0.0%	583	8.6%
3	Manoharafat-Jadibuti Pul	1032	90	8.7%	609	59.0%	332	32.2%
4	Siddhartha PP-Jadibuti Pul	209	209	100.0%	0	0.0%	0	0.0%

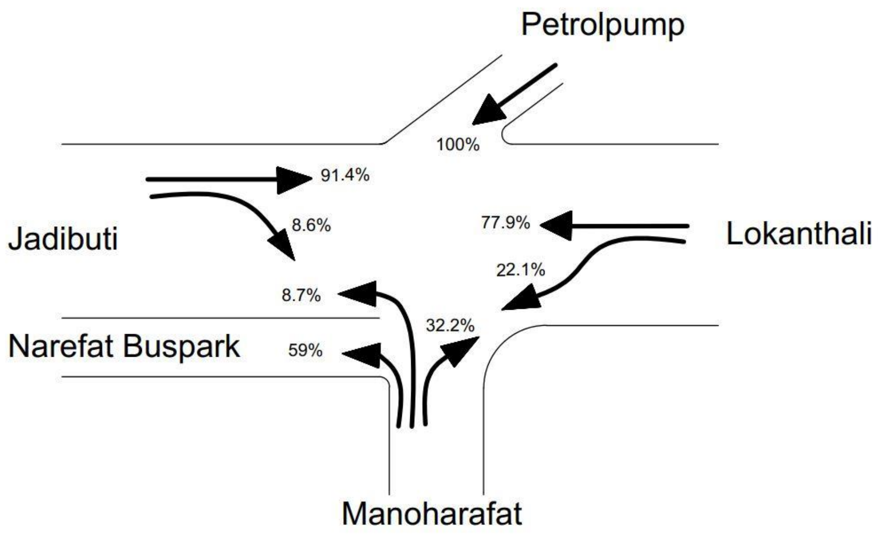


Figure 4.6: Schematic diagram of directional split at Manoharafat intersection during evening peak hour

4.3 Vehicle Input and Composition

The 18 categories of vehicles were grouped according to their class and similarities into 10 group and the three-day average percentage composition was determined. Large bus, minibus, micro and tempo being the public transportation were kept under one category and constituted 3.36% of total vehicles. The most dominant vehicle type was motorcycle with 78.09% share followed by car/jeep/van with 14.48% share. The more detailed data about the vehicle compositions for all the entry point and approaches are provided in APPENDIX B, while summary of average vehicle composition is shown in the Table 4.10 below:

Table 4.10: Average Vehicle composition in study area

S.N	Vehicle Type	Average Percentage Composition
1	Motorcycle	78.09%
2	Car/Jeep/Van	14.48%
3	Utility Pickup	1.85%
4	Public Transportation	3.36%
5	Private Bus/Micro	0.41%
6	Light Truck	0.65%
7	Heavy Truck	0.15%
8	Emergency	0.07%
9	Cycle	0.94%
10	Tractor	0.01%

4.4 Analysis of Public Transportation Operational Data

The public transportation that operates on the study area consists of large bus, minibus and micro. For the peak hour, the number of public transportation plying on both Lokanthali-Tinkune and Tinkune-Lokanthali approach varies during both morning and evening peak hours. The number of each category of public transportation (large bus, minibus, micro) plying on both the approaches and their proportion were calculated as shown in Table 4.11 below:

Table 4.11: Category of Public transportation and their share

Public Transportation	Lokanthali-Tinkune				Tinkune-Lokanthali			
	Morning		Evening		Morning		Evening	
	Total No.	Propo-rtion	Total No.	Proportion	Total No.	Propo-rtion	Total No.	Propo-rtion
Bus	95	0.54	114	0.46	105	0.51	134	0.63
Minibus	33	0.19	27	0.11	48	0.23	39	0.18
Micro	49	0.28	109	0.44	52	0.25	40	0.19
Total	**177**	**1**	**250**	**1**	**205**	**1**	**213**	**1**

The operational data like travel time, dwell time during boarding and alighting at the stops, no. of stops on this section, delay at intersection for the sample size were determined by carrying out onboard survey in both the approaches and the data are attached in the APPENDIX B. The summary of those data is shown in the Table 4.12 for Tinkune-Lokanthali approach.

Table 4.12: Average Travel time and Delay for Tinkune-Lokanthali approach

Period	Public Transport	Average Travel time (sec)	Average Delay at Stop (sec)	Average Delay at intersection (sec)	Average Total Delay (sec)
Morning peak hour	Large bus	666	236	210	446
	Minibus	711	250	227	476
	Micro	506	149	155	304
Average (in sec)		**628**	**211**	**197**	**408**
(in Minutes)		**10min 28sec**	**3min 31sec**	**3min 17 sec**	**6min 48sec**
Evening peak hour	Large bus	666	239	209	447
	Minibus	684	254	198	452
	Micro	504	158	147	306
Average (in sec)		**618**	**217**	**185**	**402**
(in Minutes)		**10min 18sec**	**3min 37 sec**	**3min 05 sec**	**6min 42sec**

There were three designated bus stops in this approach, Koteshwor, Jadibuti and Lokanthali bus stop. There were two more non-designated stops where boarding and alighting of passengers were done. Average delay at stop is the average value of these 5 stops. Intersection delay occurred at Koteshwor, Jadibuti and Manoharafat intersection.

Similarly, average travel time and delay data for Lokanthali-Tinkune approach is shown in Table 4.13.

Table 4.13: Average Travel time and Delay for Lokanthali-Tinkune approach

Period	Public Transport	Average Travel time (sec)	Average Delay at Stop (sec)	Average Delay at intersection (sec)	Average Total Delay (sec)
Morning peak hour	Large bus	682	229	223	452
	Minibus	666	239	206	444
	Micro	511	142	177	319
Average (in sec)		**620**	**203**	**202**	**405**
(in Minutes)		**10min 20sec**	**3min 23 sec**	**3min 22 sec**	**6min 45sec**
Evening peak hour	Large bus	715	282	196	478
	Minibus	604	183	190	373
	Micro	567	183	162	346
Average (in sec)		**629**	**216**	**183**	**399**
(in Minutes)		**10min 29sec**	**3min 36 sec**	**3min 02 sec**	**6min 39sec**

There were three designated bus stops in this approach Lokanthali, Koteshwor and Jadibuti bus stop. There was one non-designated stop where boarding and alighting of passengers were done. Average delay at stop is the average value of these 4 stops. Similarly, intersection delay occurred at Manoharafat, Jadibuti and Koteshwor intersection.

4.5 Simulation Analysis

Once the model was setup in VISSIM, it was simulated with the default value to check if there is a need for calibration. The total volume of vehicle with their composition during morning and evening peak hours were entered in VISSIM and routes were assigned for both periods as in Figure 4.7 and Figure 4.8.

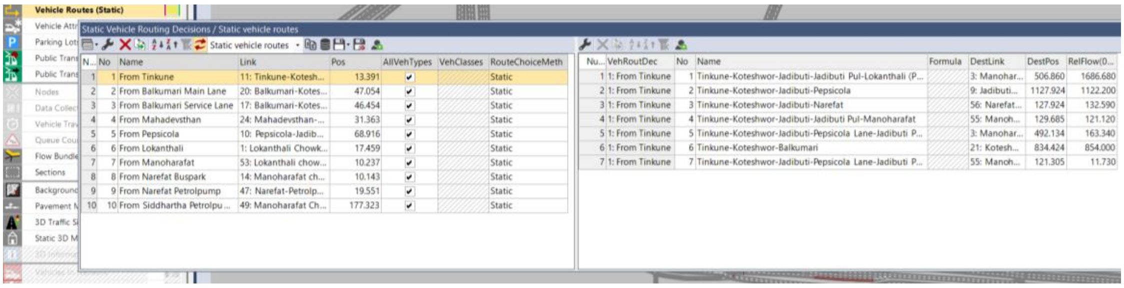


Figure 4.7: Route assignment in VISSIM (morning peak hour)

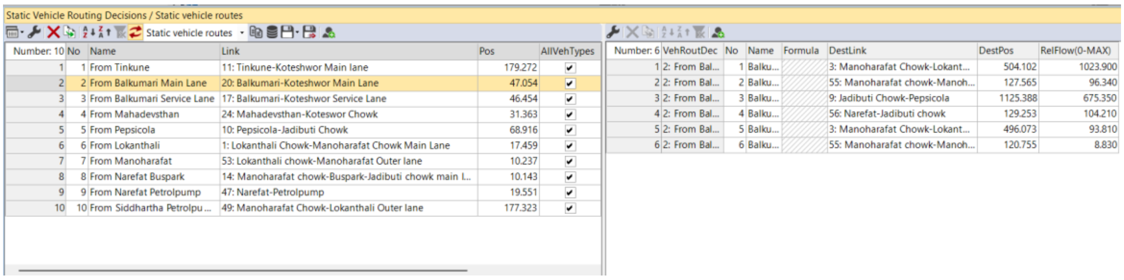


Figure 4.8: Route assignment in VISSIM (evening peak hour)

Similarly, the signal timings were added in model at both the signalized intersections for both morning and evening peak hours are shown in Figure 4.9 and Figure 4.10 below:

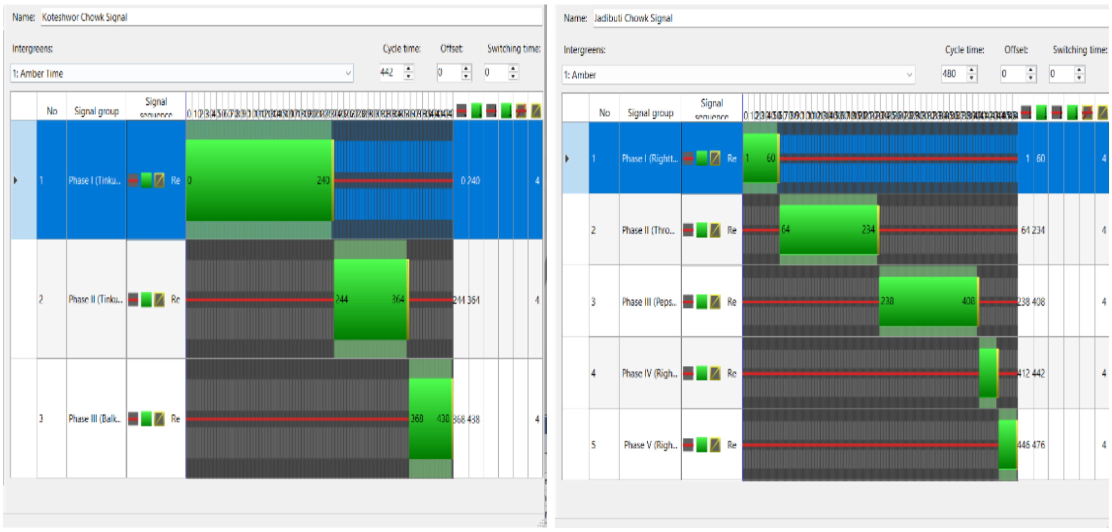


Figure 4.9: Signal timing input in VISSIM (morning peak hour)

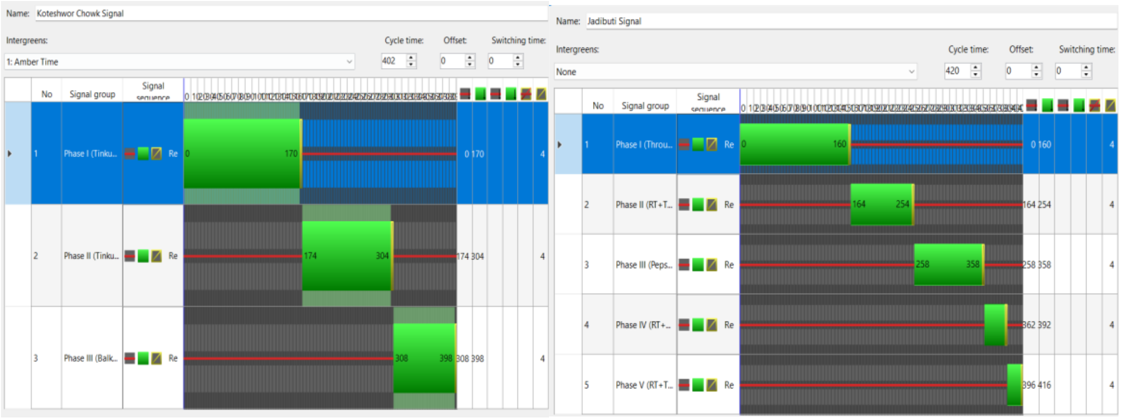


Figure 4.10: Signal timing input in VISSIM (evening peak hour)

4.5.1 Calibration of the Model

Once the model was setup with links and connectors in VISSIM, it was simulated with the default value to check if there is a need for calibration. The simulated results of traffic volume in each route were compared with the observed field value and it was found that there was a need for calibration to the model.

Calibration parameters were not directly adopted from previous studies conducted in Nepal, as those studies primarily focus on isolated intersections. In contrast, this study examines a corridor comprising three consecutive intersections, where interactions between junctions significantly influence traffic behavior.

An extensive review of previous studies on VISSIM calibration under heterogeneous traffic conditions was conducted to identify appropriate calibration parameters. From this review, nine driving behavior parameters were selected due to their strong influence on traffic operations under such conditions. Their corresponding ranges were adopted from the values recommended in previous studies. These parameters were adjusted by iterative process starting from the upper range of the recommended value till the lower range to fit the model since these parameters can’t be exactly measured in the field. The following, Wiedemann 74 and Lane change parameters with the recommended range from different literatures were adjusted by iteration process till the simulated output was within acceptable range. The values were then adopted for further study as shown in the Table 4.14.

Table 4.14: Adjusted values for the Driving behavior parameters in VISSIM

<table>
<tr><th>S. N.</th><th colspan="3">Parameters</th><th>VISSM Default Values</th><th>Range tested with reference from literature</th><th>Literature Referred</th><th>Values adopted for Calib-ration</th></tr>
<tr><td>1</td><td rowspan="4">Following</td><td rowspan="2">Look ahead distance</td><td>Min (m)</td><td>0</td><td>10-30</td><td>(Manandhar, 2023); (Acharya & Marsani, 2020); (Paul et al., 2019);</td><td>10</td></tr>
<tr><td>2</td><td>Max (m)</td><td>250</td><td>100-140</td><td>(Shrestha & Pradhananga, 2023); (Chhetri, 2023); (Kunwar et al., 2025)</td><td>100</td></tr>
<tr><td>3</td><td rowspan="2">Look back distance</td><td>Min (m)</td><td>0</td><td>5-24</td><td>(Acharya & Marsani, 2020); (Dutta & Ahmed, 2019)</td><td>5</td></tr>
<tr><td>4</td><td>Max (m)</td><td>150</td><td>80-150</td><td>(Manandhar, 2023); (Shrestha & Pradhananga, 2023)</td><td>100</td></tr>
<tr><td>5</td><td rowspan="3">Wiedemann 74</td><td colspan="2">Average standstill distance (m)</td><td>2</td><td>0.2-1.5</td><td>(Mondal & Gupta, 2020); (Acharya & Marsani, 2020); (Jayasooriya & Bandara, 2018)</td><td>0.2</td></tr>
<tr><td>6</td><td colspan="2">Additive part of safety distance</td><td>2</td><td>0.1-1.5</td><td>(Hussain et al., 2017); (Siddharth & Ramadurai, 2013); (Manandhar, 2023); (Raju et al., 2021); (Kunwar et al., 2025)</td><td>0.2</td></tr>
<tr><td>7</td><td colspan="2">Multiplicative part of safety distance</td><td>3</td><td>0-1</td><td>(Hussain et al., 2017); (Manandhar, 2023); (Mathew & Radhakrishnan, 2010)</td><td>0.25</td></tr>
<tr><td>8</td><td rowspan="2">Lane Change</td><td colspan="2">Min. clearance (front/rear) (m)</td><td>0.5</td><td>0.11-0.8</td><td>(Siddharth & Ramadurai, 2013); (Khan et al., 2022); (Mondal & Gupta, 2020);</td><td>0.2</td></tr>
<tr><td>9</td><td colspan="2">Safety distance reduction factor</td><td>0.6</td><td>0.2-0.6</td><td>(Mondal & Gupta, 2020); (Shrestha & Pradhananga, 2023);</td><td>0.2</td></tr>
</table>

Simulation runs were conducted separately for morning and evening peak hour to ensure that different random seed values for these simulation runs produced consistent results. Some snapshot of the simulation runs at three intersections are shown in the Figure 4.11 below:

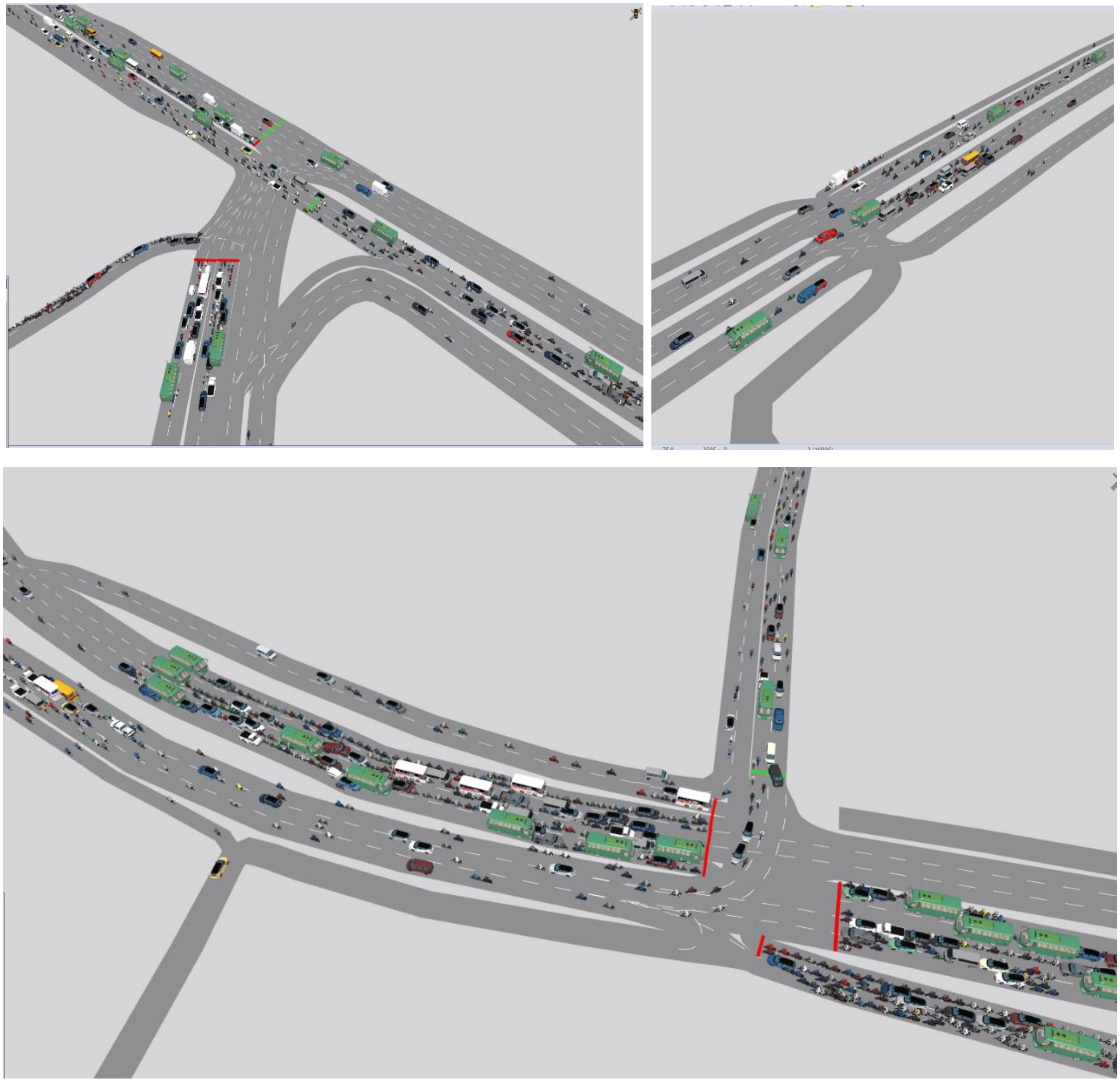


Figure 4.11: Simulation in VISSIM

4.5.1.1 Calibration of the Model for Traffic Volume

The average field data from Day 1 and Day 2 for both morning and evening peak hour were entered into the model built in VISSIM with the adjusted parameters and the simulation was run for both periods separately.

4.5.1.1.1 Calibration for Traffic Volume during Morning Peak Hour

The simulated volume was compared to the observed two-day average volume for morning peak hour, and the GEH values were then calculated for model calibration. More than 85% GEH results for traffic volume of the major selected route satisfied the threshold criteria with GEH less than 5 as shown in Table 4.15. Hence, the model was calibrated successfully for traffic volume of morning peak hour.

Table 4.15: Observed and simulated volume for major routes and GEH value for calibration (morning peak hour)

S.N	Route	Observed Volume	Simulate Volume1	Simulate Volume2	Simulated Volume3	Final Simulate Volume	GEH Value	Within Range?
1	Lokanthali-Jadibuti Pul-Jadibuti-Pepsicola	**117**	101	106	113	**115**	0.16	Yes
2	Lokanthali-Jadibuti Pul-Jadibuti-Koteshwor-Tinkune	**1989**	1713	1669	1965	**1985**	0.10	Yes
3	Lokanthali-Jadibuti Pul-Jadibuti-Narefat Petrol Pump-Balkumari Service Lane	**1230**	1054	1041	1106	**1091**	4.07	Yes
4	Lokanthali-Jadibuti Pul-Narefat Buspark	**1573**	1452	1451	1550	**1539**	0.86	Yes
5	Pepsicola-Jadibuti-Jadibuti Pul-Lokanthali	**157**	90	99	108	**109**	4.14	Yes
6	Pepsicola-Jadibuti-Koteshwor-Tinkune	**2422**	1503	1768	2023	**2023**	8.46	No
7	Pepsicola-Jadibuti-Narefat Petrolpump-Balkumari	**1497**	904	1040	1108	**1125**	10.28	No
8	Tinkune-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	**1687**	1552	1474	1881	**1893**	4.88	Yes
9	Tinkune-Koteshwor-Jadibuti-Pepsicola	**1122**	1018	940	1112	**1111**	0.34	Yes
10	Tinkune-Koteshwor-Balkumari	**854**	811	738	852	**851**	0.10	Yes
11	Balkumari-Koteshwor-Tinkune	**989**	980	716	1030	**1030**	1.29	Yes
12	Balkumari-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	**627**	566	548	684	**672**	1.75	Yes
13	Balkumari-Koteshwor-Jadibuti-Pepsicola	**417**	360	349	438	**438**	0.99	Yes
14	Mahadevsthan-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	**141**	77	131	115	**134**	0.63	Yes
15	Mahadevsthan-Koteshwor-Jadibuti-Pepsicola	**94**	46	88	77	**87**	0.74	Yes
16	Mahadevsthan-Koteshwor-Tinkune	**1100**	577	890	922	**924**	5.53	Yes
17	Narefat Petrolpump-Koteshwor-Tinkune	**1485**	1201	1291	1400	**1415**	1.84	Yes
18	Manoharafat-Jadibuti Pul-Narefat Buspark	**2275**	2250	2210	2235	**2231**	0.93	Yes

4.5.1.1.2 Calibration for Traffic Volume during Evening Peak hour

Similarly, the simulated volume was compared to the observed two-day average volume for evening peak hour, and the GEH values were then calculated for model calibration. More than 85% GEH results for traffic volume of the major selected route satisfied the threshold criteria with GEH less than 5 as shown in Table 4.16. Hence, the model was calibrated successfully for traffic volume of evening peak hour.

Table 4.16: Observed and simulated volume for major routes and GEH value for calibration (evening peak hour)

S. N	Route	Observed Volume	Simulated Volume	GEH Value	Within Range?
1	Lokanthali-Jadibuti Pul-Jadibuti-Pepsicola	173	154	1.51	Yes
2	Lokanthali-Jadibuti Pul-Jadibuti-Koteshwor-Tinkune	1345	1323	0.61	Yes
3	Lokanthali-Jadibuti Pul-Jadibuti-Narefat Petrol Pump-Balkumari Service Lane	923	898	0.84	Yes
4	Lokanthali-Jadibuti Pul-Narefat Buspark	702	641	2.35	Yes
5	Pepsicola-Jadibuti-Jadibuti Pul-Lokanthali	247	191	3.77	Yes
6	Pepsicola-Jadibuti-Koteshwor-Tinkune	1326	1202	3.49	Yes
7	Pepsicola-Jadibuti-Narefat Petrolpump-Balkumari	910	791	4.08	Yes
8	Tinkune-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	3865	4012	2.35	Yes
9	Tinkune-Koteshwor-Jadibuti-Pepsicola	2549	2504	0.90	Yes
10	Tinkune-Koteshwor-Balkumari	1445	1363	2.19	Yes
11	Balkumari-Koteshwor-Tinkune	1249	1313	1.79	Yes
12	Balkumari-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	1024	1071	1.46	Yes
13	Balkumari-Koteshwor-Jadibuti-Pepsicola	675	605	2.78	Yes
14	Mahadevsthan-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	310	339	1.60	Yes
15	Mahadevsthan-Koteshwor-Jadibuti-Pepsicola	205	211	0.45	Yes
16	Mahadevsthan-Koteshwor-Tinkune	336	319	0.94	Yes
17	Narefat Petrolpump-Koteshwor-Tinkune	425	386	1.94	Yes
18	Manoharafat-Jadibuti Pul-Narefat Buspark	607	647	1.60	Yes

4.5.1.2 Calibration of the Model for Maximum Queue Length

The maximum queue length for each given approach for three-days were measured from the video footage. Then the maximum queue length generated by the VISSIM simulation fed with two-day average field data were obtained for both morning and evening peak period.

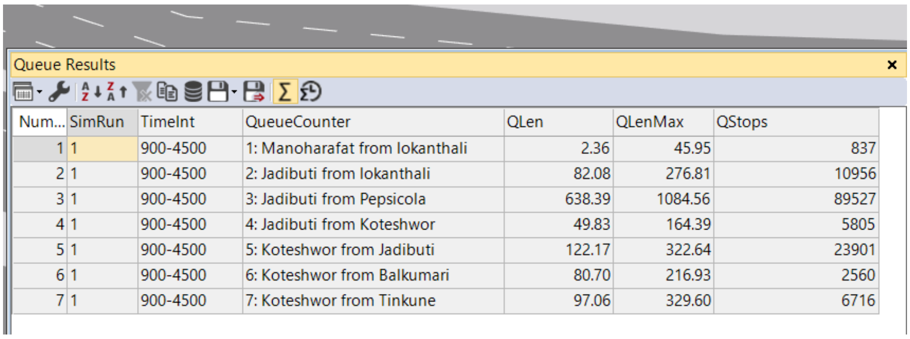
4.5.1.2.1 Calibration for Maximum Queue Length during Morning Peak hour

The observed two-day average maximum queue length was then compared with the maximum queue length generated by the VISSIM simulation for morning peak hour. The calibration of the model for queue length was performed using RMSNE statistics and has been presented in Table 4.17 and the output of VISSIM is shown in Figure 4.12.

Table 4.17: Observed and simulated maximum queue length for calibration (morning peak hour)

S. N	Approach	Observed Max Queue length (m) Day 1	Observed Max Queue length (m) Day 2	Observed Max Queue length (m) Average	Simulated Max Queue length (m)	Absolute Normalized Error
1	From Koteshwor chowk towards Tinkune	310	300	**305**	**330**	0.081
2	From Koteshwor chowk towards Balkumari	220	190	**205**	**217**	0.058
3	From Koteshwor chowk towards Jadibuti	300	290	**295**	**323**	0.093
4	From Jadibuti chowk towards Koteshwor	190	170	**180**	**164**	0.087
5	From Jadibuti chowk towards Pepsicola	1020	960	**990**	**1085**	0.096
6	From Jadibuti chowk towards Lokanthali	300	280	**290**	**277**	0.045
7	From Manoharafat chowk towards Lokanthali	50	50	**50**	**46**	0.081

The RMSNE value is calculated to be 7.92% which is less than 15%, Hence, the model was calibrated successfully.



Queue Results

Num...	SimRun	TimeInt	QueueCounter	QLen	QLenMax	QStops
1	1	900-4500	1: Manoharafat from lokanthali	2.36	45.95	837
2	1	900-4500	2: Jadibuti from lokanthali	82.08	276.81	10956
3	1	900-4500	3: Jadibuti from Pepsicola	638.39	1084.56	89527
4	1	900-4500	4: Jadibuti from Koteshwor	49.83	164.39	5805
5	1	900-4500	5: Koteshwor from Jadibuti	122.17	322.64	23901
6	1	900-4500	6: Koteshwor from Balkumari	80.70	216.93	2560
7	1	900-4500	7: Koteshwor from Tinkune	97.06	329.60	6716

Figure 4.12: Maximum queue length result after simulation for calibration in VISSIM (morning peak hour)

4.5.1.2.2 Calibration for Maximum Queue Length during Evening Peak Hour

Similarly, the observed two-day average maximum queue length was then compared with the maximum queue length generated by the VISSIM simulation for evening peak hour. The calibration of the model for queue length was performed using RMSNE statistics and has been presented in Table 4.18 and the output of VISSIM is shown in Figure 4.13.

Table 4.18: Observed and simulated maximum queue length for calibration (evening peak hour)

S. N	Approach	Observed Max Queue length (m) Day 1	Observed Max Queue length (m) Day 2	Observed Max Queue length (m) Average	Simulated Max Queue length (m)	Absolute Normalized Error
1	From Koteshwor chowk towards Tinkune	400	380	**390**	**425**	0.090
2	From Koteshwor chowk towards Balkumari	240	220	**230**	**243**	0.055
3	From Koteshwor chowk towards Jadibuti	270	240	**255**	**266**	0.042
4	From Jadibuti chowk towards Koteshwor	430	400	**415**	**432**	0.041
5	From Jadibuti chowk towards Pepsicola	420	400	**410**	**457**	0.115
6	From Jadibuti chowk towards Lokanthali	180	160	**170**	**176**	0.034
7	From Manoharafat chowk towards Lokanthali	60	40	**50**	**54**	0.089

The RMSNE value is calculated to be 7.24% which is less than 15%, Hence, the model was calibrated successfully.

Queue Results

Number: 7	SimRun	TimeInt	QueueCounter	QLen	QLenMax	QStops
1	1	900-4500	1: Manoharafat from lokanthali	1.37	54.45	397
2	1	900-4500	2: Jadibuti from lokanthali	58.28	175.72	5136
3	1	900-4500	3: Jadibuti from Pepsicola	270.07	456.98	21199
4	1	900-4500	4: Jadibuti from Koteshwor	102.70	431.82	21483
5	1	900-4500	5: Koteshwor from Jadibuti	73.57	265.80	9523
6	1	900-4500	6: Koteshwor from Balkumari	106.90	242.71	4588
7	1	900-4500	7: Koteshwor from Tinkune	68.63	425.00	10022

Figure 4.13: Maximum queue length result after simulation for calibration in VISSIM (evening peak hour)

4.5.2 Validation of the Model

The validation is meant to determine whether the calibrated simulation model can reproduce accurately the real-world traffic conditions beyond the calibration data. This is done by using different sets of data other than the data used for calibration. Since, the average of first two-day data are used for calibration of the model, it can't be used for validation. So, different sets of data i.e. field data from Day-3 were used for validation of the model. Similar to calibration, validation of the model was done for traffic volume and maximum queue length.

4.5.2.1 Validation of the Model for Traffic Volume

After the successful calibration of the model, the different set of field data from Day-3 were entered into VISSIM keeping all other parameters same as calibrated model and the simulation was run separately for both morning and evening peak period.

4.5.2.1.1 Validation for Traffic Volume during Morning Peak Hour

The simulated volume was then compared to the observed volume from Day-3 for morning peak period, and the GEH values were then calculated. More than 85% GEH results for traffic volume of the major selected route satisfied the threshold criteria with GEH less than 5 as shown in Table 4.19. Hence, the model was validated successfully for traffic volume for morning peak period.

Table 4.19: Observed and simulated volume for major routes and GEH value for validation (morning peak hour)

S. N	Route	Observed Volume	Simulated Volume	GEH Value	Within Range ?
1	Lokanthali-Jadibuti Pul-Jadibuti-Pepsicola	117	118	0.09	Yes
2	Lokanthali-Jadibuti Pul-Jadibuti-Koteshwor-Tinkune	1,979	1930	1.10	Yes
3	Lokanthali-Jadibuti Pul-Jadibuti-Narefat Petrol Pump-Balkumari Service Lane	1,249	1118	3.81	Yes
4	Lokanthali-Jadibuti Pul-Narefat Buspark	1,617	1592	0.62	Yes
5	Pepsicola-Jadibuti-Jadibuti Pul-Lokanthali	166	115	4.31	Yes
6	Pepsicola-Jadibuti-Koteshwor-Tinkune	2,383	1923	9.91	No
7	Pepsicola-Jadibuti-Narefat Petrolpump-Balkumari	1,504	1155	9.58	No
8	Tinkune-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	1,643	1867	5.34	Yes
9	Tinkune-Koteshwor-Jadibuti-Pepsicola	1,094	1108	0.43	Yes
10	Tinkune-Koteshwor-Balkumari	847	837	0.34	Yes
11	Balkumari-Koteshwor-Tinkune	1,000	1041	1.28	Yes
12	Balkumari-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	636	676	1.57	Yes
13	Balkumari-Koteshwor-Jadibuti-Pepsicola	423	437	0.67	Yes
14	Mahadevsthan-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	139	115	2.09	Yes
15	Mahadevsthan-Koteshwor-Jadibuti-Pepsicola	92	76	1.77	Yes
16	Mahadevsthan-Koteshwor-Tinkune	1,117	959	4.90	Yes
17	Narefat Petrolpump-Koteshwor-Tinkune	1,466	1382	2.23	Yes
18	Manoharafat-Jadibuti Pul-Narefat Buspark	2,154	2115	0.84	Yes

4.5.2.1.2 Validation for Traffic Volume during Evening Peak Hour

Similarly, the simulated volume was then compared to the observed volume from Day-3 during evening peak period, and the GEH values were then calculated. More than 85% GEH results for traffic volume of the major selected route satisfied the threshold criteria with GEH less than 5 as shown in Table 4.20. Hence, the model was validated successfully for traffic volume for evening peak period.

Table 4.20: Observed and simulated volume for major routes and GEH value for validation (evening peak hour)

S. N	Route	Observed Volume	Simulated Volume	GEH Value	Within Range?
1	Lokanthali-Jadibuti Pul-Jadibuti-Pepsicola	168	145	1.84	Yes
2	Lokanthali-Jadibuti Pul-Jadibuti-Koteshwor-Tinkune	1414	1371	1.16	Yes
3	Lokanthali-Jadibuti Pul-Jadibuti-Narefat Petrol Pump-Balkumari Service Lane	963	983	0.65	Yes
4	Lokanthali-Jadibuti Pul-Narefat Buspark	701	642	2.28	Yes
5	Pepsicola-Jadibuti-Jadibuti Pul-Lokanthali	239	182	3.96	Yes
6	Pepsicola-Jadibuti-Koteshwor-Tinkune	1301	1244	1.59	Yes
7	Pepsicola-Jadibuti-Narefat Petrolpump-Balkumari	885	778	3.72	Yes
8	Tinkune-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	3913	4030	1.86	Yes
9	Tinkune-Koteshwor-Jadibuti-Pepsicola	2466	2334	2.69	Yes
10	Tinkune-Koteshwor-Balkumari	1445	1409	0.95	Yes
11	Balkumari-Koteshwor-Tinkune	1244	1289	1.26	Yes
12	Balkumari-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	1043	1076	1.00	Yes
13	Balkumari-Koteshwor-Jadibuti-Pepsicola	658	639	0.73	Yes
14	Mahadevsthan-Koteshwor-Jadibuti-Jadibuti Pul-Lokanthali	310	306	0.22	Yes
15	Mahadevsthan-Koteshwor-Jadibuti-Pepsicola	195	168	2.02	Yes
16	Mahadevsthan-Koteshwor-Tinkune	354	327	1.46	Yes

S. N	Route	Observed Volume	Simulated Volume	GEH Value	Within Range?
17	Narefat Petrolpump-Koteshwor-Tinkune	420	387	1.64	Yes
18	Manoharafat-Jadibuti Pul-Narefat Buspark	615	654	1.55	Yes

4.5.2.2 Validation of the Model for Maximum Queue Length

The maximum queue length for each given approach was measured from the video footage of Day-3. This observed maximum queue length of different approaches from Day-3 was then compared with the maximum queue length generated by the VISSIM simulation fed with field data from Day-3. The validation of the model for queue length was also performed using RMSNE statistics for both morning and evening peak period.

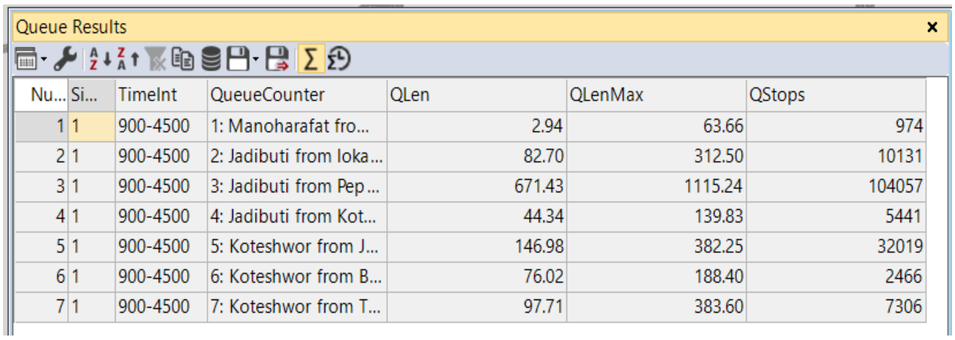
4.5.2.2.1 Validation for Maximum Queue Length during Morning Peak hour

The observed maximum queue length from Day-3 was compared with the maximum queue length generated by the VISSIM simulation for morning peak hour. The calibration of the model for queue length was performed using RMSNE statistics and has been presented in Table 4.21 and the output of VISSIM is shown in Figure 4.14.

Table 4.21: Observed and simulated maximum queue length for validation (morning peak hour)

S. N	Approach	Observed Max Queue length (m) Day 3	Simulated Max Queue length (m)	Absolute Normalized Error
1	From Koteshwor chowk towards Tinkune	335	384	0.145
2	From Koteshwor chowk towards Balkumari	210	188	0.103
3	From Koteshwor chowk towards Jadibuti	350	382	0.092
4	From Jadibuti chowk towards Koteshwor	150	140	0.068
5	From Jadibuti chowk towards Pepsicola	1030	1115	0.083
6	From Jadibuti chowk towards Lokanthali	290	313	0.078
7	From Manoharafat chowk towards Lokanthali	60	64	0.061

The RMSNE value is calculated to be 9.358% which is less than 15%, Hence, the model was validated successfully.



Queue Results

Nu...	Si...	TimeInt	QueueCounter	QLen	QLenMax	QStops
1	1	900-4500	1: Manoharafat fro...	2.94	63.66	974
2	1	900-4500	2: Jadibuti from loka...	82.70	312.50	10131
3	1	900-4500	3: Jadibuti from Pep...	671.43	1115.24	104057
4	1	900-4500	4: Jadibuti from Kot...	44.34	139.83	5441
5	1	900-4500	5: Koteshwor from J...	146.98	382.25	32019
6	1	900-4500	6: Koteshwor from B...	76.02	188.40	2466
7	1	900-4500	7: Koteshwor from T...	97.71	383.60	7306

Figure 4.14: Maximum queue length result after simulation for validation in VISSIM (morning peak hour)

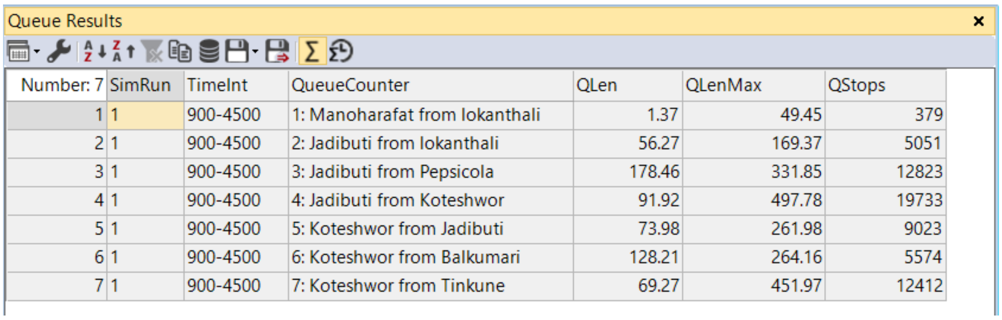
4.5.2.2.2 Validation for Maximum Queue Length during Evening Peak hour

Similarly, the observed maximum queue length from Day 3 was compared with the maximum queue length generated by the VISSIM simulation for evening peak hour. The calibration of the model for queue length was performed using RMSNE statistics and has been presented in Table 4.22 and the output of VISSIM is shown in Figure 4.15.

Table 4.22: Observed and simulated maximum queue length for validation (evening peak hour)

S. N	Approach	Observed Max Queue length (m) Day 3	Simulated Max Queue length (m)	Absolute Normalized Error
1	From Koteshwor chowk towards Tinkune	410	452	0.102
2	From Koteshwor chowk towards Balkumari	250	264	0.057
3	From Koteshwor chowk towards Jadibuti	260	262	0.008
4	From Jadibuti chowk towards Koteshwor	450	498	0.106
5	From Jadibuti chowk towards Pepsicola	380	332	0.127
6	From Jadibuti chowk towards Lokanthali	180	169	0.059
7	From Manoharafat chowk towards Lokanthali	50	49	0.011

The RMSNE value is calculated to be 8.00% which is less than 15%, Hence, the model was validated successfully.



Queue Results

Number: 7	SimRun	TimeInt	QueueCounter	QLen	QLenMax	QStops
1	1	900-4500	1: Manoharafat from lokanthali	1.37	49.45	379
2	1	900-4500	2: Jadibuti from lokanthali	56.27	169.37	5051
3	1	900-4500	3: Jadibuti from Pepsicola	178.46	331.85	12823
4	1	900-4500	4: Jadibuti from Koteshwor	91.92	497.78	19733
5	1	900-4500	5: Koteshwor from Jadibuti	73.98	261.98	9023
6	1	900-4500	6: Koteshwor from Balkumari	128.21	264.16	5574
7	1	900-4500	7: Koteshwor from Tinkune	69.27	451.97	12412

Figure 4.15: Maximum queue length result after simulation for validation in VISSIM (evening)

4.6 Scenario Analysis

After the successful calibration and validation of the model, the next step involved a systematic analysis of the performance of the various operational strategies under controlled simulation environments. For the performance evaluation of exclusive bus lane system with signal priority, exclusive bus lanes were introduced in the simulation model along the selected section modifying lane configurations and restricting access to these lanes for private vehicles. Similarly, a signal priority system that grants preferential treatment to buses approaching signalized intersections was implemented. The results generated from each of these scenarios were compared with existing model. Finally, the performance of each scenario was evaluated using performance indicators such as queue length at the intersection and travel time.

4.6.1 Description of Scenarios

The following scenarios were created in simulation environment.

4.6.1.1 Scenario S1: Base Case Scenario

The role of this base-case model has two main purposes. First, it acts as reference point of all the changes. Second, it guarantees that any positive or negative change in the other scenarios can be explained. It is thus important to ensure consistency between the field and the base-case in order to make any sensible comparisons.

The base-case scenario model was established in the VISSIM from the previously validated model. The three-day average field data were used as input for the simulation keeping other all parameters same as in calibrated and validated model. The simulation was run, and the results were obtained which serve as the base for comparison with the results of other scenarios.

4.6.1.2 Scenario S2: Exclusive Bus Lane with Existing Signal

In this scenario, the curb side exclusive bus lanes were introduced in the base-case model keeping all other parameters constant. The bus lanes were introduced similar to the express bus service layout carried out by Department of Roads in September 21, 2023 A.D. The layout showing the exclusive bus lanes is shown in Figure 4.16. Existing bus lay-bys configurations were retained in the simulation model without any geometric redesign or optimization. The simulation was run, and the results were analyzed.

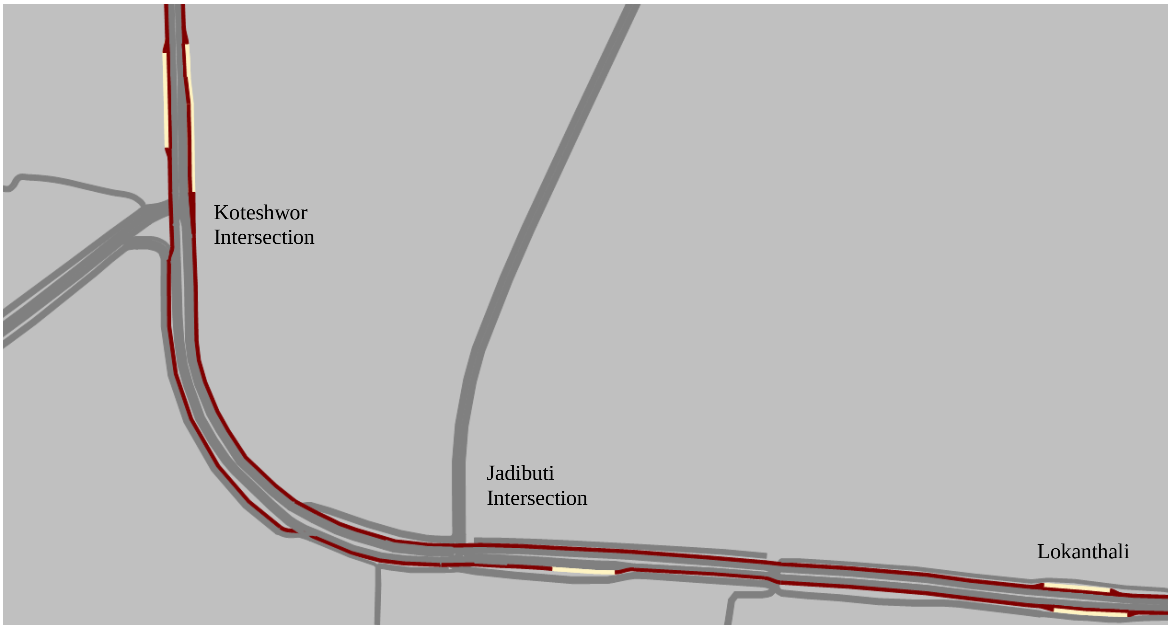


Figure 4.16: Layout showing the exclusive bus lanes in scenario S2

4.6.1.3 Scenario S3: Exclusive Bus Lane (Modified) with Existing Signal

In this scenario, alignment of the exclusive bus lanes were modified as described below, while all other parameters were kept consistent with Scenario S2.

The alignment of the exclusive bus lane on Lokanthali-Tinkune approach was slightly modified between the Manoharafat and Jadibuti intersection. After the Manoharafat intersection, the bus lane was diverted toward the bridge connecting Narefat buspark and then rejoined the original alignment immediately beyond the bridge as shown in Figure 4.17. This adjustment created additional space in the main carriageway, allowing other vehicles to operate within a narrower but more continuous lane.

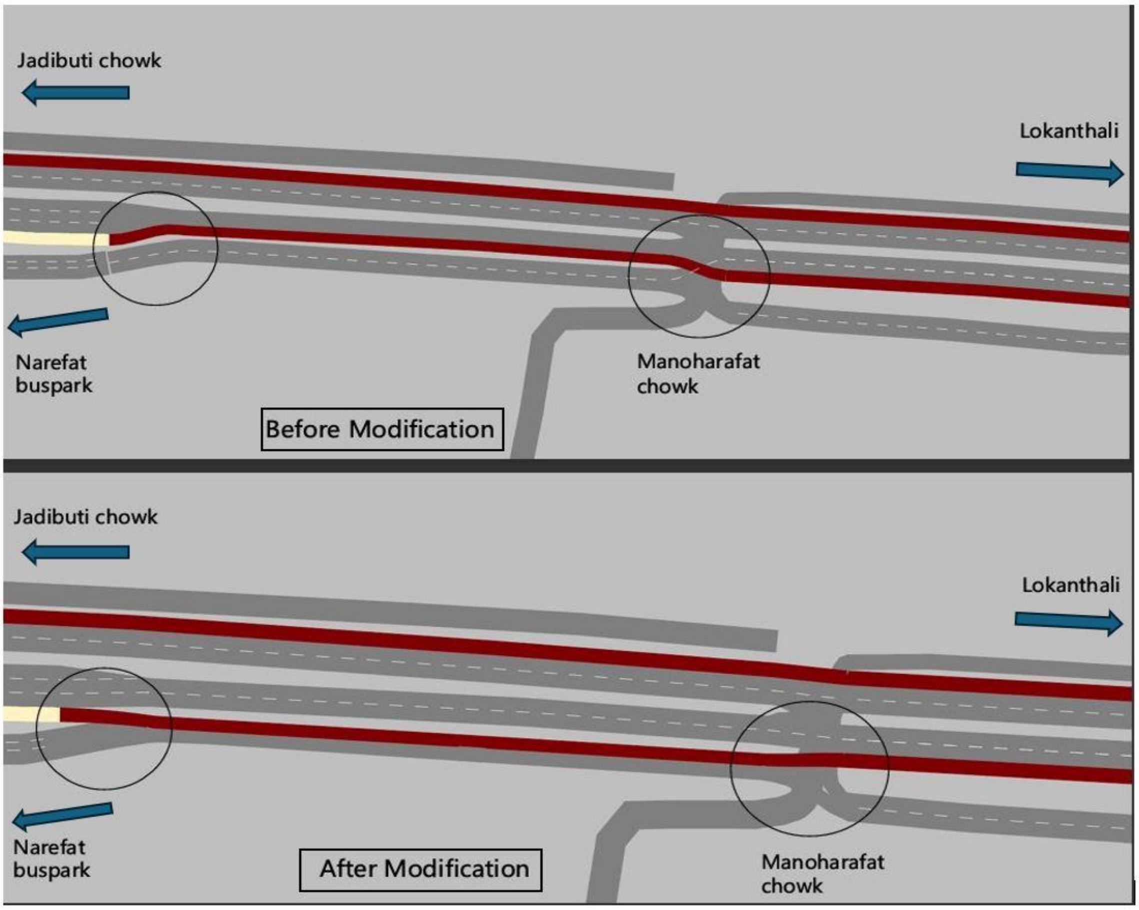


Figure 4.17: Modifications in exclusive bus lane layout near Jadibuti bridge

Similarly, prior to the Koteshwor intersection in Lokanthali-Tinkune approach, the exclusive bus lane was extended directly through the traffic island to the downstream side of the intersection, rather than merging into the main lane on upstream side.

Furthermore, the bus stop located upstream of the Koteshwor intersection in Tinkune-Lokanthali approach was relocated to the downstream side of the intersection keeping the length and capacity same as existing. This relocation freed up space on the approach, effectively making an additional lane available for mixed traffic before the intersection. By removing the bus stop from the upstream section, interruptions caused by bus dwell time and merging maneuvers were minimized. These changes are shown in Figure 4.18 below:

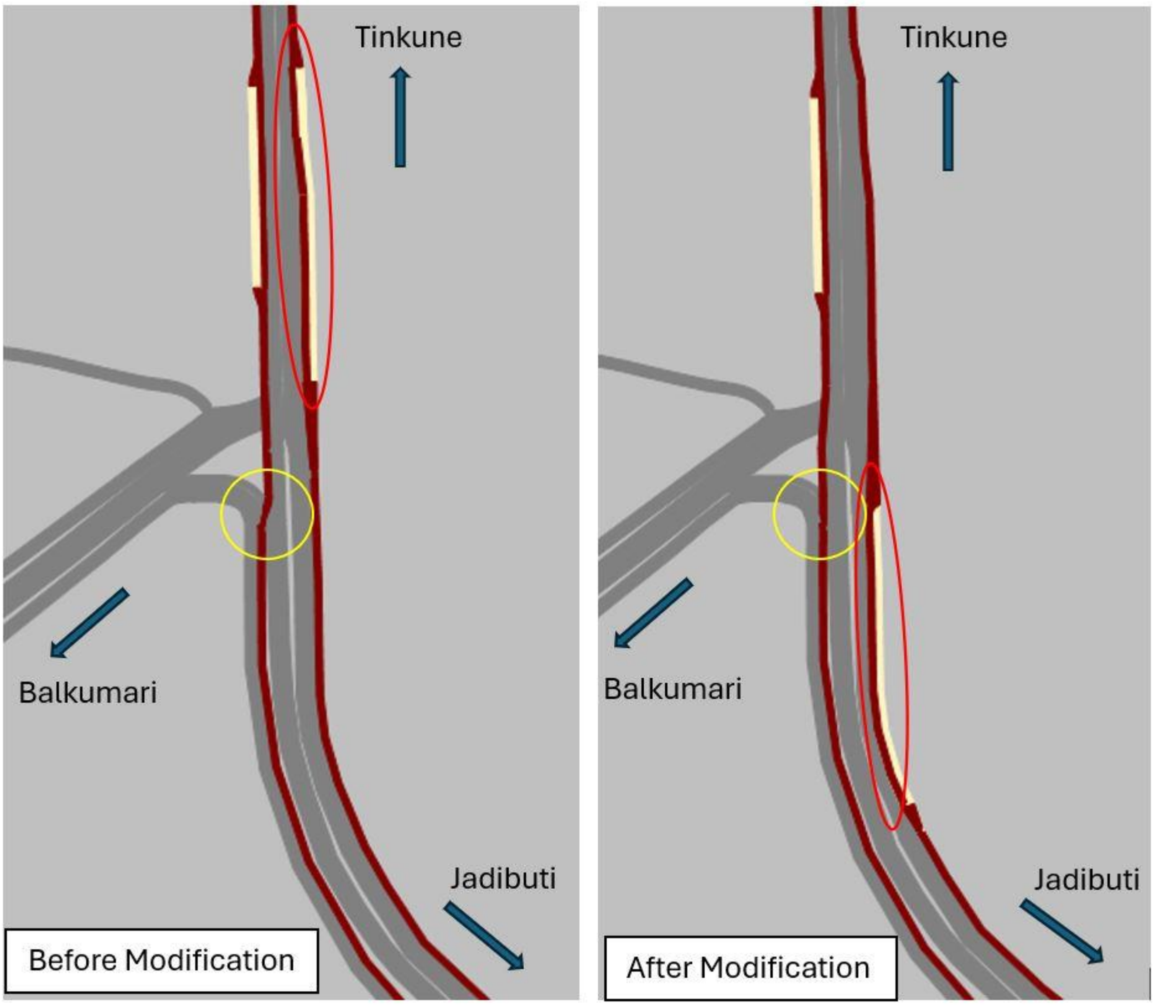


Figure 4.18: Modifications in exclusive bus lane layout near Koteshwor intersection

4.6.1.4 Scenario S4: Exclusive Bus Lane with Through Priority

In this scenario, the alignment of the bus lane was kept similar to that of scenario S3 and the priority to public transportation was introduced at both intersection. At Koteshwor intersection, public transportations from Tinkune were allowed to flow uninterruptedly towards Jadibuti through the outside lane since there is no conflict point at this lane. Similarly, at Jadibuti intersection, public transportations from Lokanthali were given full priority for uninterrupted flow through Jadibuti intersection against vehicle flowing from Narefat buspark approach. The simulation was run with these changes and the results were analyzed.

4.6.1.5 Scenario S5: Exclusive Bus Lane with Signal Priority (Phase Insertion)

In this scenario, along with the priority provided to public transportation as in Scenario S4, an additional level of signal priority was introduced on the other approaches. The phase insertion technique, one of the simplest forms of signal priority, was adopted in this study. It operates by introducing an additional phase dedicated to bus movement after each existing signal phase.

The selection of phase insertion was based on practical considerations. Advanced signal priority strategies as discussed in Section 2.4.1, such as green extension and red truncation require reliable bus detection infrastructure, including GPS-based vehicle tracking, loop detectors, or camera-based sensors and adaptive signal controllers capable of real-time phase modification. Such infrastructure is not currently available across the study corridor, and its installation would represent a significant capital investment that may not be immediately feasible in the context of Kathmandu's existing traffic management capacity. Phase insertion, however, can be implemented through minimal modifications to existing signal timing, making it a cost-effective and practically deployable near-term solution. The study therefore evaluates a realistic and accessible intervention rather than an infrastructure-intensive ideal scenario.

To implement this approach, the original phase serving buses in the exclusive bus lane was divided into smaller equal segments and inserted between each existing phase at both intersections without altering the timing of other phases and overall cycle length. The new signal time after phase insertion for morning and evening peak hour is shown in Figure 4.19 and Figure 4.20 below.

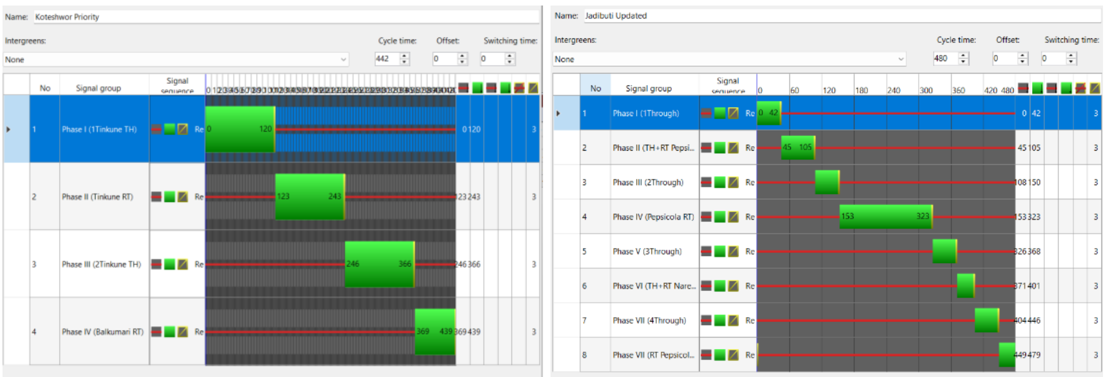


Figure 4.19: Updated signal timing for signal priority (phase insertion) for morning peak hour

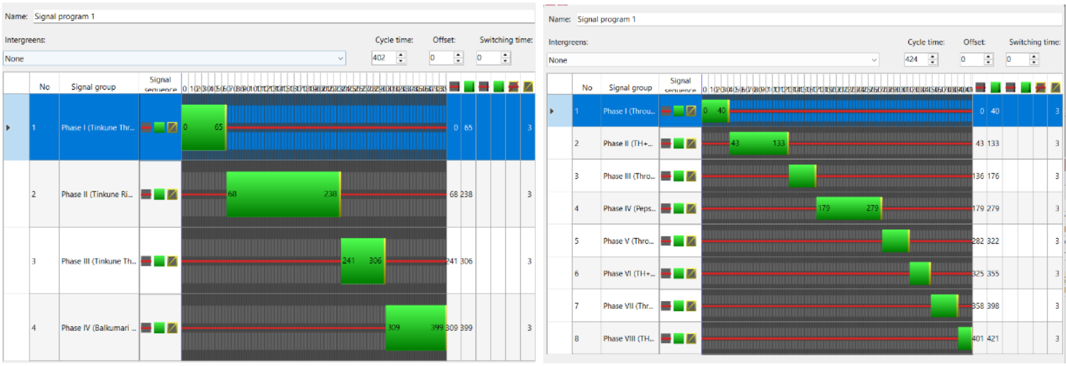


Figure 4.20: Updated signal timing for signal priority (phase insertion) for evening peak hour

4.6.2 Scenario Analysis Results

This section presents and analyzes the results obtained after simulating all the above-mentioned scenarios in VISSIM, focusing on queue length and travel time providing a comparative assessment of their impacts on overall traffic conditions.

4.6.2.1 Queue Length Analysis

Queue length is one of the performance indicators used in this study which reflects the degree of congestion. Maximum queue lengths and average queue lengths were analyzed which reflects both worst-case congestion and average congestion across twelve sections along the study network.

4.6.2.1.1 Queue Length Analysis for Morning Peak Hour

The maximum queue lengths reflecting the worst-case congestion recorded across all twelve sections for each of the five simulated scenarios during the morning peak hour, as obtained from VISSIM microsimulation is presented in Table 4.23. The percentage change was calculated with respect to base-case scenario where negative sign indicates reduction of queue length from the base-case scenario.

Table 4.23: Maximum queue length results for all scenarios (morning peak hour)

	Section No. & Name	Maximum queue lengths (m) & Percentage change w.r.t Base-case scenario								
		S1 Base Case	S2 EBL	% Change	S3 EBL Modified	% Change	S4 BSP Through	% Change	S5 BSP Phase Insertion	% Change
Normal Lanes	1: From Manoharafat chowk towards Lokanthali	158	961	508%	689	336%	675	327%	426	170%
	2: From Jadibuti chowk towards Lokanthali	252	458	82%	425	69%	433	72%	408	62%
	3: From Jadibuti chowk towards Pepsicola	1137	1405	24%	1402	23%	1405	24%	1405	23%
	4: From Jadibuti chowk towards Koteshwor	162	212	31%	162	0%	164	1%	145	-10%
	5: From Koteshwor chowk towards Jadibuti	330	609	84%	593	80%	605	83%	565	71%
	6: From Koteshwor chowk towards Balkumari	192	192	0%	192	0%	194	1%	191	-1%
	7: From Koteshwor chowk towards Tinkune	296	522	76%	300	1%	316	7%	215	-27%
Exclusive Bus Lane	8: EBL from Manoharafat chowk towards Lokanthali	158	25	-84%	26	-84%	25	-84%	21	-87%
	9: EBL from Jadibuti chowk towards Lokanthali	252	114	-55%	114	-55%	0	-100%	0	-100%
	10: EBL from Jadibuti chowk towards Koteshwor	162	141	-13%	157	-3%	156	-4%	116	-28%
	11: EBL from Koteshwor chowk towards Jadibuti	268	158	-41%	101	-62%	105	-61%	77	-71%
	12: EBL from Koteshwor chowk towards Tinkune	296	35	-88%	31	-89%	0	-100%	0	-100%

The introduction of the Exclusive Bus Lane (EBL) in Scenario S2 produces contrasting outcomes between the normal and exclusive bus lanes. On the normal traffic lanes, the reallocation of road space to buses significantly increases maximum queues on all sections. Section 1 experiences the most dramatic increase, with maximum queue length rising from 158 m to 961 m (an increase of 508%), while Section 5 increases by 84% (from 330 m to 609 m) and Section 7 by 76% (from 296 m to 522 m). These increases are attributable to the reduction in effective lane capacity for mixed traffic, which forces general vehicles to compete for fewer lanes under same condition. However, bus lanes in S2 benefit greatly, with Sections 8 and 12 dropping by 84% and 88% respectively, confirming that the physical separation of bus traffic substantially improves bus flow.

Scenario S3 achieves slight improvement over S2 where Section 1 and 2 show marginal reductions in maximum queue compared to S2. Correspondingly, the bus lanes in S3 maintain equivalent or slightly better than S2. The modifications suggest that lane modifications and shifting of bus stop towards downstream can reduce maximum queue lengths without sacrificing bus lane efficiency.

Scenario S4 produces results broadly similar to S3 on normal lanes, with notable improvements on bus lanes where Section 9 (EBL from Jadibuti towards Lokanthali) and Section 12 (EBL from Koteshwor towards Tinkune) record zero queues due to uninterrupted flow through the intersection.

Scenario S5 emerges as the most effective scenario across the morning peak hour. On the normal traffic lanes, Section 1 sees its maximum queue fall to 426 m from 961 m in S2, an increase of 170% over base case compared to 508% in S2. More significantly, several sections show queue lengths below base case under S5: Section 4 drops to 145 m (-10%), Section 6 to 191 m (-1%), and Section 7 to 215 m (-27%), indicating genuine capacity relief rather than mere redistribution.

On the exclusive bus lanes, S5 consistently achieves the highest reductions, with Section 8 falling 87%, Section 11 by 71%, and Sections 9 and 12 recording zero queues.

For clearer visualization and comparison, these results are also presented graphically in grouped bar chart shown in Figure 4.21, where the relative differences in maximum queue lengths between scenarios can be easily observed for all twelve sections during morning peak hour.

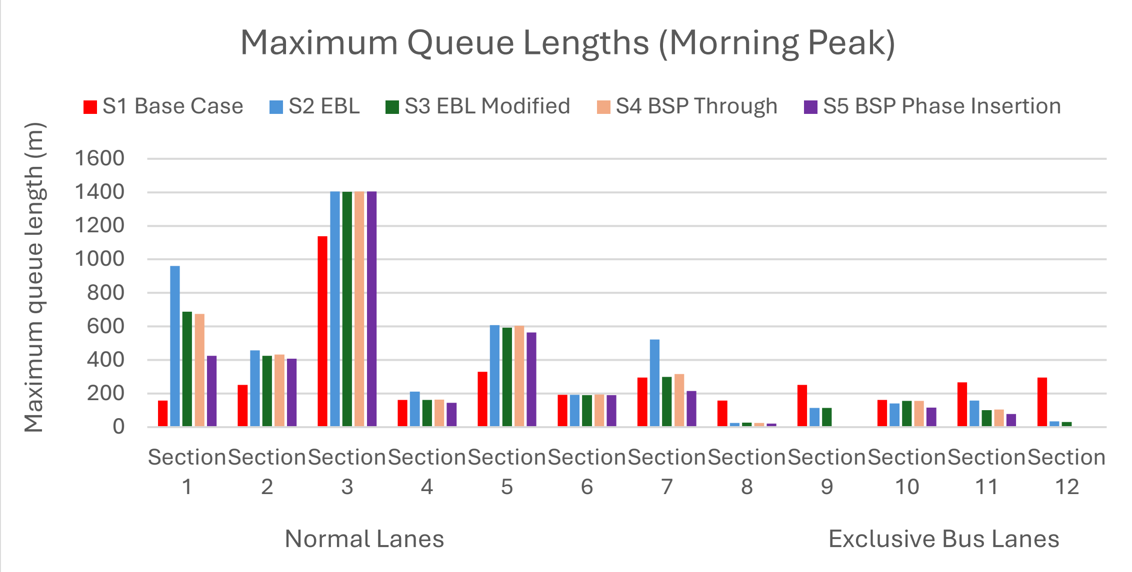


Figure 4.21: Grouped bar chart showing the maximum queue lengths for all scenarios (morning peak hour)

The corresponding average queue lengths are provided in Table 4.24, enabling a more comprehensive assessment across the network. These data reinforce the patterns observed in maximum queue analysis. The average queue rise substantially on normal lanes but decreases on exclusive bus lanes on S2. Similarly, S5 consistently records the lowest average queues across both normal and exclusive bus lanes and confirming that phase insertion directly benefits public transport flow in the network.

Table 4.24: Average queue length results for all scenarios (morning peak hour)

	Section No. & Name	Average queue lengths (m) & Percentage change w.r.t Base-case scenario								
		S1 Base Case	S2 EBL	% Change	S3 EBL Modified	% Change	S4 BSP Through	% Change	S5 BSP Phase Insertion	% Change
Normal Lanes	1: From Manoharafat chowk towards Lokanthali	77	395	415%	245	220%	232	202%	158	107%
	2: From Jadibuti chowk towards Lokanthali	82	238	191%	225	175%	220	169%	196	139%
	3: From Jadibuti chowk towards Pepsicola	677	829	23%	833	23%	822	21%	825	22%
	4: From Jadibuti chowk towards Koteshwor	51	65	28%	67	33%	67	32%	38	-25%
	5: From Koteshwor chowk towards Jadibuti	108	373	244%	361	233%	355	227%	322	197%
	6: From Koteshwor chowk towards Balkumari	72	73	1%	73	1%	73	2%	75	4%

	Section No. & Name	Average queue lengths (m) & Percentage change w.r.t Base-case scenario								
		S1 Base Case	S2 EBL	% Change	S3 EBL Modified	% Change	S4 BSP Through	% Change	S5 BSP Phase Insertion	% Change
	7: From Koteshwor chowk towards Tinkune	84	182	118%	82	-2%	81	-3%	60	-28%
Exclusive Bus Lane	8: EBL from Manoharafat chowk towards Lokanthali	77	20	-74%	20	-74%	18	-77%	17	-78%
	9: EBL from Jadibuti chowk towards Lokanthali	82	18	-78%	18	-78%	0	-100%	0	-100%
	10: EBL from Jadibuti chowk towards Koteshwor	51	15	-70%	20	-60%	21	-59%	14	-72%
	11: EBL from Koteshwor chowk towards Jadibuti	108	14	-88%	10	-90%	11	-90%	6	-94%
	12: EBL from Koteshwor chowk towards Tinkune	84	18	-79%	3	-96%	0	-100%	0	-100%

For clearer visualization and comparison, these results are also presented graphically in grouped bar chart shown in Figure 4.22, where the relative differences in average queue lengths between scenarios can be easily observed for all twelve scenarios during morning peak hour.

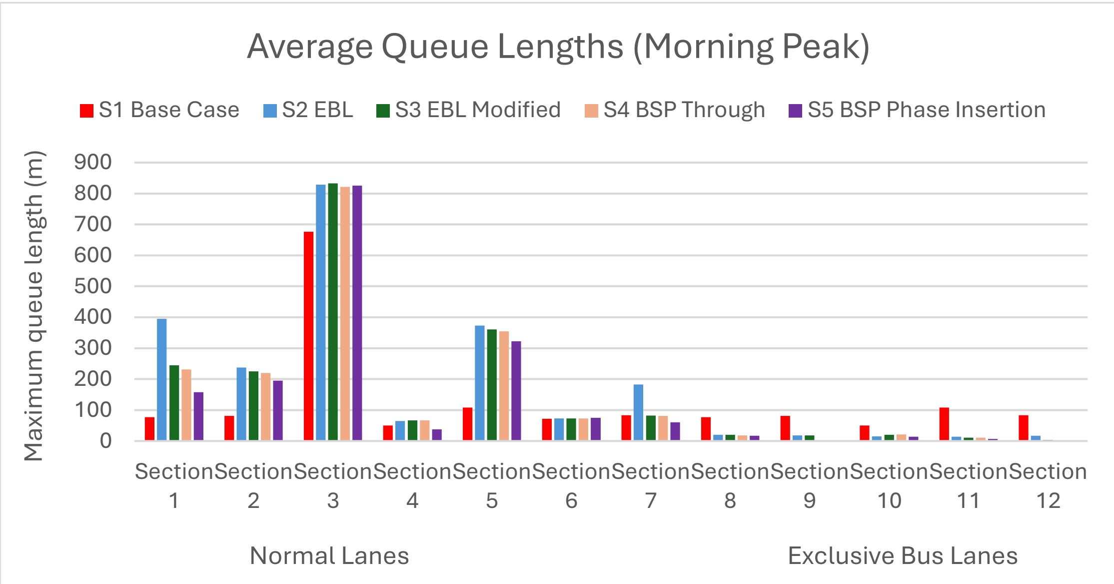


Figure 4.22: Grouped bar chart showing the average queue lengths for all scenarios (morning peak hour)

4.6.2.1.2 Queue Length Analysis for Evening Peak Hour

The evening peak hour presents a distinct pattern compared to the morning, with different directional splits and higher volumes on certain approaches, particularly those associated with the return commute towards Lokanthali from Tinkune and Balkumari. The maximum queue lengths reflecting the worst-case congestion recorded across all twelve sections for each of the five simulated scenarios during the evening peak hour, as obtained from VISSIM microsimulation is presented in Table 4.25.

Table 4.25: Maximum queue length results for all scenarios (evening peak hour)

	Section No. & Name	Maximum queues length (m) & Percentage change w.r.t Base-case scenario								
		S1 Base Case	S2 EBL	% Change	S3 EBL Modified	% Change	S4 BSP Through	% Change	S5 BSP Phase Insertion	% Change
Normal Lanes	1: From Manoharafat chowk towards Lokanthali	56	147	164%	113	102%	109	96%	89	61%
	2: From Jadibuti chowk towards Lokanthali	170	175	3%	160	-6%	160	-6%	93	-45%
	3: From Jadibuti chowk towards Pepsicola	411	580	41%	604	47%	613	49%	596	45%
	4: From Jadibuti chowk towards Koteshwor	396	556	40%	608	54%	587	48%	191	-52%
	5: From Koteshwor chowk towards Jadibuti	260	247	-5%	207	-20%	218	-16%	159	-39%
	6: From Koteshwor chowk towards Balkumari	290	295	2%	299	3%	283	-2%	251	-13%
	7: From Koteshwor chowk towards Tinkune	430	763	78%	461	7%	448	4%	245	-43%
Exclusive Bus Lane	8: EBL from Manoharafat chowk towards Lokanthali	56	19	-66%	18	-67%	15	-73%	10	-81%
	9: EBL from Jadibuti chowk towards Lokanthali	170	165	-3%	165	-3%	0	-100%	0	-100%
	10: EBL from Jadibuti chowk towards Koteshwor	396	116	-71%	147	-63%	129	-67%	73	-82%
	11: EBL from Koteshwor chowk towards Jadibuti	260	242	-7%	241	-7%	255	-2%	41	-84%
	12: EBL from Koteshwor chowk towards Tinkune	430	93	-78%	40	-91%	0	-100%	0	-100%

Similar to morning peak hour, Scenario S2 again produces the most adverse effects on normal lanes during the evening. The maximum queues in Section 1 increases by 164% (from 56m to 147m), Section 7 by 78% (from 430 m to 763 m), Section 4 by 40% (396 m to 556 m), and Section 3 by 41% (411 m to 580 m). These impacts are slightly less severe than in the morning thereby reducing the severity of lane reallocation impacts. Scenario S3 delivers mixed outcomes. While maximum queues in Section 5 falls to 207 m (-20% over base case) and Section 7 increases slightly to 461 m (+7%), but queues in Section 4 increases significantly to 608 m (+54%), indicating that bus stop reassignment shifts congestion from one intersection to another rather than resolving it. Furthermore, the performance of scenario S5 during the evening is again superior across most sections. Maximum queues in Section 4 reduces to 191 m from the base case of 396 m, a reduction of 52%, while Section 7 falls to 245 m (-43%) and Section 5 to 159 m (-39%). These improvements are substantially larger than those achievable in the morning under S5, implying that phase insertion is especially more effective during evening peak hour.

The exclusive bus lanes (EBLs) sections show more significant and consistent reduction in maximum queues. All scenarios reduce maximum queues compared to the base case, but the level of improvement varies. S2 and S3 reduce queues slightly. S5, on the other hand, brings them down to the lowest levels across all approaches with Section 8 falling 81%, Section 10 by 82%, Section 11 by 84%, and Sections 9 and 12 recording zero queues, consistent with morning results.

For clearer visualization and comparison, these results are also presented graphically in grouped bar chart shown in Figure 4.23, where the relative differences in maximum queue lengths between scenarios can be easily observed for all twelve sections during evening peak hour.

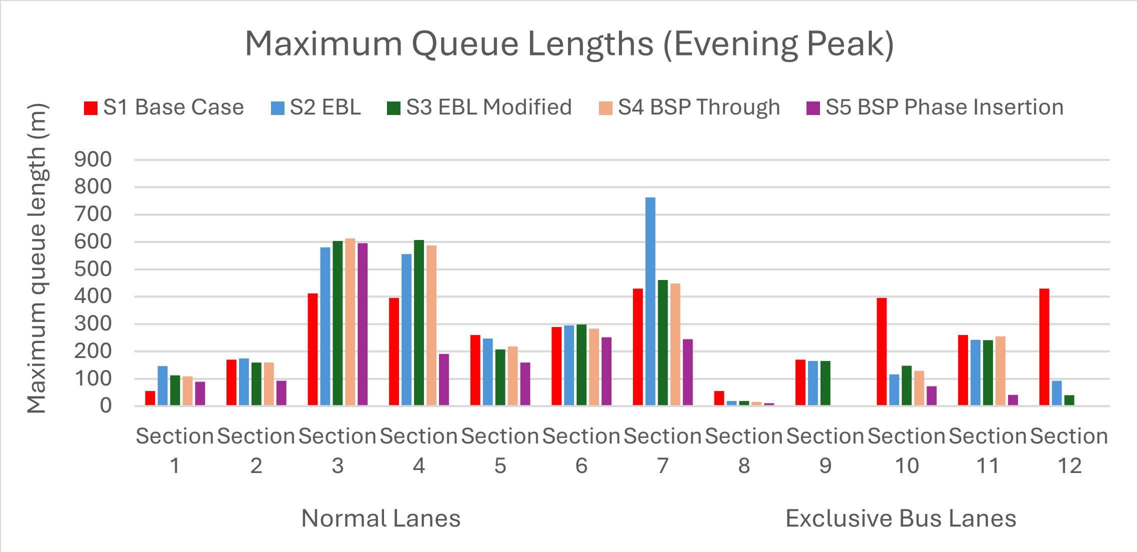


Figure 4.23: Grouped bar chart showing the maximum queue lengths for all scenarios (evening peak hour)

Similarly, the results corresponding average queue length for all the scenarios during evening peak hour is presented in Table 4.26, enabling a more comprehensive assessment across the network. These data reinforce the patterns observed in maximum queue analysis. The average queue rise substantially on normal lanes but decreases on exclusive bus lanes on S2. Similarly, S5 consistently records the lowest average queues across both normal and exclusive bus lanes and confirming that phase insertion directly benefits public transport flow in the network.

Table 4.26: Average queue length results for all scenarios (evening peak hour)

	Section No. & Name	Average queue lengths (m) & Percentage change w.r.t Base-case scenario								
		S1 Base Case	S2 EBL	% Change	S3 EBL Modified	% Change	S4 BSP Through	% Change	S5 BSP Phase Insertion	% Change
Normal Lanes	1: From Manoharafat chowk towards Lokanthali	15	19	29%	17	16%	17	10%	16	9%
	2: From Jadibuti chowk towards Lokanthali	59	60	2%	61	4%	63	7%	15	-74%
	3: From Jadibuti chowk towards Pepsicola	241	375	56%	366	52%	379	57%	362	50%
	4: From Jadibuti chowk towards Koteshwor	99	196	97%	330	232%	318	220%	51	-48%
	5: From Koteshwor chowk towards Jadibuti	70	123	75%	106	51%	108	55%	66	-6%

	Section No. & Name	Average queue lengths (m) & Percentage change w.r.t Base-case scenario								
		S1 Base Case	S2 EBL	% Change	S3 EBL Modified	% Change	S4 BSP Through	% Change	S5 BSP Phase Insertion	% Change
	6: From Koteshwor chowk towards Balkumari	126	206	63%	188	49%	129	2%	117	-7%
	7: From Koteshwor chowk towards Tinkune	170	205	21%	161	-5%	158	-7%	136	-20%
Exclusive Bus Lane	8: EBL from Manoharafat chowk towards Lokanthali	15	10	-31%	9	-44%	8	-45%	5	-65%
	9: EBL from Jadibuti chowk towards Lokanthali	59	39	-34%	34	-42%	0	-100%	0	-100%
	10: EBL from Jadibuti chowk towards Koteshwor	99	12	-88%	17	-83%	10	-89%	5	-95%
	11: EBL from Koteshwor chowk towards Jadibuti	70	17	-76%	15	-78%	26	-63%	16	-76%
	12: EBL from Koteshwor chowk towards Tinkune	170	41	-76%	18	-90%	0	-100%	0	-100%

For clearer visualization and comparison, these results are also presented graphically in grouped bar chart shown in Figure 4.24, where the relative differences in average queue lengths between scenarios can be easily observed for all twelve scenarios during Evening peak hour.

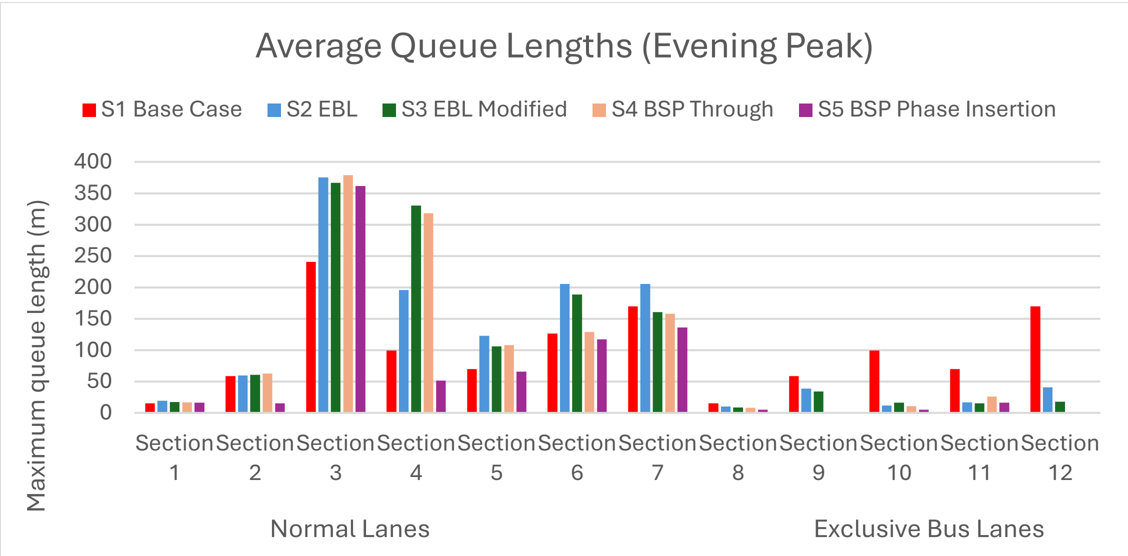


Figure 4.24: Grouped bar chart showing the average queue lengths for all scenarios (evening peak hour)

4.6.2.2 Travel Time Analysis

Travel Time is another performance indicator used in this study for evaluation of different scenarios. Travel time results for public transportations (bus, minibus and micro), all vehicles plying in the roads except public transportation and light private vehicles only (motorcycle, car, jeep) obtained from simulation of all scenarios were analyzed and compared for both morning and evening peak hours. The analysis focused on identifying variations in travel time across all scenarios.

4.6.2.2.1 Travel Time Analysis for Morning Peak Hour

The travel time for the public transport and other vehicles except public transport travelling from Tinkune to Lokanthali and vice-versa are presented in Table 4.27 which was obtained after the simulation of all five scenarios during morning peak hour in VISSIM. The percentage changes with respect to the base case where negative sign indicates reduction of travel time from the base-case scenario are further summarized in the accompanying Table 4.28 below:

Table 4.27: Travel time result for all scenarios (morning peak hour)

S.N	Appr-oach	Vehicle Class	Travel Time (in seconds)				
			S1 Base Case	S2 EBL	S3 EBL Modified	S4 BSP Through	S5 BSP Phase Insertion
1	Tinkune-Lokanthali	Large Bus	666	558	531	523	514
2		Mini Bus	711	585	572	555	529
3		Micro	506	484	474	450	450
4		Average of PT	628	545	531	517	505
5		All Vehicle except PT	331	400	340	334	288
6		Private Vehicles	330	399	340	334	287
7	Lokanthali-Tinkune	Large Bus	682	588	580	539	489
8		Mini Bus	666	629	625	562	514
9		Micro	511	507	505	426	424
10		Average of PT	620	579	570	509	476
11		All Vehicle except PT	438	869	855	853	731
12		Private Vehicles	437	870	855	855	732

Table 4.28: Percentage change on travel time w.r.t base-case scenario for all scenarios (morning peak hour)

S.N	Appr-oach	Vehicle Class	% Change w.r.t Base-case scenario			
			S2 EBL	S3 EBL Modified	S4 BSP Through	S5 BSP Phase Insertion
1	Tinkune-Lokanthali	Large Bus	-16%	-20%	-21%	-23%
2		Mini Bus	-18%	-20%	-22%	-26%
3		Micro	-4%	-6%	-11%	-11%
4		Average of PT	-13%	-16%	-18%	-20%
5		All Vehicle except PT	21%	3%	1%	-13%
6		Private Vehicles	21%	3%	1%	-13%
7	Lokanthali-Tinkune	Large Bus	-14%	-15%	-21%	-28%
8		Mini Bus	-6%	-6%	-16%	-23%
9		Micro	-1%	-1%	-17%	-17%
10		Average of PT	-7%	-8%	-18%	-23%
11		All Vehicle except PT	98%	95%	95%	67%
12		Private Vehicles	99%	96%	95%	67%

The introduction of the EBL in Scenario S2 yields immediate and significant travel time benefits for PT in the Tinkune-Lokanthali approach. Large buses improve by 16% (666 s to 558 s), mini buses by 18% (711s to 585s), micro by 4% (506s to 484s), and PT in average improve by 13% (628s to 545s). The Lokanthali-Tinkune approach presents slightly less travel time benefits for PT in Scenario S2 than opposite approach where PT improve by 1-14% to that of base case, with the overall PT average improving by 7% (620s to 579s). These reductions directly reflect the benefit of segregated lanes in eliminating public transportation conflicts with other vehicles and enabling them to maintain more consistent movement. Scenario S3 offers a marginal improvement whereas scenario S4 extends these improvements further in both approaches. Scenario S5 demonstrates the most significant improvement in public transport average travel time during the morning peak hour in both directions. In particular, the Lokanthali-Tinkune approach exhibits a slightly greater improvement, with travel time decreasing to 476s (-23% vs base case), whereas the Tinkune-Lokanthali direction records a comparatively smaller improvement, with travel time reduced to 505s (-20% vs base case).

However, for other vehicles except PT, plying on normal lanes in scenario S2 during the morning peak hour increases the travel time substantially in both directions: Tinkune-Lokanthali approach increases by 21% (331s to 400s), and Lokanthali-Tinkune increases sharply by 98% (438s to 869s), as the reduced lane availability for general traffic intensifies congestion, an outcome that is entirely consistent with the queue results discussed above. Scenario S3 offers an incremental improvement over S2 for particularly Tinkune-Lokanthali approach. This suggests that the modifications introduced in S3 partially restore capacity for general traffic without substantially compromising public transport efficiency.

Scenario S5 achieves the most favorable outcomes for other vehicles plying in Tinkune-Lokanthali approach where the travel time drops by 13% (331s to 288 s) from that base case scenario. In contrast, Lokanthali-Tinkune approach exhibits less favorable performance for other vehicles. Although travel time is reduced to 731s, it remains 67% higher than the base case. Nevertheless, this still represents a notable mitigation of adverse impacts when compared to Scenarios S2 and S3, indicating that S5 offers a comparatively improved balance between public transport priority and general traffic performance.

To sum up, Scenario S5 comes out superior because it shows a better balance and gives public transport the strongest priority and the largest travel-time savings on both approaches, but it doesn’t punish private vehicles as severely as other scenarios. In fact, the implementation of signal priority in conjunction with the exclusive bus lane (EBL) is not only beneficial for PT in both approaches, but also for the other vehicles plying on the normal lanes of Tinkune-Lokanthali approach.

For clearer visualization and comparison, these results are also presented graphically in line chart shown in Figure 4.25, where the relative differences in travel times between scenarios can be easily observed for vehicle classes during morning peak hour.

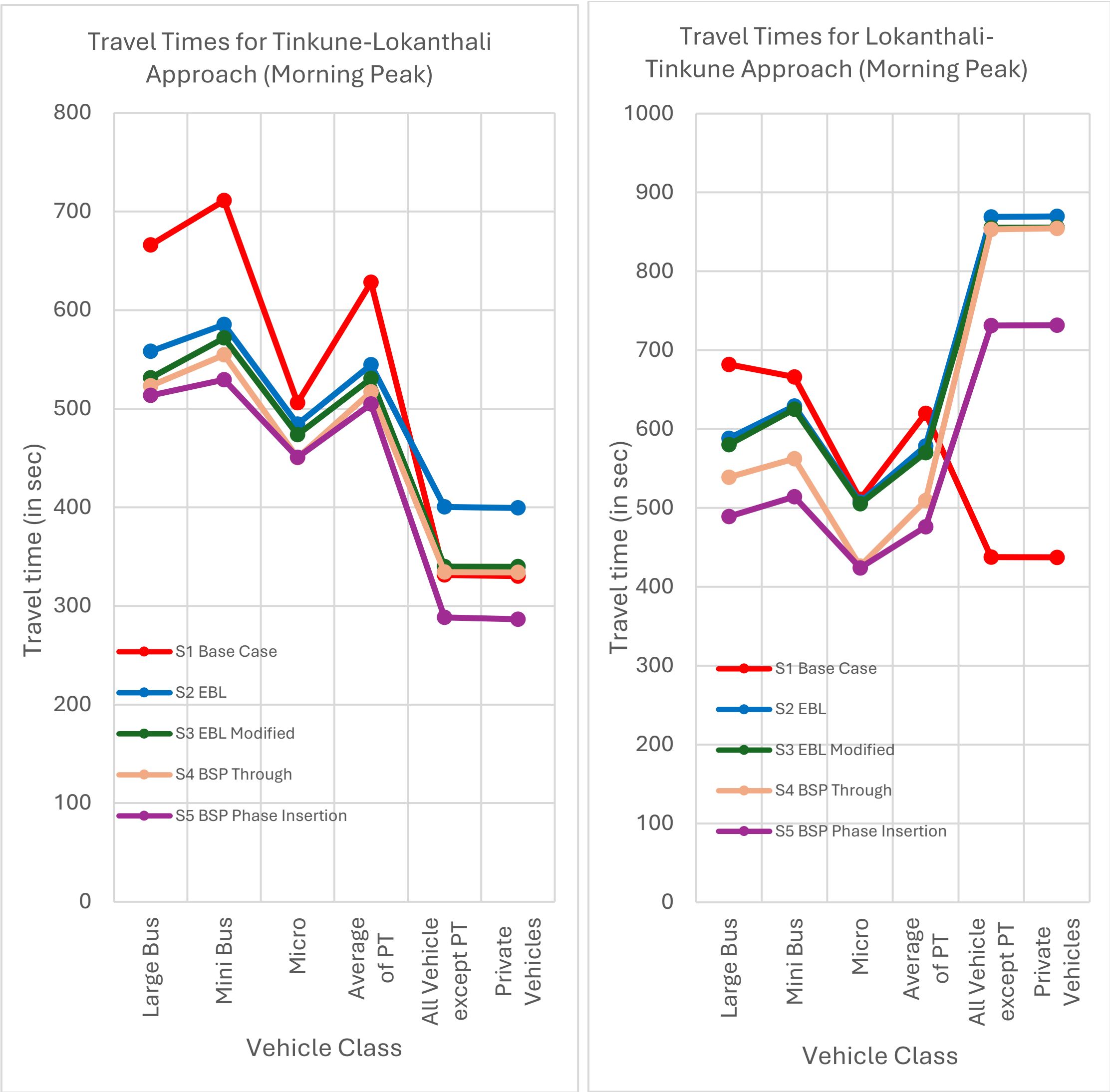


Figure 4.25: Line chart showing the travel time results for all scenarios (morning peak hour)

4.6.2.2.2 Travel Time Analysis for Evening Peak Hour

The travel time for the different vehicle classes travelling from Tinkune to Lokanthali and vice-versa are presented in Table 4.29, which was obtained after the simulation of all five scenarios during evening peak hour in VISSIM. The percentage changes with respect to the base case where negative sign indicates reduction of travel time from the base-case scenario are further summarized in the accompanying Table 4.30.

Table 4.29: Travel time result for all scenarios (evening peak hour)

S.N	Appr-oach	Vehicle Class	Travel Time (in seconds)				
			S1 Base Case	S2 EBL	S3 EBL Modified	S4 BSP Through	S5 BSP Phase Insertion
1	Tinkune-Lokanthali	Large Bus	666	584	570	558	521
2		Mini Bus	684	600	577	589	503
3		Micro	504	511	509	500	464
4		Average of PT	618	576	558	532	492
5		All Vehicle except PT	341	426	415	411	329
6		Private Vehicles	341	425	414	411	329
7	Lokanthali-Tinkune	Large Bus	715	504	500	486	475
8		Mini Bus	604	560	556	538	516
9		Micro	567	441	439	436	419
10		Average of PT	692	502	498	487	472
11		All Vehicle except PT	391	517	491	488	390
12		Private Vehicles	389	515	489	487	389

Table 4.30: Percentage change on travel time w.r.t base-case scenario for all scenarios (evening peak hour)

S.N	Appr-oach	Vehicle Class	% Change w.r.t Base-case scenario			
			S2 EBL	S3 EBL Modified	S4 BSP Through	S5 BSP Phase Insertion
1	Tinkune-Lokanthali	Large Bus	-12%	-14%	-16%	-22%
2		Mini Bus	-12%	-16%	-14%	-26%
3		Micro	1%	1%	-1%	-8%
4		Average of PT	-7%	-10%	-14%	-20%
5		All Vehicle except PT	25%	22%	21%	-3%
6		Private Vehicles	25%	22%	21%	-4%
7	Lokanthali-Tinkune	Large Bus	-30%	-30%	-32%	-34%
8		Mini Bus	-7%	-8%	-11%	-15%
9		Micro	-22%	-23%	-23%	-26%
10		Average of PT	-28%	-28%	-30%	-32%
11		All Vehicle except PT	32%	26%	25%	0%
12		Private Vehicles	33%	26%	25%	0%

Travel time for PT in the Tinkune-Lokanthali approach in scenario S2 improve by 12% except micro which remains similar to that of base case, with the overall PT average falling to 576s (-7%). In Lokanthali-Tinkune approach, PT average, however, drops substantially from 692s to 502s (-28%), which is considerably more pronounced than the opposite approach. Scenario S5 demonstrates the most significant improvement in public transport travel time during the evening peak in both directions. In particular, the Lokanthali-Tinkune approach exhibits a greater reduction, with travel time decreasing to 472s (-32% vs base case), whereas the Tinkune-Lokanthali direction records a comparatively smaller improvement, with travel time reduced to 492s (-20% vs base case). This indicates that the implementation of signal priority in conjunction with the exclusive bus lane (EBL) is more effective for the PT in the Lokanthali-Tinkune approach during evening peak hour.

Scenario S2 during the evening peak hour increases the travel time for other vehicles plying in normal lanes in both directions: Tinkune-Lokanthali approach rises 25% to 426s, and Lokanthali-Tinkune approach rises 32% to 517s. Scenarios S3 and S4 continue to show elevated travel times relative to the base case, though the increases are less severe than in S2, mirroring the morning findings. Scenario S5 delivers benefits not only for PT but also for other vehicles during evening peak hour for both approaches, where the travel time falls slightly below or remain constant to that of the base case unlike the increment in morning peak hour.

To sum up, not only, the travel time of PT has greatly improved in scenario S5 for both approaches, but also the travel time for others vehicles plying in normal lanes improved slightly when signal priority was used along with exclusive bus lane system during evening peak hour.

For clearer visualization and comparison, these results are also presented graphically in line chart shown in Figure 4.26, where the relative differences in travel times between scenarios can be easily observed for vehicle classes during evening peak hour.

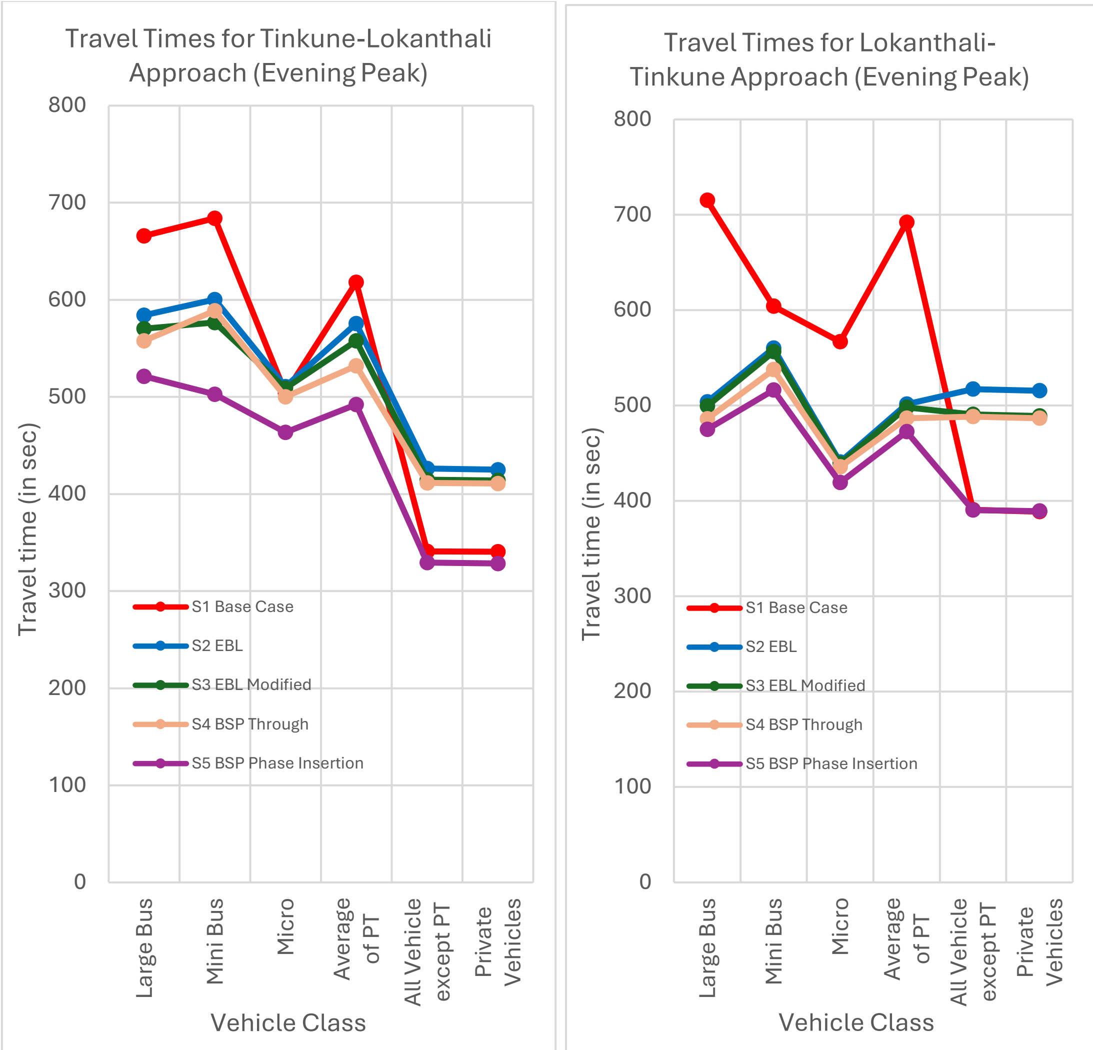


Figure 4.26: Line chart showing the travel time results for all scenarios (evening peak hour)

4.7 Discussions

The results from the scenario analysis indicates that the introduction of only exclusive bus lanes as in S2 prioritize public transport by providing separate lane, but it heavily penalizes general traffic. It reduces queues in EBL from 3% to 88% during both morning and evening period but worsens the queues in normal lanes up to 508% during morning and 164% during evening peak hour. Similarly, the travel time for public transport reduces by 7% & 13% during morning and 28% & 7% during evening peak hour for Lokanthali-Tinkune and Tinkune Lokanthali approach respectively, whereas the travel time for other vehicles in normal lanes increases by 21-99%, with greater increase in Lokanthali-Tinkune approach during morning and 25-33% during evening peak hour.

However, signal priority when used in conjunction with the exclusive bus lanes as in S5, delivers the most consistent results. It preserves the major improvements for public transportation by eliminating queues to minimal level while also softening the negative impact on normal lanes. The result from scenario analysis indicates the queues in EBL reduces to 28-100% during morning and 68-100% during evening peak hour. In normal lanes, however, the queue worsens up to 170% during morning and 61% during evening peak hour in some sections. Similarly, the travel time for public transport reduces by 20% & 23% during morning and 20% & 32% during evening peak hour for Tinkune-Lokanthali and Lokanthali-Tinkune approach respectively, whereas the travel time for other vehicles in normal lanes across both approaches almost remain constant or decreases slightly during evening peak hour but travel time drops by 13% in Tinkune-Lokanthali approach and increases by 67% in Lokanthali-Tinkune approach during morning peak hours. Nevertheless, this still represents a notable mitigation of adverse impacts when compared to introducing only EBL where travel time reach up to 99% above the base case. It is also important to look at this result in relation to the main objective of the intervention. While other vehicles account for substantial share of vehicle volumes, public transport carry significantly more passengers per vehicle. As a result, the total time saved by reducing public transportation travel time by 20-32% is likely greater than extra delay faced by other vehicles. So, Scenario S5 still performs better when evaluated from a different perspective, focusing on the movement of people rather than the movement of vehicles.

Taken together, the queue and travel time analyses, signal priority when used in conjunction with the EBL yields superior performance, as it offers a comparatively improved balance between public transport priority and general traffic performance. This approach delivers the greatest travel time savings and lowest queue length for public transport while imposing less severe adverse impacts on other vehicles compared to exclusive bus lanes implemented alone during both morning and evening peak hours.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study aimed to evaluate the potential effectiveness of exclusive bus lanes with signal priority in heterogeneous traffic conditions, using the Kathmandu-Bhaktapur Road as a case study. A comprehensive approach was undertaken during the study involving traffic volume data collection, vehicle classification, conversion into Passenger Car Units (PCUs), calculation of directional split at two signalized and one unsignalized intersection. The traffic data were processed to reflect actual conditions, and an appropriate simulation model was developed using those data for local traffic characteristics. The model was then calibrated for traffic volume and maximum queue lengths using the average field data of first two days. Then it was validated using field data of third day. After that, the base model was creating using calibrated and validated model and various scenarios involving exclusive bus lanes and signal priority were simulated using VISSIM and their performance were analyzed using queue length and travel time as performance indicator.

Analyzing the results of all the scenarios, introduction of exclusive bus lanes prioritizes public transport by providing separate lane, thereby reducing the queues in exclusive bus lanes by 3-88% during both morning and evening peak hour. But it heavily penalizes general traffic by amplifying the queue in the normal lanes. The queues worsen up to 508% during morning and 164% during evening peak hour. Similarly, the travel time for public transport reduces by 7-13% during morning and 7-28% during evening peak hour, whereas the travel time for other vehicles in normal lanes increases by 21-99%, with greater increase in Lokanthali-Tinkune approach during morning and 25-33% during evening peak hour.

Signal priority when used with exclusive bus lanes delivers the most consistent results across every approach. It preserves the major improvements for public transportation by eliminating queues to minimal level while also softening the negative impact on normal lanes. The queues in exclusive bus lanes gets further reduced by 18-100% during morning and 68-100% during evening peak hour. In normal lanes, queues previously worsen by 508% and 164% drops to 170% during morning and 61% during evening respectively. Although the queue is still above base case but it still represents a notable mitigation of adverse impacts.

The travel time results also show the similar pattern. Public transport gets faster after the bus lane is introduced, but signal priority when used with exclusive bus lanes delivers the biggest gains in both directions. The travel time for public transport reduces by 20-23% during morning and 20-32% during evening peak hour where buses, minibuses, and micros all have minimum travel times, whereas the travel time for other vehicles in normal lanes across both approaches almost remain constant during evening peak hour but travel time drops by 13% in Tinkune-Lokanthali approach and increases by 67% in Lokanthali-Tinkune approach during morning peak hours. Although the travel time in Lokanthali-Tinkune approach is higher than base case, it still represents a notable mitigation of adverse impacts when compared to introducing only EBL where travel time increased up to 99% above the base case. On Tinkune-Lokanthali approach, not only public transportation, but other vehicles also performed better under this condition.

This concludes that signal priority used in conjunction with exclusive bus lanes is the most effective option among the five scenarios studied. It offers a comparatively improved balance between public transport priority and general traffic performance delivering the greatest travel time savings and lowest queue length for public transport while imposing less severe adverse impacts on other vehicles during both morning and evening peak hours.

5.2 Limitations and Recommendation for Future Works

5.2.1 Study Area Boundary and Wider Network Applicability

For this analysis, a simulation model was developed for a corridor of approximately 1.75 km in length between Tinkune and Lokanthali, which is the most congested section of the corridor where vehicle conflicts and intersection delays are most significant. However, it doesn’t attempt to model the entire road network that this section is part of. As a result, the model doesn’t incorporate spillover effects, where increased queues in normal lanes may extend to adjacent roads and intersections outside the study area.

Future studies should extend the simulation model to broader network boundary which would allow the measurement of spillback effects beyond the 1.75km study section and give the more-clearer picture of how bus lane and signal priority strategies behave under broader traffic conditions.

5.2.2 Pedestrian-Vehicle Interaction

The simulation model focuses exclusively on vehicular flow and does not explicitly represent pedestrian movements, crossings, or pedestrian-vehicle interactions. This exclusion was intentionally adopted to simplify the model so that only vehicular effects of exclusive bus lanes and signal priority could be studied. However, this assumption may lead to a slight overestimation of operational performance, particularly at intersections with high pedestrian activity, such as Koteshwor and Jadibuti.

Future simulation studies should incorporate these pedestrian flow data and crossing behaviors to generate less optimistic and more practical evaluation of exclusive bus lanes and signal priority.

5.2.3 Advance Signal Priority Strategies

The signal priority component of this study was implemented using phase insertion as the primary control strategy. While it is a recognized and effective form of signal priority, it represents a relatively simple technique compared to more advance strategies documented in the Section 2.4.1, such as green extension and red truncation.

It is acknowledged that these advanced signal priority strategies operate in real time and may yield superior performance under the same conditions. So, future research should evaluate the comparative performance of advanced signal priority strategies against the phase insertion technique adopted in this study across peak and off-peak periods.

5.2.4 Curb-side Bus Lane Operations

The study is limited to the performance evaluation of curb-side bus lanes only, and does not consider median-side bus lanes. Also, the side-friction effects on exclusive bus lanes are not taken under consideration. However, priority is given to the public transportation operating on bus lanes against the left turning vehicles.

For future work, the analysis could be extended to compare median-side bus lanes to better understand their relative performance under heterogeneous traffic conditions.

Further studies may also incorporate mixed-traffic interactions in greater detail, such as side friction effects.

5.2.5 Bus Lay-bys Capacity and Adequacy

Existing bus lay-bys configurations were retained in the simulation model without any geometric redesign or optimization. The study did not explicitly evaluate the adequacy of bus lay-bys length and capacity. Although no major spillback effects were observed during simulation, the operational performance of the existing bus lay-bys was beyond the scope of this research.

Future studies may incorporate detailed geometric design and optimization of bus lay-bys to assess their adequacy and influence under exclusive bus lane system.

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APPENDIX A: Data Collection Formats

Road: **Intersection:**
Approach: **MORNING/EVENING PEAK HOURS (Day 1)** **Leg:**
CCTV location *Date of Data Colllection: 2025* **Turning Movement:**

Date	Time	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw Cart	Tractor	Excavtor	Total Volume	Remarks
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy							
January 26, 2025 (Sunday)	9:00-9:15																				
	9:15-9:30																				
	9:30-9:45																				
	9:45-10:00																				
	10:00-10:15																				
	10:15-10:30																				
	10:30-10:45																				
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	5:15-5:30																				
	5:30-5:45																				
	5:45-6:00																				
	6:00-6:15																				
	6:15-6:30																				
	6:30-6:45																				
	6:45-7:00																				

a. Traffic Count Survey Format

Approach: PT Type:
Vehicle Route: Trip Code:
Vehicle No: Time of Survey/Start Time:
Vehicle Identification:

Start/End	Location	Time Spent	Cause of Delay	Remarks

b. Onboard Public Transportation Survey Format

APPENDIX B: Summary of Data

15-minute PCU and Volume for 3 days at Koteshwor intersection

Time	January 26, 2025 (Sunday)		January 27, 2025 (Monday)		January 28, 2025 (Tuesday)		Three-day Average		Hourly		Remarks
	PCU	Veh	PCU	Veh	PCU	Veh	PCU	Veh	PCU	Veh	
9:00-9:15	2108.35	3426	2038.7	3409	2128.9	3458	2091.98	3431			
9:15-9:30	2383.15	4044	2286.8	3883	2274.5	3900	2314.82	3942			
9:30-9:45	2595.15	4583	2596.1	4512	2597.35	4518	2596.20	4538			
9:45-10:00	2552.55	4517	2518.25	4505	2559.8	4570	2543.53	4531	9546.53	16442	
10:00-10:15	2605	4486	2558.85	4466	2505.75	4388	2556.53	4447	10011	17457	
10:15-10:30	2481.55	4249	2525.15	4235	2513.45	4237	2506.72	4240	**10203**	**17755**	**Morning Peak**
10:30-10:45	2373.85	3975	2345.35	4007	2359	3974	2359.40	3985	9966.18	17203	
10:45-11:00	2105.45	3578	2176.4	3708	2104.35	3603	2128.73	3630	9551.38	16302	
11:00-11:15	2168.85	3585	2169.7	3649	2170.8	3618	2169.78	3617	9164.63	15473	
11:15-11:30	2149.45	3607	2119.7	3613	2124	3671	2131.05	3630	8788.97	14863	
11:30-11:45	1931.35	3280	1897.85	3264	1885.1	3243	1904.77	3262	8334.33	14140	
11:45-12:00	1929.25	3227	1877.25	3239	1912.25	3346	1906.25	3271	8111.85	13781	
4:00-4:15	2181.75	3447	2143.3	3376	2144.6	3367	2156.55	3397			
4:15-4:30	2532.85	4236	2529.45	4155	2441.55	4120	2501.28	4170			
4:30-4:45	2482.5	4175	2465.95	4216	2422.05	4169	2456.83	4187			
4:45-5:00	2629.45	4379	2552.85	4357	2624.2	4418	2602.17	4385	9716.83	16138	
5:00-5:15	2693.35	4474	2696.05	4559	2683.15	4462	2690.85	4498	10251.1	17240	
5:15-5:30	2686.9	4584	2731.35	4712	2698.55	4601	2705.60	4632	10455.5	17702	
5:30-5:45	2799.5	4829	2686.9	4663	2765.5	4794	2750.63	4762	10749.3	18277	
5:45-6:00	2728	4721	2725.9	4843	2726.45	4765	2726.78	4776	**10873.9**	**18669**	**Evening Peak**
6:00-6:15	2442.4	4231	2385.55	4172	2386.6	4141	2404.85	4181	10587.9	18352	
6:15-6:30	2539.25	4290	2475.2	4172	2600.05	4489	2538.17	4317	10420.4	18037	
6:30-6:45	2406.75	4101	2355.55	4028	2351.2	3998	2371.17	4042	10041	17317	
6:45-7:00	2263.9	3876	2233.8	3842	2221.55	3785	2239.75	3834	9553.93	16375	

15-minute PCU and Volume for 3 days at Jadibuti intersection

Time	January 26, 2025 (Sunday)		January 27, 2025 (Monday)		January 28, 2025 (Tuesday)		Three-day Average		Hourly		Remarks
	PCU	Veh	PCU	Veh	PCU	Veh	PCU	Veh	PCU	Veh	
9:00-9:15	1849.9	3124	1840.25	3162	1813.35	3029	1834.50	3105			
9:15-9:30	1808.8	3039	1797.2	3076	1824.65	3218	1810.22	3111			
9:30-9:45	2129.2	3855	2134.15	3845	2045.4	3673	2102.92	3791			
9:45-10:00	1981.85	3566	1965.45	3565	2001.75	3588	1983.02	3573	7730.65	13580	
10:00-10:15	1859.4	3332	1899.9	3389	1911.1	3406	1890.13	3376	7786.28	13851	
10:15-10:30	1976.15	3459	2022.65	3507	2038	3552	2012.27	3506	**7988.33**	**14246**	**Morning Peak**
10:30-10:45	2055.3	3679	2031.45	3748	1980.1	3619	2022.28	3682	7907.70	14137	
10:45-11:00	1780.15	3227	1889.65	3448	1811.85	3357	1827.22	3344	7751.90	13908	
11:00-11:15	1959.65	3454	1865.65	3404	1909.95	3434	1911.75	3431	7773.52	13963	
11:15-11:30	1931.65	3462	1854.95	3425	1854.1	3374	1880.23	3420	7641.48	13877	
11:30-11:45	1825.25	3240	1748.95	3148	1777.3	3187	1783.83	3192	7403.03	13387	
11:45-12:00	1700.6	3015	1655.85	2954	1655.45	3001	1670.63	2990	7246.45	13033	
4:00-4:15	1864.35	3144	1775.85	2982	1797.05	3020	1812.42	3049			
4:15-4:30	2158.75	3832	2138.9	3757	2137.65	3817	2145.10	3802			
4:30-4:45	2113	3734	2160.35	3856	2079.3	3764	2117.55	3785			
4:45-5:00	2272.6	3996	2194.5	3942	2222.85	3953	2229.98	3964	8305.05	14599	
5:00-5:15	2281.15	4002	2296.45	4101	2249.5	3979	2275.70	4027	8768.33	15578	
5:15-5:30	2287.4	4119	2305.4	4251	2253.25	4132	2282.02	4167	8905.25	15943	
5:30-5:45	2343.4	4256	2289.6	4152	2325.5	4255	2319.50	4221	9107.20	16379	
5:45-6:00	2305.9	4146	2307	4216	2277.25	4212	2296.72	4191	**9173.93**	**16607**	**Evening Peak**
6:00-6:15	2161.55	3995	2123.9	3932	2142.5	3916	2142.65	3948	9040.88	16527	
6:15-6:30	2091.3	3841	2117.75	3813	2175.45	4082	2128.17	3912	8887.03	16272	
6:30-6:45	2012.85	3691	1992.65	3654	1968.6	3612	1991.37	3652	8558.90	15703	
6:45-7:00	1963.5	3581	1930.1	3507	1914	3454	1935.87	3514	8198.05	15026	

Morning peak hourly PCU and Volume for all approaches along the network

SN	Location	Morning Peak Hour (9:30-10:30 am)									
		Day 1 (Sunday)		Day2 (Monday)		Average of Day 1 and Day 2		Day 3 (Tuesday)		Three-Days Average	
		Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume
1	Lokanthali to Jadibuti (Total Entry)	2819	4844	2850	4972	2835	4912	2856	4962	2842	4925
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	238	594	260	655	249	628	249	639	249	630
3	Manoharafat to Jadibuti Lane (Left Turn)	77	112	76	120	77	116	64	103	72	112
4	Manoharafat to Buspark Lane (Left Turn)	836	2261	855	2289	845	2275	810	2154	834	2235
5	Lokanthali to Jadibuti Lane (Through)	2076	3276	2129	3395	2102	3336	2101	3345	2102	3339
6	Lokanthali to Buspark Lane (Left Turn)	743	1568	721	1577	732	1573	756	1617	740	1587
7	Lokanthali to Jadibuti to Koteswor (Through)	2326	3861	2384	3920	2355	3891	2350	3825	2353	3869
8	Lokanthali to Pepsicola (Right Turn)	64	121	86	162	75	142	74	137	75	140
9	Pepsicola to Lokanthali (Left Turn)	81	160	98	176	89	168	102	178	94	171
10	Pepsicola to Koteshwor (Right turn)	1987	4002	1930	3835	1959	3919	1952	3887	1956	3908
12	Narefat to Pepsicola (Through)	108	249	108	242	108	246	120	284	112	258
13	Narefat to Lokanthali (Right turn)	100	181	111	207	105	194	110	203	107	197
14	Narefat to Koteswor (Left Turn)	381	952	434	989	408	971	428	1024	414	988
15	Narefat Petrolpump to Koteshwor to Tinkune	616	1535	568	1431	592	1485	583	1466	589	1477
16	Jadibuti to Koteswor to Balkumari (Left Turn)	1874	3753	1865	3789	1869	3771	1851	3798	1863	3780
17	Jadibuti to Koteswor to Tinkune (Through)	3596	6249	3491	5960	3543	6105	3496	6020	3528	6076
18	Balkumari to Tinkune (Left Turn)	784	1000	780	977	782	989	781	1000	781	992
19	Balkumari to Jadibuti (Right Turn)	715	1173	746	1232	730	1203	745	1230	735	1212
20	Tinkune to Koteswor to Jadibuti (Through)	1999	3199	2011	3269	2005	3234	1998	3179	2003	3216
21	Tinkune to Koteswor to Balkumari (Right Turn)	612	854	643	854	628	854	638	847	631	852

Morning peak hourly PCU and Volume for all approaches along the network

SN	Location	Morning Peak Hour (9:30-10:30 am)									
		Day 1 (Sunday)		Day2 (Monday)		Average of Day 1 and Day 2		Day 3 (Tuesday)		Three-Days Average	
		Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume
22	Mahadevsthan to Tinkune (Left Turn)	437	1087	446	1112	442	1100	446	1117	443	1105
23	Mahadevsthan to Jadibuti (Through)	113	269	114	273	113	271	112	268	113	270
24	Mahadevsthan to Balkumari (Right Turn)	105	251	104	252	104	252	109	254	106	252
25	Koteshwor to Jadibuti to Lokanthali (Through)	1805	2857	1811	2940	1808	2899	1767	2850	1794	2882
26	Koteshwor to Jadibuti to Pepsicola (Left Turn)	994	1644	959	1636	976	1640	964	1609	972	1630
27	Koteshwor to Jadibuti to Narefat (Right Turn)	100	185	102	199	101	192	129	222	110	202
28	Koteshwor to Jadibuti to Pepsicola lane to Lokanthali (Through)	174	251	177	259	176	255	161	256	171	255
29	Jadibuti to Jadibuti Pul to Manoharafat (Right Turn)	110	211	113	229	112	220	113	218	112	219
30	Manoharafat to Lokanthali (Right Turn)	188	372	162	339	175	356	172	340	174	350
31	Tinkune-Koteshwor Approach Total	2611	4053	2654	4123	2633	4088	2636	4026	2634	4067
32	Balkumari Approach Total	1499	2173	1526	2209	1512	2191	1526	2230	1517	2204
33	Pepsicola Approach Total	2066	4161	2028	4011	2047	4092	2054	4065	2049	4076
34	Mahadevsthan Approach Total	654	1607	663	1637	659	1629	667	1639	662	1631
35	Narefat Buspark Approach Total	589	1382	653	1438	621	1420	659	1511	633	1441
36	Manoharafat Corridor Approach	1101	2745	1093	2748	1097	2751	1045	2597	1080	2695
37	Jadibuti-Koteshwor Approach	5470	10002	5355	9749	5413	9876	5348	9818	5391	9856
38	Lokanthali-Jadibuti Approach	2391	3982	2470	4082	2430	4032	2424	3962	2428	4009
39	Koteshwor-Jadibuti Approach	2900	4686	2871	4775	2885	4731	2860	4681	2877	4714
40	Jadibuti-Jadibuti Pul Approach	1985	3198	2019	3323	2002	3261	1980	3231	1995	3251
41	Jadibuti to Jadibuti Pul to Lokanthali (Through)	1875	2987	1906	3094	1890	3041	1867	3013	1883	3031
42	Koteshwor to Pepsicola Lane (Left Turn)	1140	1888	1136	1895	1138	1892	1125	1865	1134	1883

Evening peak hourly PCU and Volume for all approaches along the network

SN	Location	Evening Peak Hour (5:00-6:00 pm)									
		Day 1 (Sunday)		Day2 (Monday)		Average of Day 1 and Day 2		Day 3 (Tuesday)		Three-Days Average	
		Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume
1	Lokanthali to Jadibuti (Total Entry)	2191	3107	2192	3181	2192	3148	2203	3246	2195	3178
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	100	204	100	209	100	210	107	213	102	209
3	Manoharafat to Jadibuti Lane (Left Turn)	70	84	63	90	67	87	67	96	67	90
4	Manoharafat to Buspark Lane (Left Turn)	234	584	250	629	242	607	252	615	245	609
5	Lokanthali to Jadibuti Lane (Through)	1772	2425	1774	2459	1773	2442	1776	2545	1774	2476
6	Lokanthali to Buspark Lane (Left Turn)	419	682	418	722	419	702	427	701	421	702
7	Lokanthali to Jadibuti to Koteswor (Through)	1829	2538	1770	2515	1799	2527	1790	2592	1796	2548
8	Lokanthali to Pepsicola (Right Turn)	113	175	135	209	124	192	110	182	119	189
9	Pepsicola to Lokanthali (Left Turn)	127	260	139	279	133	270	122	262	130	267
10	Pepsicola to Koteshwor (Right turn)	1228	2187	1258	2285	1243	2236	1202	2186	1230	2219
12	Narefat to Pepsicola (Through)	188	438	185	421	186	430	183	417	185	425
13	Narefat to Lokanthali (Right turn)	102	231	112	237	107	234	108	209	108	226
14	Narefat to Koteswor (Left Turn)	248	521	271	538	259	530	264	545	261	535
15	Narefat Petrolpump to Koteshwor to Tinkune	179	417	183	427	181	425	178	420	180	421
16	Jadibuti to Koteswor to Balkumari (Left Turn)	1347	2076	1319	2136	1333	2106	1292	2055	1319	2089
17	Jadibuti to Koteswor to Tinkune (Through)	2075	3057	2031	3081	2053	3069	2046	3021	2051	3053
18	Balkumari to Tinkune (Left Turn)	918	1225	952	1265	935	1249	939	1244	936	1246
19	Balkumari to Jadibuti (Right Turn)	1184	2023	1131	1977	1158	2004	1175	2017	1163	2004
20	Tinkune to Koteswor to Jadibuti (Through)	3910	7503	3942	7625	3926	7564	3931	7564	3928	7564
21	Tinkune to Koteswor to Balkumari (Right Turn)	977	1455	971	1435	974	1445	989	1445	979	1445

Evening peak hourly PCU and Volume for all approaches along the network

SN	Location	Evening Peak Hour (5:00-6:00 pm)									
		Day 1 (Sunday)		Day2 (Monday)		Average of Day 1 and Day 2		Day 3 (Tuesday)		Three-Days Average	
		Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume	Peak hourly PCU	Peak hourly Volume
22	Mahadevsthan to Tinkune (Left Turn)	134	332	137	340	135	336	145	354	138	342
23	Mahadevsthan to Jadibuti (Through)	232	611	229	602	231	607	229	599	230	604
24	Mahadevsthan to Balkumari (Right Turn)	131	326	128	316	130	321	129	323	129	322
25	Koteshwor to Jadibuti to Lokanthali (Through)	3201	6169	3185	6297	3193	6233	3276	6357	3221	6274
26	Koteshwor to Jadibuti to Pepsicola (Left Turn)	1935	3458	1907	3419	1921	3439	1807	3319	1883	3399
27	Koteshwor to Jadibuti to Narefat (Right Turn)	246	546	237	520	241	533	244	509	242	525
28	Koteshwor to Jadibuti to Pepsicola lane to Lokanthali (Through)	241	520	253	528	247	524	307	589	267	546
29	Jadibuti to Jadibuti Pul to Manoharafat (Right Turn)	263	575	274	585	269	580	270	590	269	583
30	Manoharafat to Lokanthali (Right Turn)	166	351	157	315	161	333	162	330	161	332
31	Tinkune-Koteshwor Approach Total	4887	8958	4913	9060	4900	9009	4920	9009	4907	9008
32	Balkumari Approach Total	2102	3248	2083	3242	2093	3245	2113	3261	2099	3250
33	Pepsicola Approach Total	1355	2447	1398	2564	1376	2506	1325	2448	1359	2486
34	Mahadevsthan Approach Total	497	1269	494	1258	496	1264	503	1276	498	1266
35	Narefat Buspark Approach Total	538	1190	568	1196	553	1193	554	1171	553	1184
36	Manoharafat Corridor Approach	470	1019	470	1034	470	1027	480	1041	473	1032
37	Jadibuti-Koteshwor Approach	3422	5133	3350	5217	3386	5175	3338	5076	3370	5142
38	Lokanthali-Jadibuti Approach	1942	2713	1904	2724	1923	2719	1900	2774	1916	2737
39	Koteshwor-Jadibuti Approach	5382	10173	5329	10236	5356	10205	5327	10185	5346	10198
40	Jadibuti-Jadibuti Pul Approach	3431	6660	3437	6813	3434	6737	3507	6828	3458	6767
41	Jadibuti to Jadibuti Pul to Lokanthali (Through)	3168	6085	3162	6228	3165	6157	3237	6238	3189	6184
42	Koteshwor to Pepsicola Lane (Left Turn)	2176	3978	2160	3947	2168	3963	2114	3908	2150	3944

KOTESHWOR INTERSCETION APPROACH PCU

DAY 1

Time	20 Tinkune (TH) to Jadibuti	21 Tinkune (RT) to Balkumari	19 Jadibuti (TH) to Tinkune	17 Jadibuti (LT) to Balkumari	23 Balkumari (RT) to Jadibuti	24 Balkumari (LT) to Tinkune	25 Mahadevstahan (RT) to Jadibuti	27 Mahadevstahan (LT) to Tinkune	28 Mahadevstahan (RT) to Balkumari	Total PCU	Hourly PCU
9:00-9:15	415.25	184.7	712.9	345.4	189.7	156.6	19.15	59.9	24.75	2108.35	
9:15-9:30	406.05	142.95	850.2	406.8	220.45	201.2	35.05	95.45	25	2383.15	
9:30-9:45	508.9	145.7	1035.4	463.6	84.6	186.5	15.3	117.9	37.25	2595.15	
9:45-10:00	499	154.2	854.2	495.4	176.8	195.3	24.8	132.4	20.45	2552.55	9639.2
10:00-10:15	533.9	184	835.5	482.7	192.6	215.3	30.85	107.5	22.65	2605	10136
10:15-10:30	457.15	128.5	870.7	432.25	260.85	186.85	41.55	79.5	24.2	2481.55	10234
10:30-10:45	458.8	193.45	682.9	394.8	260.65	255.45	30.65	75.4	21.75	2373.85	10013
10:45-11:00	450.4	152.45	614.6	352.7	199.5	224.4	32.75	55.4	23.25	2105.45	9565.9
11:00-11:15	493.65	151.85	658.1	333.95	209.65	210.95	32.5	54.65	23.55	2168.85	9129.7
11:15-11:30	507.4	138.05	630.4	326.4	221.6	222.15	25.65	52.9	24.9	2149.45	8797.6
11:30-11:45	443.15	150.1	590.6	309	157.4	193.55	24	43.75	19.8	1931.35	8355.1
11:45-12:00	422	117.7	579.15	306.6	162.9	233.4	27.1	53.7	26.7	1929.25	8178.9
4:00-4:15	574.35	194.4	389.4	284.6	356.15	241.75	56.35	48.5	36.25	2181.75	
4:15-4:30	904.45	165.45	576.95	338.3	253.9	180.85	47.75	33.05	32.15	2532.85	
4:30-4:45	852.6	232.45	429.2	335.55	275.35	248.3	41.05	29.85	38.15	2482.5	
4:45-5:00	882	283.7	422.9	357.7	332.3	218.65	65.35	37.35	29.5	2629.45	9826.6
5:00-5:15	1000.1	172.3	605.05	355.55	256.85	194.1	48.95	28.65	31.8	2693.35	10338
5:15-5:30	957.45	299.3	467.25	342.4	263.35	234.55	52.35	33.1	37.15	2686.9	10492
5:30-5:45	908.8	213.15	559.8	328.9	396.65	249.5	78.3	35.95	28.45	2799.5	10809
5:45-6:00	1044.1	291.8	443.1	319.7	267.3	239.4	52.7	36	33.9	2728	10908
6:00-6:15	847.85	212.3	364.4	296.35	363.9	229.2	77.85	24.8	25.75	2442.4	10657
6:15-6:30	977.1	165.15	475.5	285.7	294.2	216.4	55.8	30.05	39.35	2539.25	10509
6:30-6:45	800.4	287.2	413.8	280.95	294.75	202.4	71.05	27.6	28.6	2406.75	10116
6:45-7:00	939.25	161.35	376.25	265.95	237.1	177.75	46.55	27.2	32.5	2263.9	9652.3

KOTESHWOR INTERSCETION APPROACH PCU											
DAY 2											
Time	20 Tinkune (TH) to Jadibuti	21 Tinkune (RT) to Balkumari	19 Jadibuti (TH) to Tinkune	17 Jadibuti (LT) to Balkumari	23 Balkumari (RT) to Jadibuti	24 Balkumari (LT) to Tinkune	25 Mahadevstahan (RT) to Jadibuti	27 Mahadevstahan (LT) to Tinkune	28 Mahadevstahan (RT) to Balkumari	Total PCU	Hourly PCU
9:00-9:15	405.35	180.8	667.15	323.25	184	164.55	23.7	66.2	23.7	2038.7	
9:15-9:30	404.45	152.75	802.6	388.1	167.2	211.7	37.55	95.6	26.85	2286.8	
9:30-9:45	496.8	151.9	1006.95	439.15	146.7	178.6	17.6	123.1	35.3	2596.1	
9:45-10:00	491.95	170.3	828.85	488.7	167.7	194.6	25.4	131.25	19.5	2518.25	9439.9
10:00-10:15	505.15	195.9	811.25	487.45	186.95	207.95	31.65	106.9	25.65	2558.85	9960
10:15-10:30	517.05	125.05	843.7	449.3	244.45	198.6	39.05	84.45	23.5	2525.15	10198
10:30-10:45	448.35	187.95	702.65	391.25	248.35	239.5	30.95	74.45	21.9	2345.35	9947.6
10:45-11:00	469.1	151.05	634.05	380.1	193.05	226.55	38.4	58.55	25.55	2176.4	9605.8
11:00-11:15	438.85	152.15	693.75	339.95	218.65	208.95	37.55	54.6	25.25	2169.7	9216.6
11:15-11:30	461.05	145.25	652.5	333.75	213.75	208.25	27.35	53.85	23.95	2119.7	8811.2
11:30-11:45	431.8	149.3	575.65	306.65	150.05	188.85	28.9	44.5	22.15	1897.85	8363.7
11:45-12:00	420.8	126.4	559.65	296.45	158.6	218.15	23.6	47.95	25.65	1877.25	8064.5
4:00-4:15	551.45	191.1	404.85	300.85	325.6	237.95	53.4	41.55	36.55	2143.3	
4:15-4:30	878.25	172.1	593.85	323.95	263.6	180.9	51.7	34.65	30.45	2529.45	
4:30-4:45	879.2	245.05	417.6	311.15	273.4	232.95	42.15	32	32.45	2465.95	
4:45-5:00	855.6	279.05	403	352.05	307.45	225.3	65.1	33.95	31.35	2552.85	9691.6
5:00-5:15	1027.35	175.25	588.65	352.1	246.3	197.9	48.15	26.4	33.95	2696.05	10244
5:15-5:30	990.45	277.7	493.35	347.5	253.6	247.1	50.55	36.1	35	2731.35	10446
5:30-5:45	855.45	227.1	522.55	296.9	385.1	263.7	73.45	36.15	26.5	2686.9	10667
5:45-6:00	1068.55	290.65	426.45	322.6	246.35	243.3	57.15	38.35	32.5	2725.9	10840
6:00-6:15	819.3	239.65	349.15	288.5	350.85	211.6	67.15	29.25	30.1	2385.55	10530
6:15-6:30	930.35	168.55	457.9	293.95	284.15	219.6	56.05	30.85	33.8	2475.2	10274
6:30-6:45	823.25	277.45	404.2	248.1	268.15	215.3	63.2	28.2	27.7	2355.55	9942.2
6:45-7:00	904.5	181.35	399.85	247.15	221.55	176.85	49.75	26.2	26.6	2233.8	9450.1

KOTESHWOR INTERSCETION APPROACH PCU											
DAY 3											
Time	20 Tinkune (TH) to Jadibuti	21 Tinkune (RT) to Balkumari	19 Jadibuti (TH) to Tinkune	17 Jadibuti (LT) to Balkumari	23 Balkumari (RT) to Jadibuti	24 Balkumari (LT) to Tinkune	25 Mahadevstahan (RT) to Jadibuti	27 Mahadevstahan (LT) to Tinkune	28 Mahadevstahan (RT) to Balkumari	Total PCU	Hourly PCU
9:00-9:15	425.8	178.15	718.05	340.85	181.3	177.85	23.95	59.35	23.6	2128.9	
9:15-9:30	382.1	149.05	814.7	399	174	197.85	39.1	93.05	25.65	2274.5	
9:30-9:45	482.6	153	983.75	459.75	153.5	192.45	17.15	121	34.15	2597.35	
9:45-10:00	473.4	165.55	882.15	493.95	165.85	197.9	24.8	133.85	22.35	2559.8	9560.6
10:00-10:15	529.7	180.45	790.2	461.15	177.85	201.55	29.95	108	26.9	2505.75	9937.4
10:15-10:30	512.55	139	840.2	436.55	247.85	188.6	40.4	83.15	25.15	2513.45	10176
10:30-10:45	458.65	183.05	708	367.1	262.05	246.7	31.4	76.95	25.1	2359	9938
10:45-11:00	437.05	145.7	605.5	367.95	202.3	229.05	35.1	57.3	24.4	2104.35	9482.6
11:00-11:15	469.85	143.05	663.75	356.15	209.7	209.55	37.8	57.85	23.1	2170.8	9147.6
11:15-11:30	503.5	132.3	627.95	331.8	213.75	207.65	28.15	55.75	23.15	2124	8758.2
11:30-11:45	421.55	158	568.95	318.2	143.3	180.9	25.85	47.95	20.4	1885.1	8284.3
11:45-12:00	423.95	127.65	582.55	298	162.85	215.55	25.35	51.6	24.75	1912.25	8092.2
4:00-4:15	538	188	405.3	302.6	336.4	247.75	49.65	44.35	32.55	2144.6	
4:15-4:30	848.4	163.95	555.65	317.95	273.9	176.35	47.55	30.95	26.85	2441.55	
4:30-4:45	834.45	239.6	406.5	330.25	263.05	234.75	44.25	29.45	39.75	2422.05	
4:45-5:00	875.6	290.6	399.95	368.15	328.6	231.35	61	39.85	29.1	2624.2	9632.4
5:00-5:15	969.85	177.8	605.6	348.4	262.65	206.05	50.4	29.95	32.45	2683.15	10171
5:15-5:30	963.55	294.6	487.2	325.8	264.1	238.6	53.9	38.2	32.6	2698.55	10428
5:30-5:45	915.7	229.75	513.5	320	398.75	246	73	38.45	30.35	2765.5	10771
5:45-6:00	1081.95	286.8	439.4	297.8	249	248.25	51.65	38.05	33.55	2726.45	10874
6:00-6:15	819.4	210.6	342.85	286.2	356	239.3	73.6	30.15	28.5	2386.6	10577
6:15-6:30	1030.5	172.95	484.35	284.05	276.95	212.6	62.95	34.7	41	2600.05	10479
6:30-6:45	797.1	271.05	401.45	266.3	274.4	221.85	59.8	28.2	31.05	2351.2	10064
6:45-7:00	903.3	159.85	404.85	246	219.1	181.45	43.5	29.8	33.7	2221.55	9559.4

KOTESHWOR INTERSCETION APPROACH VOLUME											
DAY 1											
Time	20 Tinkune (TH) to Jadibuti	21 Tinkune (RT) to Balkumari	19 Jadibuti (TH) to Tinkune	17 Jadibuti (LT) to Balkumari	23 Balkumari (RT) to Jadibuti	24 Balkumari (LT) to Tinkune	25 Mahadevstahan (RT) to Jadibuti	27 Mahadevstahan (LT) to Tinkune	28 Mahadevstahan (RT) to Balkumari	Total Volume	Hourly Volume
9:00-9:15	568	226	1244	655	292	195	50	146	50	3426	
9:15-9:30	631	192	1466	824	290	262	89	228	62	4044	
9:30-9:45	764	206	1857	968	122	249	39	293	85	4583	
9:45-10:00	766	213	1586	991	289	234	56	333	49	4517	16570
10:00-10:15	893	253	1417	939	324	275	66	259	60	4486	17630
10:15-10:30	776	182	1389	855	438	242	108	202	57	4249	17835
10:30-10:45	756	249	1138	735	449	337	68	188	55	3975	17227
10:45-11:00	731	209	1033	663	346	323	81	129	63	3578	16288
11:00-11:15	762	201	1073	625	334	317	84	131	58	3585	15387
11:15-11:30	799	189	1106	582	384	300	63	120	64	3607	14745
11:30-11:45	730	184	1018	561	293	271	63	105	55	3280	14050
11:45-12:00	694	159	967	572	277	297	63	132	66	3227	13699
4:00-4:15	1006	264	540	458	549	300	133	110	87	3447	
4:15-4:30	1698	253	778	530	451	251	122	80	73	4236	
4:30-4:45	1572	358	601	539	502	341	108	65	89	4175	
4:45-5:00	1663	408	587	572	577	257	167	81	67	4379	16237
5:00-5:15	1848	273	854	535	423	258	131	72	80	4474	17264
5:15-5:30	1852	446	703	524	452	302	136	82	87	4584	17612
5:30-5:45	1772	328	828	514	695	330	206	85	71	4829	18266
5:45-6:00	2031	408	672	503	453	335	138	93	88	4721	18608
6:00-6:15	1708	305	495	443	632	305	202	68	73	4231	18365
6:15-6:30	1894	269	581	424	526	271	152	70	103	4290	18071
6:30-6:45	1602	394	568	419	514	282	190	63	69	4101	17343
6:45-7:00	1789	260	513	387	423	242	120	59	83	3876	16498

KOTESHWOR INTERSCETION APPROACH VOLUME

DAY 2

Time	20 Tinkune (TH) to Jadibuti	21 Tinkune (RT) to Balkumari	19 Jadibuti (TH) to Tinkune	17 Jadibuti (LT) to Balkumari	23 Balkumari (RT) to Jadibuti	24 Balkumari (LT) to Tinkune	25 Mahadevstahan (RT) to Jadibuti	27 Mahadevstahan (LT) to Tinkune	28 Mahadevstahan (RT) to Balkumari	Total Volume	Hourly Volume
9:00-9:15	598	238	1189	612	286	212	57	163	54	3409	
9:15-9:30	624	203	1377	781	237	264	97	235	65	3883	
9:30-9:45	783	201	1713	910	237	233	39	312	84	4512	
9:45-10:00	800	218	1529	1009	279	240	60	325	45	4505	16309
10:00-10:15	853	253	1415	961	315	262	75	264	68	4466	17366
10:15-10:30	833	182	1303	909	401	242	99	211	55	4235	17718
10:30-10:45	751	247	1162	780	443	319	73	183	49	4007	17213
10:45-11:00	756	204	1068	742	328	314	92	138	66	3708	16416
11:00-11:15	737	202	1141	650	340	295	91	128	65	3649	15599
11:15-11:30	767	187	1095	632	384	292	72	125	59	3613	14977
11:30-11:45	720	185	1000	584	280	264	63	109	59	3264	14234
11:45-12:00	699	173	1003	559	275	292	59	116	63	3239	13765
4:00-4:15	959	239	536	507	514	302	125	101	93	3376	
4:15-4:30	1648	261	774	502	451	244	121	76	78	4155	
4:30-4:45	1654	379	585	501	519	317	106	73	82	4216	
4:45-5:00	1631	408	578	589	546	274	178	77	76	4357	16104
5:00-5:15	1902	287	870	548	410	268	125	67	82	4559	17287
5:15-5:30	1971	422	717	566	430	306	130	85	85	4712	17844
5:30-5:45	1635	336	811	480	700	350	194	92	65	4663	18291
5:45-6:00	2117	390	683	542	437	341	153	96	84	4843	18777
6:00-6:15	1617	339	485	476	643	287	176	77	72	4172	18390
6:15-6:30	1778	277	558	450	506	289	149	76	89	4172	17850
6:30-6:45	1667	374	546	379	474	281	168	67	72	4028	17215
6:45-7:00	1745	277	530	386	416	231	130	59	68	3842	16214

KOTESHWOR INTERSCETION APPROACH VOLUME											
DAY 3											
Time	20 Tinkune (TH) to Jadibuti	21 Tinkune (RT) to Balkumari	19 Jadibuti (TH) to Tinkune	17 Jadibuti (LT) to Balkumari	23 Balkumari (RT) to Jadibuti	24 Balkumari (LT) to Tinkune	25 Mahadevstahan (RT) to Jadibuti	27 Mahadevstahan (LT) to Tinkune	28 Mahadevstahan (RT) to Balkumari	Total Volume	Hourly Volume
9:00-9:15	557	221	1245	670	281	225	60	149	50	3458	
9:15-9:30	631	189	1425	778	242	257	94	222	62	3900	
9:30-9:45	727	204	1706	971	237	250	39	306	78	4518	
9:45-10:00	729	214	1647	1021	268	242	56	340	53	4570	16446
10:00-10:15	907	230	1339	942	305	264	73	261	67	4388	17376
10:15-10:30	816	199	1328	864	420	244	100	210	56	4237	17713
10:30-10:45	752	233	1134	743	456	334	72	191	59	3974	17169
10:45-11:00	719	201	1000	718	356	322	84	139	64	3603	16202
11:00-11:15	741	189	1075	678	339	314	88	135	59	3618	15432
11:15-11:30	806	181	1109	647	371	295	72	130	60	3671	14866
11:30-11:45	688	189	987	613	272	259	65	116	54	3243	14135
11:45-12:00	756	169	1016	593	281	287	58	126	60	3346	13878
4:00-4:15	941	249	542	496	514	301	126	108	90	3367	
4:15-4:30	1659	251	749	495	465	236	120	74	71	4120	
4:30-4:45	1587	368	576	544	507	314	110	70	93	4169	
4:45-5:00	1639	415	584	599	575	282	164	90	70	4418	16074
5:00-5:15	1817	285	851	537	422	266	130	73	81	4462	17169
5:15-5:30	1874	427	710	528	453	298	140	90	81	4601	17650
5:30-5:45	1745	345	788	501	713	339	195	94	74	4794	18275
5:45-6:00	2128	388	672	489	429	341	134	97	87	4765	18622
6:00-6:15	1597	297	478	463	658	313	188	75	72	4141	18301
6:15-6:30	2075	288	590	418	489	274	171	80	104	4489	18189
6:30-6:45	1606	353	541	415	489	290	161	68	75	3998	17393
6:45-7:00	1725	255	528	361	401	248	115	66	86	3785	16413

JADIBUTI INTERSCETION APPROACH PCU

DAY 1

Time	6 Lokanthali (TH) to Koteshwor	5 Lokanthali (RT) to Pepsicola	9 Pepsicola (RT) to Koteswor	7 Pepsicola (LT) to Lokanthali	33 Koteswor (TH) to Lokanthali	31 Koteswor (RT) to Jadibuti Buspark	35 Koteswor (LT) to Pepsicola	36 Jadibuti Buspark (TH) to Pepsicola	14 Jadibuti Buspark (RT) to Lokanthali	16 Jadibuti Buspark (LT) to Koteswor	Total PCU	Hourly PCU
9:00-9:15	612.1	15.95	362.6	26.9	403.35	27.6	194.35	25.1	26.95	155	1849.9	
9:15-9:30	612.5	13.35	345.3	20.7	423.95	25.5	214.6	13.2	27.35	112.35	1808.8	
9:30-9:45	698.6	17.9	622.8	20	376.7	13.6	245.2	19.7	32.05	81.15	2127.7	
9:45-10:00	494.8	8.75	573.55	19.85	444.3	26.25	247.05	29.6	21.35	116.35	1981.9	7768.25
10:00-10:15	547	10.25	351.6	17.5	507.35	31.8	226.7	41.9	18.8	106.5	1859.4	7777.75
10:15-10:30	585.85	27.5	437.85	23.3	476.8	28.55	275.2	16.7	27.45	76.95	1976.2	7945.1
10:30-10:45	604.15	17.25	448.6	27.35	472.5	40.2	240.4	38.7	29.85	136.3	2055.3	7872.7
10:45-11:00	557.4	12.35	346.25	22.4	435.75	25.55	224.35	21.9	23.9	110.3	1780.2	7671
11:00-11:15	616.85	17.1	395.65	26.4	457.05	33.05	248.7	29.45	26.55	108.85	1959.7	7771.25
11:15-11:30	569.25	12	380	28.25	470.75	38.35	248.55	28.55	15.95	140	1931.7	7726.75
11:30-11:45	588.75	18.15	433.2	23.55	333.15	30.5	267.4	31.55	18.85	80.15	1825.3	7496.7
11:45-12:00	507.3	27.8	361.65	34.95	367.4	26.5	212.1	34.7	22.9	105.3	1700.6	7417.15
4:00-4:15	398.05	31.65	269.35	36.4	614.9	58.7	319.25	37.2	34.15	64.7	1864.4	
4:15-4:30	457.2	40.95	288.1	34.7	783.3	52.75	364.05	39.9	26.8	71	2158.8	
4:30-4:45	439.9	32.4	313.45	40.9	731.35	33.4	415.25	34.3	15.75	56.3	2113	
4:45-5:00	465.95	37.85	305.85	27.1	828.9	46.55	405.2	48.8	17.4	89	2272.6	8408.7
5:00-5:15	453.3	25.1	292.95	43.3	799.5	58.25	469.15	53.5	26.3	59.8	2281.2	8825.5
5:15-5:30	480.6	26.45	324.15	28	762.7	58.15	471.8	42.3	23.2	70.05	2287.4	8954.15
5:30-5:45	437.25	30.8	313.25	29.25	812.25	66.75	514.75	46.2	30.9	62	2343.4	9184.55
5:45-6:00	457.65	30.95	297.9	26.55	826.95	62.85	479.3	45.65	21.85	56.25	2305.9	9217.85
6:00-6:15	415.15	28.3	263.6	25.1	836.1	46	417.5	50.85	24	54.95	2161.6	9098.25
6:15-6:30	439.25	19.25	228.4	37.5	744.5	57.1	481	18.35	23.1	42.85	2091.3	8902.15
6:30-6:45	450.25	22.8	217.55	34.7	621.45	62.35	485.4	49.15	19.3	49.9	2012.9	8571.6
6:45-7:00	362.3	28.65	216.8	30	735.65	48.05	439.2	47.1	18.8	36.95	1963.5	8229.2

JADIBUTI INTERSCETION APPROACH PCU												
DAY 2												
Time	6 Lokanthali (TH) to Koteshwor	5 Lokanthali (RT) to Pepsicola	9 Pepsicola (RT) to Koteswor	7 Pepsicola (LT) to Lokanthali	33 Koteswor (TH) to Lokanthali	31 Koteswor (RT) to Jadibuti Buspark	35 Koteswor (LT) to Pepsicola	36 Jadibuti Buspark (TH) to Pepsicola	14 Jadibuti Buspark (RT) to Lokanthali	16 Jadibuti Buspark (LT) to Koteswor	Total PCU	Hourly PCU
9:00-9:15	594.15	14.7	359.05	31.65	371.65	27.15	217.25	28.5	33.4	162.75	1840.3	
9:15-9:30	615.4	22.6	383.55	17.3	356.2	28.95	224.05	16.7	25.75	106.7	1797.2	
9:30-9:45	729.45	20.3	554.35	27.75	417.6	17.1	226.4	18.6	29.45	93.15	2134.2	
9:45-10:00	538.15	21.35	512.35	21.4	420.3	27.35	237.4	32.05	24.9	130.2	1965.5	7737.05
10:00-10:15	526.45	21.05	412.45	21.55	453.5	28	243.25	39.55	26.45	127.65	1899.9	7796.7
10:15-10:30	590.15	23.2	451	26.9	519.1	29.9	251.55	17.3	30.3	83.25	2022.7	8022.15
10:30-10:45	588.45	18.7	466.6	21.9	453.25	34.95	259.5	27.55	23.6	136.95	2031.5	7919.45
10:45-11:00	592.5	22.35	377.55	24.3	414.35	38	249.7	28	21.55	121.35	1889.7	7843.65
11:00-11:15	597.5	14.85	372.6	18.6	416.15	33.9	245	24.45	21.7	120.9	1865.7	7809.4
11:15-11:30	549.35	16.2	391.95	23.5	437.75	34.35	230.05	26.65	21.9	123.25	1855	7641.7
11:30-11:45	558.85	17.35	387.45	23.85	329.25	30.95	253.55	26.1	24.3	97.3	1749	7359.2
11:45-12:00	488	16.5	374.65	28.65	347.25	27.35	228.4	26.85	20.9	97.3	1655.9	7125.4
4:00-4:15	395.25	32.5	257.6	32.2	550.05	55.1	316.3	36.75	32.45	67.65	1775.9	
4:15-4:30	450.5	29.6	276.3	29.25	801.35	57.3	354.9	45.25	28.6	65.85	2138.9	
4:30-4:45	450.55	27.8	317.8	36.05	765.5	41.65	397.6	32.55	22.8	68.05	2160.4	
4:45-5:00	455.5	36.85	298.55	28.55	768.35	45.65	417.15	44.45	19.2	80.25	2194.5	8269.6
5:00-5:15	441.55	30.85	319.7	33.65	834.45	56.1	431.25	47.85	28.35	72.7	2296.5	8790.2
5:15-5:30	458.85	27.7	337.2	38.05	754.85	58.7	484.05	44.65	31.35	70	2305.4	8956.7
5:30-5:45	414.4	40.25	320.9	37.85	769.2	57.65	499.9	46.75	31.5	71.2	2289.6	9085.95
5:45-6:00	454.8	36	280.55	29.65	826.75	64.05	491.85	45.6	21.1	56.65	2307	9198.45
6:00-6:15	404.2	28	250.95	25.8	802.1	54.05	436.85	45.65	23.6	52.7	2123.9	9025.9
6:15-6:30	444.5	23.35	224.8	31.3	758.95	54.9	463.7	36.55	27.2	52.5	2117.8	8838.25
6:30-6:45	444.4	23.65	208.6	33.75	639.5	54.35	468.75	39.65	27.25	52.75	1992.7	8541.3
6:45-7:00	372.4	29.05	211.9	33.05	688.3	44.85	442.65	43.65	21.55	42.7	1930.1	8164.4

JADIBUTI INTERSCETION APPROACH PCU												
DAY 3												
Time	6 Lokanthali (TH) to Koteshwor	5 Lokanthali (RT) to Pepsicola	9 Pepsicola (RT) to Koteswor	7 Pepsicola (LT) to Lokanthali	33 Koteswor (TH) to Lokanthali	31 Koteswor (RT) to Jadibuti Buspark	35 Koteswor (LT) to Pepsicola	36 Jadibuti Buspark (TH) to Pepsicola	14 Jadibuti Buspark (RT) to Lokanthali	16 Jadibuti Buspark (LT) to Koteswor	Total PCU	Hourly PCU
9:00-9:15	604.25	12.8	347.25	26.4	411.8	33.45	185.8	32.6	27.65	131.35	1813.4	
9:15-9:30	633.5	18.7	391.65	22.2	337.5	25.05	232.65	22.5	26.8	114.1	1824.7	
9:30-9:45	647.45	22.05	545.25	25.25	399.6	21.2	233.95	23.4	34.25	93	2045.4	
9:45-10:00	553.35	15.35	566.1	25.65	393	36.15	237.9	32.1	26.25	115.9	2001.8	7685.15
10:00-10:15	555.05	14.35	402.7	22.65	459.4	36.1	242	33.95	27.05	117.85	1911.1	7782.9
10:15-10:30	593.8	22.1	437.65	28.9	515.35	35.2	250.25	30.45	22.85	101.45	2038	7996.25
10:30-10:45	565.5	20.55	436.75	23.95	470.45	33.45	248.2	33.95	31.55	115.75	1980.1	7930.95
10:45-11:00	571.8	16.75	351.55	27.75	403	35.55	235.9	32.3	22.7	114.55	1811.9	7741.05
11:00-11:15	586.2	18.8	403.55	21.25	443.5	32.75	241.9	26.65	25.9	109.45	1910	7739.9
11:15-11:30	533.75	12.5	356.25	30.1	462.35	46.2	238.05	25.05	17.4	132.45	1854.1	7556
11:30-11:45	555.95	17.95	442.5	22.75	334.8	27.55	232.35	28.05	24.9	90.5	1777.3	7353.2
11:45-12:00	511.9	18.75	327.45	28.15	376.95	25.95	222.05	26.55	23.85	93.85	1655.5	7196.8
4:00-4:15	399.85	30.65	265.8	31	541.35	62.15	320.55	41.65	34.9	69.15	1797.1	
4:15-4:30	459.15	41.05	281.75	30.55	761.9	61.25	346.7	44.4	34.6	76.3	2137.7	
4:30-4:45	426.8	33.45	317.95	33.3	719.65	45.75	376.35	41.15	23.85	61.05	2079.3	
4:45-5:00	461.95	36.7	284.85	26.8	812.3	53.05	399.85	50.4	19.4	77.55	2222.9	8236.85
5:00-5:15	462.35	28.6	298.8	37.2	825.15	60.05	397.7	47.75	25.7	66.2	2249.5	8689.3
5:15-5:30	467.05	24.45	311.5	30	767.05	61.4	452.1	44.25	29.75	65.7	2253.3	8804.9
5:30-5:45	419.05	31.2	299.15	33.2	843.25	61.4	479.8	46	31.8	80.65	2325.5	9051.1
5:45-6:00	441.35	26.05	292.65	22	840.6	60.95	477.05	44.65	21	50.95	2277.3	9105.5
6:00-6:15	433.9	30.35	275.95	27.35	747.55	52.15	450.8	40.45	24.55	59.45	2142.5	8998.5
6:15-6:30	416.7	20.85	234.15	30.5	869.45	53.4	450.55	31.9	22.8	45.15	2175.5	8920.7
6:30-6:45	436.85	28.45	219.2	27.25	620.15	53.6	457.55	41.4	27.6	56.55	1968.6	8563.8
6:45-7:00	370.1	23.75	207.55	28.75	681.65	47.15	445.1	39.15	20.15	50.65	1914	8200.55

JADIBUTI INTERSCETION APPROACH VOLUME

DAY 1

Time	6 Lokanthali (TH) to Koteshwor	5 Lokanthali (RT) to Pepsicola	9 Pepsicola (RT) to Koteswor	7 Pepsicola (LT) to Lokanthali	33 Koteswor (TH) to Lokanthali	31 Koteswor (RT) to Jadibuti Buspark	35 Koteswor (LT) to Pepsicola	36 Jadibuti Buspark (TH) to Pepsicola	14 Jadibuti Buspark (RT) to Lokanthali	16 Jadibuti Buspark (LT) to Koteswor	Total PCU	Hourly PCU
9:00-9:15	975	24	675	55	611	50	255	60	48	371	3124	
9:15-9:30	964	25	671	30	611	51	349	38	41	259	3039	
9:30-9:45	1213	33	1321	36	509	24	410	52	56	200	3854	
9:45-10:00	802	18	1177	46	681	47	400	65	41	289	3566	13583
10:00-10:15	902	20	686	37	819	60	407	89	37	275	3332	13791
10:15-10:30	944	50	817	41	848	54	427	43	47	188	3459	14211
10:30-10:45	983	32	875	58	785	74	416	91	56	309	3679	14036
10:45-11:00	981	19	651	51	703	53	404	56	43	266	3227	13697
11:00-11:15	1065	33	742	46	705	73	404	58	50	278	3454	13819
11:15-11:30	979	25	745	55	755	70	422	67	33	311	3462	13822
11:30-11:45	982	37	786	45	589	60	437	77	37	190	3240	13383
11:45-12:00	846	52	651	65	596	65	371	80	43	246	3015	13171
4:00-4:15	606	48	449	69	1026	120	544	79	53	150	3144	
4:15-4:30	652	60	499	74	1534	121	614	77	51	150	3832	
4:30-4:45	670	58	515	73	1394	81	712	74	32	125	3734	
4:45-5:00	630	62	520	56	1547	113	748	110	39	171	3996	14706
5:00-5:15	682	39	493	83	1469	132	808	122	55	119	4002	15564
5:15-5:30	658	46	592	67	1504	129	829	96	57	141	4119	15851
5:30-5:45	600	46	571	58	1591	145	941	105	64	135	4256	16373
5:45-6:00	598	44	531	52	1605	140	880	115	55	126	4146	16523
6:00-6:15	549	53	487	55	1685	103	759	127	56	121	3995	16516
6:15-6:30	588	33	411	89	1490	130	898	50	52	100	3841	16238
6:30-6:45	607	47	391	64	1255	139	913	118	44	113	3691	15673
6:45-7:00	501	47	410	55	1365	107	860	101	43	92	3581	15108

JADIBUTI INTERSCETION APPROACH VOLUME												
DAY 2												
Time	6 Lokanthali (TH) to Koteshwor	5 Lokanthali (RT) to Pepsicola	9 Pepsicola (RT) to Koteswor	7 Pepsicola (LT) to Lokanthali	33 Koteswor (TH) to Lokanthali	31 Koteswor (RT) to Jadibuti Buspark	35 Koteswor (LT) to Pepsicola	36 Jadibuti Buspark (TH) to Pepsicola	14 Jadibuti Buspark (RT) to Lokanthali	16 Jadibuti Buspark (LT) to Koteswor	Total PCU	Hourly PCU
9:00-9:15	936	29	681	52	592	43	307	71	47	404	3162	
9:15-9:30	938	35	776	35	557	51	350	42	44	248	3076	
9:30-9:45	1236	36	1166	46	636	33	390	47	58	197	3845	
9:45-10:00	863	36	1058	42	685	51	403	70	44	313	3565	13648
10:00-10:15	855	42	783	41	774	52	418	85	48	291	3389	13875
10:15-10:30	966	48	828	47	845	63	425	40	57	188	3507	14306
10:30-10:45	1005	38	912	50	799	65	438	68	47	326	3748	14209
10:45-11:00	1063	31	727	55	668	67	442	66	40	289	3448	14092
11:00-11:15	1057	34	720	42	681	66	421	52	47	284	3404	14107
11:15-11:30	973	30	766	49	746	73	404	64	41	279	3425	14025
11:30-11:45	954	30	731	42	570	67	427	62	46	219	3148	13425
11:45-12:00	822	29	686	53	577	60	396	65	42	224	2954	12931
4:00-4:15	571	56	442	57	929	113	547	71	50	146	2982	
4:15-4:30	633	52	491	65	1540	117	583	89	49	138	3757	
4:30-4:45	686	49	507	70	1485	96	708	77	38	140	3856	
4:45-5:00	654	58	507	61	1471	109	777	99	46	160	3942	14537
5:00-5:15	685	54	560	71	1554	124	759	105	59	130	4101	15656
5:15-5:30	644	45	650	76	1540	136	858	106	59	137	4251	16150
5:30-5:45	569	54	576	73	1528	126	904	106	68	148	4152	16446
5:45-6:00	617	56	499	59	1675	134	898	104	51	123	4216	16720
6:00-6:15	527	47	470	55	1612	126	820	107	52	116	3932	16551
6:15-6:30	595	46	399	74	1448	118	874	88	60	111	3813	16113
6:30-6:45	599	48	363	70	1299	118	900	95	55	107	3654	15615
6:45-7:00	497	50	382	65	1321	103	867	93	39	90	3507	14906

JADIBUTI INTERSCETION APPROACH VOLUME												
DAY 3												
Time	6 Lokanthali (TH) to Koteshwor	5 Lokanthali (RT) to Pepsicola	9 Pepsicola (RT) to Koteswor	7 Pepsicola (LT) to Lokanthali	33 Koteswor (TH) to Lokanthali	31 Koteswor (RT) to Jadibuti Buspark	35 Koteswor (LT) to Pepsicola	36 Jadibuti Buspark (TH) to Pepsicola	14 Jadibuti Buspark (RT) to Lokanthali	16 Jadibuti Buspark (LT) to Koteswor	Total PCU	Hourly PCU
9:00-9:15	985	24	639	53	598	53	247	70	49	311	3029	
9:15-9:30	1037	28	808	40	532	51	384	45	39	254	3218	
9:30-9:45	1089	40	1153	43	578	40	386	57	65	222	3673	
9:45-10:00	891	27	1169	48	610	57	389	74	47	276	3588	13508
10:00-10:15	888	27	748	39	802	60	423	82	43	294	3406	13885
10:15-10:30	957	43	817	48	860	65	411	71	48	232	3552	14219
10:30-10:45	952	41	884	54	790	70	420	82	57	269	3619	14165
10:45-11:00	1033	33	674	63	669	66	424	75	41	279	3357	13934
11:00-11:15	1037	34	768	43	708	68	396	57	51	272	3434	13962
11:15-11:30	933	25	720	56	778	81	396	64	32	289	3374	13784
11:30-11:45	941	34	813	45	558	61	410	67	44	214	3187	13352
11:45-12:00	878	35	590	53	655	61	395	67	41	226	3001	12996
4:00-4:15	583	48	449	63	880	135	566	87	56	153	3020	
4:15-4:30	661	61	486	70	1500	140	604	81	54	160	3817	
4:30-4:45	647	61	528	64	1390	113	701	89	41	130	3764	
4:45-5:00	675	60	484	55	1503	124	751	114	39	148	3953	14554
5:00-5:15	699	40	510	76	1545	129	695	106	47	132	3979	15513
5:15-5:30	670	46	586	68	1517	127	826	101	53	138	4132	15828
5:30-5:45	610	50	554	65	1627	125	899	109	58	158	4255	16319
5:45-6:00	613	46	536	53	1668	128	899	101	51	117	4212	16578
6:00-6:15	580	48	507	60	1488	120	836	95	59	123	3916	16515
6:15-6:30	558	37	431	75	1756	118	864	84	53	106	4082	16465
6:30-6:45	597	49	395	61	1243	120	893	94	47	113	3612	15822
6:45-7:00	508	39	365	57	1284	111	854	89	45	102	3454	15064

Vehicle Input Data for VISSIM Day 3																					
MORNING PEAK HOUR (9:30-10:30am)																					
S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw Cart	Tractor	Excavtor	Hourly PCU	Hourly Volume
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy							
1	Lokanthali to Jadibuti (Total Entry)	3717	784	86	39	55	0	53	35	95	15	5	26	10	5	35	0	2	0	2856.5	4962
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	603	20	3	1	3	0	2	0	2	0	0	1	0	0	4	0	0	0	249.35	639
3	Narefat Petrolpump to Koteshwor to Tinkune	1374	68	8	3	2	0	4	1	2	1	1	1	0	0	1	0	0	0	582.6	1466
4	Balkumari to Tinkune (Left Turn)	582	209	15	3	20	52	15	12	62	5	1	4	3	2	14	0	1	0	780.5	1000
5	Balkumari to Jadibuti (Right Turn)	889	155	35	4	52	0	11	24	6	6	2	20	13	1	12	0	0	0	745.05	1230
6	Tinkune-Koteshwor Approach Total	2871	590	66	40	68	22	57	63	166	12	10	12	4	4	37	0	4	0	2636.3	4026
7	Pepsicola Approach Total	3359	417	53	19	58	0	10	9	60	14	9	15	7	3	30	0	2	0	2054.2	4065
8	Mahadevsthan Approach Total	1461	102	5	13	11	1	0	0	0	1	6	1	0	3	35	0	0	0	666.85	1639
9	Narefat Buspark Approach Total	1320	81	24	5	16	0	6	6	5	1	4	3	2	2	35	0	1	0	658.5	1511
142:	Manoharafat Corridor Approach	2405	116	19	12	17	0	2	0	2	5	5	4	0	0	10	0	0	0	1045.3	2597

Vehicle Input Data for VISSIM Day Average of Day 1 and 2																					
MORNING PEAK HOUR (9:30-10:30am)																					
S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw Cart	Tractor	Excavtor	Hourly PCU	Hourly Volume
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy							
1	Lokanthali to Jadibuti (Total Entry)	3667	779	96	32	73	0	48	32	96	16	6	24	8	4	27	1	3	0	2834.6	4912
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	580	29	2	1	2	0	1	0	2	0	0	3	0	0	7	0	1	0	248.8	628
3	Narefat Petrolpump to Koteshwor to Tinkune	1385	67	12	4	6	0	4	1	4	0	0	0	0	0	2	0	0	0	592.23	1485
4	Balkumari to Tinkune (Left Turn)	565	211	15	5	19	53	18	11	64	6	1	4	4	1	16	0	1	0	781.85	994
5	Balkumari to Jadibuti (Right Turn)	858	162	36	4	52	0	11	23	6	6	2	20	12	1	14	0	0	0	730.33	1207
6	Tinkune-Koteshwor Approach Total	2928	598	69	43	79	20	60	59	155	17	7	13	3	4	38	0	2	1	2632.7	4096
7	Pepsicola Approach Total	3392	424	41	18	69	0	11	8	61	12	4	19	4	2	25	0	2	0	2047.1	4092
8	Mahadevsthan Approach Total	1455	102	5	12	10	1	0	0	0	3	5	1	0	4	31	0	0	0	658.85	1629
9	Narefat Buspark Approach Total	1243	83	16	7	18	0	5	7	7	2	4	5	1	1	20	0	1	0	620.68	1420
142:	Manoharafat Corridor Approach	2554	134	18	10	13	0	2	0	1	6	2	5	0	0	6	0	0	0	1097.1	2751

Vehicle Input Data for VISSIM Day Average of Day 1 and 2 and 3																					
MORNING PEAK HOUR (9:30-10:30am)																					
S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw Cart	Tractor	Excavtor	Hourly PCU	Hourly Volume
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy							
1	Lokanthali to Jadibuti (Total Entry)	3684	780	92	34	67	0	49	33	95	16	6	25	9	4	29	0	2	0	2841.9	4925
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	588	26	2	1	2	0	1	0	2	0	0	2	0	0	6	0	0	0	248.98	630
3	Narefat Petrolpump to Koteshwor to Tinkune	1381	67	11	4	4	0	4	1	3	0	0	0	0	0	2	0	0	0	589.02	1477
4	Balkumari to Tinkune (Left Turn)	571	210	15	4	19	52	17	11	63	5	1	4	3	1	15	0	1	0	781.4	992
5	Balkumari to Jadibuti (Right Turn)	868	159	35	4	52	0	11	23	6	6	2	20	12	1	13	0	0	0	735.23	1212
6	Tinkune-Koteshwor Approach Total	2909	595	67	41	75	21	58	60	159	15	7	13	3	4	38	0	2	0	2633.9	4067
7	Pepsicola Approach Total	3380	421	44	18	65	0	10	8	60	12	6	17	5	2	26	0	2	0	2049.5	4076
8	Mahadevsthan Approach Total	1457	102	5	12	10	1	0	0	0	2	5	1	0	3	33	0	0	0	661.52	1631
9	Narefat Buspark Approach Total	1268	82	18	6	17	0	5	6	6	1	3	3	1	1	24	0	0	0	633.28	1441
42:	Manoharafat Corridor Approach	2504	127	18	11	14	0	2	0	1	5	2	4	0	0	7	0	0	0	1079.8	2695

Vehicle Input Data for VISSIM Day 3																					
EVENING PEAK HOUR (5:00pm-6:00pm)																					
S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw Cart	Tractor	Excavtor	Hourly PCU	Hourly Volume
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy							
1	Lokanthali to Jadibuti (Total Entry)	2200	478	64	37	83	0	115	29	108	26	11	31	14	8	41	0	1	0	2203.2	3246
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	179	18	1	0	4	0	0	0	2	1	1	3	0	0	2	0	2	0	107.05	213
3	Narefat Petrolpump to Koteshwor to Tinkune	374	28	5	1	4	0	0	1	2	0	0	0	0	0	5	0	0	0	178.4	420
4	Balkumari to Tinkune (Left Turn)	736	237	23	20	42	42	14	16	70	8	3	4	1	4	24	0	0	0	938.9	1244
5	Balkumari to Jadibuti (Right Turn)	1464	311	42	6	69	0	19	21	5	15	2	31	12	1	18	0	1	0	1174.5	2017
6	Tinkune-Koteshwor Approach Total	7134	1218	121	25	64	18	49	44	215	24	8	20	2	12	53	0	2	0	4920	9009
7	Pepsicola Approach Total	1906	274	39	12	69	0	14	6	46	6	6	16	9	3	42	0	0	0	1324.5	2448
8	Mahadevsthan Approach Total	1163	60	3	6	13	1	0	0	0	0	4	1	0	0	25	0	0	0	502.55	1276
9	Narefat Buspark Approach Total	972	84	22	6	16	0	8	4	9	4	3	5	2	0	36	0	0	0	554.4	1171
.42:	Manoharafat Corridor Approach	864	104	13	6	17	0	3	0	2	5	2	3	0	0	22	0	0	0	479.8	1041

Vehicle Input Data for VISSIM Day Average of Day 1 and 2																					
EVENING PEAK HOUR (5:00pm-6:00pm)																					
S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw Cart	Tractor	Excavtor	Hourly PCU	Hourly Volume
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy							
1	Lokanthali to Jadibuti (Total Entry)	2102	457	75	35	87	0	107	26	117	25	11	39	21	8	36	1	1	0	2191.6	3148
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	175	16	4	1	4	0	0	0	1	0	1	3	1	0	2	0	2	0	99.63	210
3	Narefat Petrolpump to Koteshwor to Tinkune	375	27	4	3	7	0	1	0	2	0	0	1	0	0	4	0	1	0	181.2	425
4	Balkumari to Tinkune (Left Turn)	739	238	22	21	44	36	15	15	73	5	2	4	1	5	27	0	1	1	934.78	1249
5	Balkumari to Jadibuti (Right Turn)	1459	301	44	7	70	0	21	22	5	14	2	30	10	1	16	0	1	1	1157.8	2004
6	Tinkune-Koteshwor Approach Total	7140	1181	127	32	64	21	47	47	211	25	11	21	2	14	71	0	2	0	4899.8	9016
7	Pepsicola Approach Total	1935	275	36	18	73	0	15	6	46	15	9	19	7	4	38	0	1	1	1376.5	2498
8	Mahadevsthan Approach Total	1161	62	4	4	10	1	0	0	0	0	5	2	0	1	21	0	0	0	495.78	1271
9	Narefat Buspark Approach Total	1013	91	17	9	17	0	5	4	8	5	5	2	2	2	23	0	1	0	552.85	1204
142:	Manoharafat Corridor Approach	856	100	15	6	20	0	4	0	3	4	2	4	0	0	19	1	0	0	470.2	1034

Vehicle Input Data for VISSIM Day Average of Day 1 and 2 and 3

EVENING PEAK HOUR (5:00pm-6:00pm)

S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw Cart	Tractor	Excavtor	Hourly PCU	Hourly Volume
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy							
1	Lokanthali to Jadibuti (Total Entry)	2134	464	71	36	86	0	109	27	114	25	11	36	18	8	37	1	1	0	2195.5	3178
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	176	17	3	0	4	0	0	0	1	0	1	3	0	0	2	0	2	0	102.1	209
3	Narefat Petrolpump to Koteshwor to Tinkune	375	27	4	2	6	0	1	0	2	0	0	0	0	0	4	0	0	0	180.27	421
4	Balkumari to Tinkune (Left Turn)	738	238	22	21	43	38	15	15	72	6	2	4	1	5	26	0	0	0	936.15	1246
5	Balkumari to Jadibuti (Right Turn)	1461	304	43	6	69	0	20	21	5	14	2	30	11	1	16	0	1	0	1163.3	2004
6	Tinkune-Koteshwor Approach Total	7137	1194	125	29	64	20	47	45	212	25	10	20	2	12	64	0	2	0	4906.5	9008
7	Pepsicola Approach Total	1925	275	36	16	71	0	15	6	46	11	7	18	7	4	39	0	0	0	1359.1	2476
8	Mahadevsthan Approach Total	1161	61	2	4	10	1	0	0	0	0	4	1	0	0	22	0	0	0	498.03	1266
9	Narefat Buspark Approach Total	999	88	18	7	16	0	5	3	7	5	4	3	1	1	27	0	0	0	553.37	1184
.42:	Manoharafat Corridor Approach	858	101	14	6	19	0	3	0	2	4	2	3	0	0	20	0	0	0	473.4	1032

Input Vehicle Composition for VISSIM Day 3

MORNING PEAK HOUR (9:30-10:30am)

S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw	Tractor	Excavtor
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy					
1	Lokanthali to Jadibuti (Total Entry)	0.749	0.158	0.017	0.008	0.011	0	0.011	0.007	0.019	0.003	0.001	0.005	0.002	0	0.007	0	0	0
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	0.944	0.031	0.005	0.002	0.005	0	0.003	0	0.003	0	0	0.002	0	0	0.006	0	0	0
3	Narefat Petrolpump to Koteshwor to Tinkune	0.937	0.046	0.005	0.002	0.001	0	0.003	7E-04	0.001	7E-04	7E-04	7E-04	0	0	7E-04	0	0	0
4	Balkumari to Tinkune (Left Turn)	0.582	0.209	0.015	0.003	0.02	0.052	0.015	0.012	0.062	0.005	0.001	0.004	0.003	0	0.014	0	0	0
5	Balkumari to Jadibuti (Right Turn)	0.723	0.126	0.028	0.003	0.042	0	0.009	0.02	0.005	0.005	0.002	0.016	0.011	0	0.01	0	0	0
6	Tinkune-Koteshwor Approach Total	0.713	0.147	0.016	0.01	0.017	0.005	0.014	0.016	0.041	0.003	0.002	0.003	1E-03	0	0.009	0	0	0
7	Pepsicola Approach Total	0.826	0.103	0.013	0.005	0.014	0	0.002	0.002	0.015	0.003	0.002	0.004	0.002	0	0.007	0	0	0
8	Mahadevsthan Approach Total	0.891	0.062	0.003	0.008	0.007	6E-04	0	0	0	6E-04	0.004	6E-04	0	0	0.021	0	0	0
9	Narefat Buspark Approach Total	0.874	0.054	0.016	0.003	0.011	0	0.004	0.004	0.003	7E-04	0.003	0.002	0.001	0	0.023	0	0	0
10	Manoharafat Corridor Approach	0.926	0.045	0.007	0.005	0.007	0	8E-04	0	8E-04	0.002	0.002	0.002	0	0	0.004	0	0	0

Input Vehicle Composition for VISSIM Average of Day 1 and 2

MORNING PEAK HOUR (9:30-10:30am)

S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw	Tractor	Excavtor
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy					
1	Lokanthali to Jadibuti (Total Entry)	0.747	0.159	0.02	0.007	0.015	0	0.01	0.007	0.02	0.003	0.001	0.005	0.002	0	0.005	0	0	0
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	0.924	0.046	0.003	0.002	0.003	0	0.002	0	0.003	0	0	0.005	0	0	0.011	0	0	0
3	Narefat Petrolpump to Koteshwor to Tinkune	0.933	0.045	0.008	0.003	0.004	0	0.003	7E-04	0.003	0	0	0	0	0	0.001	0	0	0
4	Balkumari to Tinkune (Left Turn)	0.568	0.212	0.015	0.005	0.019	0.053	0.018	0.011	0.064	0.006	0.001	0.004	0.004	0	0.016	0	0	0
5	Balkumari to Jadibuti (Right Turn)	0.711	0.134	0.03	0.003	0.043	0	0.009	0.019	0.005	0.005	0.002	0.017	0.01	0	0.012	0	0	0
6	Tinkune-Koteshwor Approach Total	0.715	0.146	0.017	0.01	0.019	0.005	0.015	0.014	0.038	0.004	0.002	0.003	7E-04	0	0.009	0	0	0
7	Pepsicola Approach Total	0.829	0.104	0.01	0.004	0.017	0	0.003	0.002	0.015	0.003	1E-03	0.005	1E-03	0	0.006	0	0	0
8	Mahadevsthan Approach Total	0.893	0.063	0.003	0.007	0.006	6E-04	0	0	0	0.002	0.003	6E-04	0	0	0.019	0	0	0
9	Narefat Buspark Approach Total	0.875	0.058	0.011	0.005	0.013	0	0.004	0.005	0.005	0.001	0.003	0.004	7E-04	0	0.014	0	0	0
10	Manoharafat Corridor Approach	0.928	0.049	0.007	0.004	0.005	0	7E-04	0	4E-04	0.002	7E-04	0.002	0	0	0.002	0	0	0

Input Vehicle Composition for VISSIM Average of Day 1 and 2 and 3

MORNING PEAK HOUR (9:30-10:30am)

S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw	Tractor	Excavtor
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy					
1	Lokanthali to Jadibuti (Total Entry)	0.748	0.158	0.019	0.007	0.014	0	0.01	0.007	0.019	0.003	0.001	0.005	0.002	0	0.006	0	0	0
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	0.933	0.041	0.003	0.002	0.003	0	0.002	0	0.003	0	0	0.003	0	0	0.01	0	0	0
3	Narefat Petrolpump to Koteshwor to Tinkune	0.935	0.045	0.007	0.003	0.003	0	0.003	7E-04	0.002	0	0	0	0	0	0.001	0	0	0
4	Balkumari to Tinkune (Left Turn)	0.576	0.212	0.015	0.004	0.019	0.052	0.017	0.011	0.064	0.005	0.001	0.004	0.003	0	0.015	0	0	0
5	Balkumari to Jadibuti (Right Turn)	0.716	0.131	0.029	0.003	0.043	0	0.009	0.019	0.005	0.005	0.002	0.017	0.01	0	0.011	0	0	0
6	Tinkune-Koteshwor Approach Total	0.715	0.146	0.016	0.01	0.018	0.005	0.014	0.015	0.039	0.004	0.002	0.003	7E-04	0	0.009	0	0	0
7	Pepsicola Approach Total	0.829	0.103	0.011	0.004	0.016	0	0.002	0.002	0.015	0.003	0.001	0.004	0.001	0	0.006	0	0	0
8	Mahadevsthan Approach Total	0.893	0.063	0.003	0.007	0.006	6E-04	0	0	0	0.001	0.003	6E-04	0	0	0.02	0	0	0
9	Narefat Buspark Approach Total	0.88	0.057	0.012	0.004	0.012	0	0.003	0.004	0.004	7E-04	0.002	0.002	7E-04	0	0.017	0	0	0
10	Manoharafat Corridor Approach	0.929	0.047	0.007	0.004	0.005	0	7E-04	0	4E-04	0.002	7E-04	0.001	0	0	0.003	0	0	0

Input Vehicle Composition for VISSIM Day 3																				
EVENING PEAK HOUR (5:00pm-6:00pm)																				
S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw	Tractor	Excavtor
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy					
1	Lokanthali to Jadibuti (Total Entry)	0.678	0.147	0.02	0.011	0.026	0	0.035	0.009	0.033	0.008	0.003	0.01	0.004	0	0.013	0	0	0
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	0.84	0.085	0.005	0	0.019	0	0	0	0.009	0.005	0.005	0.014	0	0	0.009	0	0	0
3	Narefat Petrolpump to Koteshwor to Tinkune	0.89	0.067	0.012	0.002	0.01	0	0	0.002	0.005	0	0	0	0	0	0.012	0	0	0
4	Balkumari to Tinkune (Left Turn)	0.592	0.191	0.018	0.016	0.034	0.034	0.011	0.013	0.056	0.006	0.002	0.003	8E-04	0	0.019	0	0	0
5	Balkumari to Jadibuti (Right Turn)	0.726	0.154	0.021	0.003	0.034	0	0.009	0.01	0.002	0.007	1E-03	0.015	0.006	0	0.009	0	0	0
6	Tinkune-Koteshwor Approach Total	0.792	0.135	0.013	0.003	0.007	0.002	0.005	0.005	0.024	0.003	9E-04	0.002	2E-04	0	0.006	0	0	0
7	Pepsicola Approach Total	0.779	0.112	0.016	0.005	0.028	0	0.006	0.002	0.019	0.002	0.002	0.007	0.004	0	0.017	0	0	0
8	Mahadevsthan Approach Total	0.911	0.047	0.002	0.005	0.01	8E-04	0	0	0	0	0.003	8E-04	0	0	0.02	0	0	0
9	Narefat Buspark Approach Total	0.83	0.072	0.019	0.005	0.014	0	0.007	0.003	0.008	0.003	0.003	0.004	0.002	0	0.031	0	0	0
10	Manoharafat Corridor Approach	0.83	0.1	0.012	0.006	0.016	0	0.003	0	0.002	0.005	0.002	0.003	0	0	0.021	0	0	0

Input Vehicle Composition for VISSIM Average of Day 1 and 2																				
EVENING PEAK HOUR (5:00pm-6:00pm)																				
S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw	Tractor	Excavtor
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy					
1	Lokanthali to Jadibuti (Total Entry)	0.668	0.145	0.024	0.011	0.028	0	0.034	0.008	0.037	0.008	0.003	0.012	0.007	0	0.011	0	0	0
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	0.833	0.076	0.019	0.005	0.019	0	0	0	0.005	0	0.005	0.014	0.005	0	0.01	0	0	0
3	Narefat Petrolpump to Koteshwor to Tinkune	0.882	0.064	0.009	0.007	0.016	0	0.002	0	0.005	0	0	0.002	0	0	0.009	0	0	0
4	Balkumari to Tinkune (Left Turn)	0.592	0.191	0.018	0.017	0.035	0.029	0.012	0.012	0.058	0.004	0.002	0.003	8E-04	0	0.022	0	0	0
5	Balkumari to Jadibuti (Right Turn)	0.728	0.15	0.022	0.003	0.035	0	0.01	0.011	0.002	0.007	1E-03	0.015	0.005	0	0.008	0	0	0
6	Tinkune-Koteshwor Approach Total	0.792	0.131	0.014	0.004	0.007	0.002	0.005	0.005	0.023	0.003	0.001	0.002	2E-04	0	0.008	0	0	0
7	Pepsicola Approach Total	0.775	0.11	0.014	0.007	0.029	0	0.006	0.002	0.018	0.006	0.004	0.008	0.003	0	0.015	0	0	0
8	Mahadevsthan Approach Total	0.913	0.049	0.003	0.003	0.008	8E-04	0	0	0	0	0.004	0.002	0	0	0.017	0	0	0
9	Narefat Buspark Approach Total	0.841	0.076	0.014	0.007	0.014	0	0.004	0.003	0.007	0.004	0.004	0.002	0.002	0	0.019	0	0	0
10	Manoharafat Corridor Approach	0.828	0.097	0.015	0.006	0.019	0	0.004	0	0.003	0.004	0.002	0.004	0	0	0.018	0	0	0

Input Vehicle Composition for VISSIM Average of Day 1 and 2 and 3

EVENING PEAK HOUR (5:00pm-6:00pm)

S.N	Location	Bike	Cars				Public transport				Private		Truck		Emergency	Cycle	Ricksaw	Tractor	Excavtor
			Car	Jeep	Van	Utility Pickup	Tempo	Micro	Mini Bus	Large Bus	Bus	Micro	Light	Heavy					
1	Lokanthali to Jadibuti (Total Entry)	0.671	0.146	0.022	0.011	0.027	0	0.034	0.008	0.036	0.008	0.003	0.011	0.006	0	0.012	0	0	0
2	Siddhartha Petrolpump to Jadibuti Lane (Total)	0.842	0.081	0.014	0	0.019	0	0	0	0.005	0	0.005	0.014	0	0	0.01	0	0	0
3	Narefat Petrolpump to Koteshwor to Tinkune	0.891	0.064	0.01	0.005	0.014	0	0.002	0	0.005	0	0	0	0	0	0.01	0	0	0
4	Balkumari to Tinkune (Left Turn)	0.592	0.191	0.018	0.017	0.035	0.03	0.012	0.012	0.058	0.005	0.002	0.003	8E-04	0	0.021	0	0	0
5	Balkumari to Jadibuti (Right Turn)	0.729	0.152	0.021	0.003	0.034	0	0.01	0.01	0.002	0.007	1E-03	0.015	0.005	0	0.008	0	0	0
6	Tinkune-Koteshwor Approach Total	0.792	0.133	0.014	0.003	0.007	0.002	0.005	0.005	0.024	0.003	0.001	0.002	2E-04	0	0.007	0	0	0
7	Pepsicola Approach Total	0.777	0.111	0.015	0.006	0.029	0	0.006	0.002	0.019	0.004	0.003	0.007	0.003	0	0.016	0	0	0
8	Mahadevsthan Approach Total	0.917	0.048	0.002	0.003	0.008	8E-04	0	0	0	0	0.003	8E-04	0	0	0.017	0	0	0
9	Narefat Buspark Approach Total	0.844	0.074	0.015	0.006	0.014	0	0.004	0.003	0.006	0.004	0.003	0.003	8E-04	0	0.023	0	0	0
10	Manoharafat Corridor Approach	0.831	0.098	0.014	0.006	0.018	0	0.003	0	0.002	0.004	0.002	0.003	0	0	0.019	0	0	0

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Lokanthali to Tinkune | **MORNING PEAK HOUR** | **Vehicle Type: BUS**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (in sec)														Vehicle No.
		Lokanthali Stop	Manoharafat Intersection	Jadibuti Stop	Jadibuti Intersection	Petrol Pump Stop	Koteshwor Intersection	Koteswor Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	10:15:36	177	0	43	187	0	20	60	0.43625	0.00875	756	280	207	487	269	Ba4Kha 8480
2	11:15:30	70	0	60	93	30	39	65	11:25:50	0:10:20	620	225	132	357	263	006Kha8375
3	10:07:08	35	20	60	76	0	188	86	10:18:54	0:11:46	706	181	284	465	241	Ba5Kha 2781
4	10:57:00	47	15	10	55	0	148	58	11:06:17	0:09:17	557	115	218	333	224	Ba4Kha 2547
5	11:42:48	178	10	20	38	0	175	55	11:54:38	0:11:50	710	253	223	476	234	006Kha 2970
6	10:08:27	119	30	112	114	10	125	80	10:21:51	0:13:24	804	321	269	590	214	006Kha 2988
7	10:12:58	130	35	133	70	0	132	65	10:26:03	0:13:05	785	328	237	565	220	006Kha 4781
8	10:14:03	87	20	38	145	0	95	85	10:25:42	0:11:39	699	210	260	470	229	Ba6Kha 1791
9	10:17:45	57	15	124	155	0	127	75	10:30:50	0:13:05	785	256	297	553	232	006Kha 2987
10	10:25:13	100	30	104	30	0	40	50	10:34:43	0:09:30	570	254	100	354	216	006Kha 2965
11	10:27:05	98	12	43	157	0	95	80	10:39:17	0:12:12	732	221	264	485	247	006Kha 1586
12	10:31:39	193	10	45	140	0	104	55	10:44:35	0:12:56	776	293	254	547	229	Ba5Kha 3703
13	10:36:23	96	0	62	170	0	30	30	10:46:20	0:09:57	597	188	200	388	209	006Kha 2994
14	10:38:36	53	10	125	88	0	105	75	10:50:05	0:11:29	689	253	203	456	233	006Kha 7527
15	10:45:58	45	0	80	50	0	155	95	10:56:56	0:10:58	658	220	205	425	233	006Kha 7517
16	10:49:46	45	0	68	111	0	93	35	10:59:26	0:09:40	580	148	204	352	228	Ba5Kha 4774
17	10:33:56	61	10	75	104	0	108	65	10:44:41	0:10:45	645	201	222	423	222	Ba3Kha 3587
18	10:41:21	31	0	65	98	0	95	75	10:51:06	0:09:45	585	171	193	364	221	006Kha 2996
19	10:47:16	50	0	62	85	0	150	85	10:58:11	0:10:55	655	197	235	432	223	006Kha 2986
20	9:21:44	95	10	75	95	0	142	95	9:33:50	0:12:06	726	265	247	512	214	Ba5Kha 9106
21	9:38:20	85	15	55	92	0	110	70	9:48:40	00:10:20	620	210	217	427	193	Ba3Kha3785
22	9:45:56	62	0	78	118	10	95	65	9:56:46	00:10:50	650	215	213	428	222	006Kha 9502
23	9:52:19	105	10	50	105	0	125	70	10:04:09	00:11:50	710	225	240	465	245	Ba5Kha 3709
24	9:58:11	48	20	84	75	0	85	55	10:08:11	00:10:00	600	187	180	367	233	Ba5Kha 3703
25	10:05:41	135	0	70	105	0	140	75	10:18:01	00:12:20	740	280	245	525	215	006Kha 2987
26	10:08:24	80	25	90	82	0	115	70	10:19:44	00:11:20	680	240	222	462	218	006Kha 2965
27	10:12:36	98	0	52	135	0	85	60	10:23:46	00:11:10	670	210	220	430	240	Ba4Kha 2542
28	10:15:10	130	0	85	95	0	105	85	10:27:30	00:12:20	740	300	200	500	240	006Kha2998
29	10:21:00	55	25	90	80	20	105	70	10:32:10	00:11:10	670	235	210	445	225	006Kha2983
30	10:25:30	105	20	38	130	0	90	55	10:36:50	00:11:20	680	198	240	438	242	Ba4Kha 7092
31	10:27:45	80	10	85	112	0	140	70	10:39:45	00:12:00	720	235	262	497	223	006Kha 7523
32	10:30:42	88	30	70	88	0	120	75	10:42:22	00:11:40	700	233	238	471	229	006Kha 7519
33	10:36:15	85	0	85	125	0	85	70	10:48:05	00:11:50	710	240	210	450	260	Ba3Kha 5120
34	10:41:55	120	0	48	98	0	125	77	10:53:25	00:11:30	690	245	223	468	222	006Kha2981
35	10:45:23	35	20	82	115	0	102	60	10:56:33	00:11:10	670	177	237	414	256	006Kha2974
	Average	**88**	**11**	**70**	**103**	**2**	**108**	**68**	**-**	**0**	**682**	**229**	**223**	**452**	**230**	**-**

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Lokanthali to Tinkune — **MORNING PEAK HOUR** — **Vehicle Type: MINIBUS**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (in sec)														Vehicle No.
		Lokanthali Stop	Manoharafat Intersection	Jadibuti Stop	Jadibuti Intersection	Petrol Pump Stop	Koteshwor Intersection	Koteswor Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	10:07:36	101	71	35	41	0	0	95	10:17:21	0:09:45	585	231	112	343	242	Ba3Kha 2341
2	11:13:33	80	0	57	0	0	137	41	11:22:38	0:09:05	545	178	137	315	230	Ba3Kha 5235
3	10:07:33	43	0	80	70	0	170	96	10:18:48	0:11:15	675	219	240	459	216	Ba3Kha 3783
4	10:47:40	32	20	42	200	10	127	36	10:59:03	0:11:23	683	120	347	467	216	Ba 3Kha 7758
5	10:19:20	233	0	45	20	0	150	95	10:32:12	0:12:52	772	373	170	543	229	Ba5Kha 538
6	10:28:58	53	0	40	114	0	65	85	10:38:42	0:09:44	584	178	179	357	227	Ba3Kha 6228
7	10:39:28	69	15	54	71	0	98	85	10:49:35	0:10:07	607	208	184	392	215	Ba3Kha 2466
8	10:42:20	200	0	63	20	0	135	95	10:54:40	0:12:20	740	358	155	513	227	Ba4Kha 5761
9	10:47:50	90	10	60	136	0	84	78	10:58:59	0:11:09	669	228	230	458	211	Ba4Kha 1988
10	10:50:31	85	0	30	40	0	65	85	10:59:19	0:08:48	528	200	105	305	223	Ba3Kha 4436
11	10:53:45	62	15	25	162	10	110	145	11:06:25	0:12:40	760	242	287	529	231	006Kha 7919
12	11:04:28	147	20	100	191	0	70	80	11:18:06	0:13:38	818	327	281	608	210	Ba4Kha 753
13	11:11:30	16	0	25	55	10	152	91	11:20:57	0:09:27	567	142	207	349	218	Ba3Kha 5377
14	10:57:28	108	0	40	68	0	140	110	11:08:54	0:11:26	686	258	208	466	220	Ba3Kha 3584
15	9:29:44	98	20	105	125	0	98	115	9:42:41	0:12:57	777	318	243	561	216	Ba5Kha 1980
	Average	**94**	**11**	**53**	**88**	**2**	**107**	**89**	**-**	**0**	**666**	**239**	**206**	**444**	**222**	**-**

Approach: Lokanthali to Tinkune — **MORNING PEAK HOUR** — **Vehicle Type: MICRO**

S.N	Start Time	Delay Time (in sec)														Vehicle No.
		Lokanthali Stop	Manoharafat Intersection	Jadibuti Stop	Jadibuti Intersection	Petrol Pump Stop	Koteshwor Intersection	Koteswor Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	11:44:06	48	0	29	86	0	64	43	11:51:36	0:07:30	450	120	150	270	180	Ba3Kha 304
2	10:23:50	34	0	30	55	0	100	80	10:32:01	0:08:11	491	144	155	299	192	Ba2Kha 304
3	10:30:07	36	0	35	75	0	90	75	10:38:32	0:08:25	505	146	165	311	194	Ba2Kha 2174
4	10:51:38	57	10	30	35	0	135	110	11:01:10	0:09:32	572	197	180	377	195	Ba2Kha 4181
5	10:57:20	38	0	32	102	0	35	30	11:04:26	0:07:06	426	100	137	237	189	Ba2Kha 2614
6	10:58:26	34	15	35	179	0	44	55	11:07:40	0:09:14	554	124	238	362	192	Ba2Kha 2167
7	11:05:20	50	0	30	73	0	105	30	11:13:21	0:08:01	481	110	178	288	193	Ba2Kha 2607
8	11:08:20	60	20	20	111	0	115	55	11:17:54	0:09:34	574	135	246	381	193	Ba2Kha 2576
9	10:29:57	34	20	25	55	0	85	98	10:38:31	0:08:34	514	157	160	317	197	Ba2Kha2174
10	9:35:41	30	25	50	45	0	90	110	9:44:46	0:09:05	545	190	160	350	195	Ba3Kha 2198
11	9:41:47	35	15	30	80	0	70	50	9:49:53	00:08:06	486	115	165	280	206	Ba2Kha2620
12	9:47:55	35	0	25	60	0	95	55	9:55:40	00:07:45	465	115	155	270	195	Ba2Kha2159
13	9:56:15	40	15	30	90	0	85	75	10:04:55	00:08:40	520	145	190	335	185	Ba2Kha2175
14	10:04:07	35	15	35	90	0	90	80	10:12:52	00:08:45	525	150	195	345	180	Ba2Kha2602
15	10:15:25	38	0	30	70	0	80	60	10:23:20	00:07:55	475	128	150	278	197	Ba2Kha2478
16	10:19:32	50	20	40	80	0	103	75	10:28:42	00:09:10	550	165	203	368	182	Ba2Kha2163
17	10:23:20	30	15	25	75	0	75	70	10:31:30	00:08:10	490	125	165	290	200	Ba3Kha2051
18	10:29:35	60	10	35	95	0	85	80	10:38:45	00:09:10	550	175	190	365	185	Ba2Kha5205
19	10:33:18	45	0	30	85	0	90	75	10:42:08	00:08:50	530	150	175	325	205	Ba2Kha2191
20	10:37:30	52	0	33	95	0	85	70	10:46:16	00:08:46	526	155	180	335	191	Ba3Kha2011
	Average	**42**	**9**	**31**	**82**	**-**	**86**	**69**	**-**	**0**	**511**	**142**	**177**	**319**	**192**	**-**

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Lokanthali to Tinkune **EVENING PEAK HOUR** **Vehicle Type: BUS**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (in sec)														Vehicle No.
		Lokanthali Stop	Manoharafat Intersection	Jadibuti Stop	Jadibuti Intersection	Petrol Pump Stop	Koteshwor Intersection	Koteswor Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	17:23:40	45	0	55	63	0	79	92	17:33:07	0:09:27	567	192	142	334	233	Ba4Kha 7092
2	17:56:20	57	30	40	50	0	81	87	18:05:55	0:09:35	575	184	161	345	230	Na5Kha 4014
3	18:37:18	90	0	55	125	10	75	50	18:47:36	0:10:18	618	205	200	405	213	Ba3Kha 4471
4	18:17:20	48	35	225	149	20	53	175	18:33:09	0:15:49	949	468	237	705	244	006Kha 2998
5	18:19:43	63	30	146	74	0	115	162	18:33:29	0:13:46	826	371	219	590	236	006Kha 7517
6	18:21:28	101	15	160	137	0	45	42	18:33:59	0:12:31	751	303	197	500	251	006Kha 9391
7	18:26:07	91	30	120	101	15	85	136	18:39:54	0:13:47	827	362	216	578	249	006Kha 4779
8	18:37:20	111	35	130	152	0	56	65	18:50:29	0:13:09	789	306	243	549	240	006Kha 9358
9	18:39:11	121	20	95	82	0	75	60	18:50:35	0:11:24	684	276	177	453	231	006Kha 7538
10	16:48:25	86	20	90	113	0	105	95	17:01:00	0:12:35	755	271	238	509	246	Ba5Kha 3764
11	17:16:27	55	0	62	81	0	75	87	17:26:30	0:10:03	603	204	156	360	243	006Kha 2971
12	17:19:42	68	0	55	86	0	112	80	17:30:20	0:10:38	638	203	198	401	237	Ba5Kha 3595
13	17:26:27	75	15	48	108	10	98	114	17:38:10	0:11:43	703	247	221	468	235	006Kha 9395
14	18:11:15	95	20	72	96	0	67	135	18:23:20	0:12:05	725	302	183	485	240	Ba5Kha 3724
15	18:19:22	84	10	74	85	0	92	77	18:30:18	0:10:56	656	235	187	422	234	Ba5Kha 3742
16	18:21:53	117	30	125	65	20	75	132	18:35:02	0:13:09	789	394	170	564	225	006Kha 7519
17	18:35:37	90	15	95	145	0	68	115	18:48:24	0:12:47	767	300	228	528	239	006Kha 9371
18	18:38:15	75	0	55	85	0	90	119	18:49:04	0:10:49	649	249	175	424	225	Ba3Kha 5120
19	18:48:52	89	15	70	122	0	45	123	19:00:47	0:11:55	715	282	182	464	251	006Kha 2894
20	17:03:15	82	0	95	98	0	80	105	17:14:57	00:11:42	702	282	178	460	242	Ba3Kha3785
21	17:09:25	68	15	85	105	0	75	95	17:20:50	00:11:25	685	248	195	443	242	Ba5Kha 3703
22	17:13:10	95	20	90	90	10	85	110	17:25:30	00:12:20	740	305	195	500	240	006Kha 7527
23	17:19:55	55	0	75	115	0	70	85	17:31:00	00:11:05	665	215	185	400	265	006Kha 7515
24	17:28:45	105	30	120	80	0	90	120	17:41:15	00:12:30	750	345	200	545	205	006Kha 6728
25	17:39:25	75	0	90	100	15	78	100	17:51:00	00:11:35	695	280	178	458	237	Na8Kha 4014
26	17:45:10	88	10	100	95	0	82	98	17:57:10	00:12:00	720	286	187	473	247	Ba5Kha 3715
27	17:52:35	80	15	70	120	0	65	95	18:03:55	00:11:20	680	245	200	445	235	Ba3Kha 9402
28	17:57:33	115	35	105	85	0	80	120	18:10:23	00:12:50	770	340	200	540	230	006Kha 2957
29	18:04:13	80	20	92	102	0	76	102	18:15:53	00:11:40	700	274	198	472	228	006Kha 1586
30	18:08:40	75	20	80	110	0	72	90	18:20:10	00:11:30	690	245	202	447	243	Ba5Kha 9106
31	18:14:15	98	30	115	88	10	88	115	18:27:15	00:13:00	780	338	206	544	236	Ba3Kha 5808
32	18:20:45	52	20	75	125	0	68	95	18:32:00	00:11:15	675	222	213	435	240	Ba5Kha 3707
33	18:24:21	100	25	120	92	0	80	118	18:36:56	00:12:35	755	338	197	535	220	Ba5Kha 3711
34	18:29:14	78	0	95	105	15	80	99	18:41:14	00:12:00	720	287	185	472	248	006Kha 2966
35	17:14:55	85	0	105	96	0	77	108	17:27:00	00:12:05	725	298	173	471	254	006Kha 2991
36	17:26:15	65	30	85	108	0	85	88	17:38:00	00:11:45	705	238	223	461	244	005Kha 9502
37	17:33:10	92	15	98	99	0	79	107	17:45:20	0:12:10	730	297	193	490	240	006Kha 2984
38	17:39:05	65	20	65	130	20	66	85	17:50:35	00:11:30	690	235	216	451	239	006Kha 9357
39	17:47:40	90	30	105	93	0	84	112	17:59:45	00:12:05	725	307	207	514	211	Ba3Kha 6045
	Average	**82**	**17**	**93**	**101**	**4**	**78**	**102**	**-**	**0**	**715**	**282**	**196**	**478**	**237**	**-**

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Lokanthali to Tinkune — **EVENING PEAK HOUR** — **Vehicle Type:** MINIBUS

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (in sec)														Vehicle No.
		Lokanthali Stop	Manoharafat Intersection	Jadibuti Stop	Jadibuti Intersection	Petrol Pump Stop	Koteshwor Intersection	Koteswor Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	17:37:59	28	19	55	65	0	87	85	17:47:46	0:09:47	587	168	171	339	248	Ba3Kha 2452
2	18:15:55	40	20	35	40	15	70	82	18:24:40	0:08:45	525	172	130	302	223	Ba4Kha 5832
3	18:22:07	42	35	30	70	0	150	115	18:33:13	0:11:06	666	187	255	442	224	Ba3Kha 2950
4	18:29:49	41	0	35	86	0	55	48	18:38:05	0:08:16	496	124	141	265	231	Ba3Kha 7219
5	18:31:57	57	15	55	100	0	135	95	18:43:51	0:11:54	714	207	250	457	257	Ba 4Kha 5977
6	18:25:17	131	0	35	91	0	92	85	18:36:13	0:10:56	656	251	183	434	222	Ba2Kha 6392
7	16:17:47	50	20	55	85	0	95	110	16:28:25	0:10:38	638	215	200	415	223	Ba3Kha 4817
8	16:50:48	30	0	33	112	0	67	80	16:59:53	0:09:05	545	143	179	322	223	Ba3Kha 2953
9	17:15:25	95	10	52	105	0	81	55	17:25:40	0:10:15	615	202	196	398	217	Ba3Kha 2988
10	17:32:11	35	0	35	80	0	112	90	17:42:06	0:09:55	595	160	192	352	243	Ba3Kha 2424
	-	**55**	**12**	**42**	**83**	**2**	**94**	**85**	**-**	**0**	**604**	**183**	**190**	**373**	**231**	**-**

Approach: Lokanthali to Tinkune — **EVENING PEAK HOUR** — **Vehicle Type:** MICRO

S.N	Start Time	Delay Time (in sec)														Vehicle No.
		Lokanthali Stop	Manoharafat Intersection	Jadibuti Stop	Jadibuti Intersection	Petrol Pump Stop	Koteshwor Intersection	Koteswor Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	17:23:55	66	0	30	32	0	111	72	17:32:47	0:08:52	532	168	143	311	221	Ba3Kha 2014
2	18:23:23	50	0	55	40	0	98	97	18:32:54	0:09:31	571	202	138	340	231	Ba2Kha 2170
3	18:27:28	51	20	54	66	0	112	84	18:37:41	0:10:13	613	189	198	387	226	Ba3Kha 2014
4	18:30:01	47	10	20	45	0	105	105	18:39:17	0:09:16	556	172	160	332	224	Ba2Kha 2173
5	18:33:57	23	10	30	65	0	145	96	18:43:55	0:09:58	598	149	220	369	229	Ba2Kha 2604
6	18:36:19	46	0	52	110	0	65	30	18:44:44	0:08:25	505	128	175	303	202	Ba2Kha 2332
7	16:42:28	65	15	83	85	0	75	102	16:53:21	0:10:53	653	250	175	425	228	Ba2Kha 2168
8	16:50:48	48	20	70	35	0	86	115	17:00:40	0:09:52	591.5	233	141	374	217.5	Ba2Kha 2062
9	17:22:23	20	0	85	55	0	77	66	17:30:58	0:08:35	515	171	132	303	212	Ba2Kha 5201
10	17:38:25	30	0	47	62	0	80	95	17:47:21	0:08:56	536	172	142	314	222	Ba2Kha 2174

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Lokanthali to Tinkune **EVENING PEAK HOUR** **Vehicle Type: MICRO**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (in sec)														Vehicle No.
		Lokanthali Stop	Manoharafat Intersection	Jadibuti Stop	Jadibuti Intersection	Petrol Pump Stop	Koteshwor Intersection	Koteswor Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
11	17:45:10	45	0	60	58	0	95	88	17:54:30	00:09:20	560	193	153	346	214	Ba2Kha2171
12	17:48:35	42	0	48	62	0	100	90	17:58:05	00:09:30	570	180	162	342	228	Ba3Kha2011
13	17:53:33	40	20	50	55	0	70	95	18:02:49	00:09:16	556	185	145	330	226	Ba2Kha2654
14	17:55:10	35	0	65	60	0	98	85	18:04:45	00:09:35	575	185	158	343	232	Ba2Kha2165
15	17:59:05	50	0	55	70	0	85	92	18:08:50	00:09:45	585	197	155	352	233	Ba3Kha2013
16	18:05:13	48	15	45	60	0	80	90	18:14:33	00:09:20	560	183	155	338	222	Ba2Kha2176
17	18:09:40	42	0	50	65	0	90	80	18:19:00	00:09:20	560	172	155	327	233	Ba2Kha2614
18	18:14:30	48	0	58	75	0	85	98	18:24:10	00:09:40	580	204	160	364	216	Ba2Kha2185
19	18:22:45	45	20	50	55	0	90	90	18:32:05	00:09:20	560	185	165	350	210	Ba2Kha2478
20	18:27:21	38	15	62	58	0	92	87	18:36:51	00:09:30	570	187	165	352	218	Ba2Kha2163
21	18:35:14	40	20	45	63	0	100	76	18:44:54	00:09:40	580	161	183	344	236	Ba2Kha2498
22	18:39:27	45	0	59	70	0	108	96	18:49:02	00:09:35	575	200	178	378	197	Ba3Kha2051
23	18:43:14	29	0	42	60	0	94	82	18:52:29	00:09:15	555	153	154	307	248	Ba2Kha2620
24	18:47:35	49	10	55	45	0	92	80	18:57:05	00:09:30	570	184	147	331	239	Ba2Kha9740
25	17:06:17	48	0	65	50	0	88	84	17:15:22	00:09:05	545	197	138	335	210	Ba2Kha2191
26	17:15:42	36	20	55	52	0	88	75	17:24:42	00:09:00	540	166	160	326	214	Ba2Kha2158
27	17:26:27	44	0	60	64	0	96	89	17:35:52	00:09:25	565	193	160	353	212	Ba2Kha 7008
28	17:35:27	50	15	30	65	0	110	97	17:45:32	00:10:05	605	177	190	367	238	Ba2Kha5205
29	17:49:42	47	0	40	70	0	100	105	17:59:17	00:09:35	575	192	170	362	213	Ba3Kha2188
30	17:56:27	43	0	58	60	0	92	85	18:05:57	00:09:30	570	186	152	338	232	Ba2Kha2159
31	18:03:18	50	15	50	72	0	105	75	18:13:18	00:10:00	600	175	192	367	233	Ba2Kha2175
32	18:14:20	50	25	30	50	0	95	78	18:23:30	00:09:10	550	158	170	328	222	Ba2Kha2609
33	18:24:43	39	0	55	60	0	90	82	18:34:03	00:09:20	560	176	150	326	234	Ba2Kha2603
34	18:38:28	38	0	50	70	0	100	90	18:47:58	00:09:30	570	178	170	348	222	Ba2Kha2186
35	17:19:30	55	10	57	40	0	110	65	17:28:55	00:09:25	565	177	160	337	228	Ba2Kha2607
36	17:35:11	42	15	45	65	0	95	88	17:44:46	00:09:35	575	175	175	350	225	Ba2Kha5213
37	17:51:15	50	0	65	60	0	100	94	18:00:55	00:09:40	580	209	160	369	211	Ba3Kha2027
38	18:04:10	55	15	65	40	0	105	85	18:13:40	00:09:30	570	205	160	365	205	Ba2Kha2479
39	18:19:25	45	0	60	65	0	98	87	18:28:30	00:09:05	545	192	163	355	190	Ba2Kha2615
40	18:27:55	50	10	52	55	0	100	70	18:36:55	00:09:00	540	172	165	337	203	Ba2Kha2173
	Average	**45**	**8**	**53**	**60**	**-**	**95**	**86**	**-**	**0**	**567**	**183**	**162**	**346**	**221**	**-**

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Tinkune to Lokanthali **MORNING PEAK HOUR** **Vehicle Type: BUS**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (Sec)															Vehicle No.
		Koteswor Stop	Koteshwor Intersection	Koteshwor Stop2 (Ilegal)	Jadibuti Stop	Jadibuti Intersection	Jadibuti Stop2 (Ilegal)	Manoharafat Intersection	Lokanthali Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	9:35:22	125	106	0	21	157	0	0	23	9:45:34	0.00708	612	169	263	432	180	006Kha 6728
2	9:35:07	193	92	0	46	59	0	0	100	9:46:42	0.00804	695	339	151	490	205	Na8Kha 4014
3	10:08:00	186	124	0	10	85	20	0	25	10:18:40	0.00741	640	241	209	450	190	Ba3Kha 3758
4	10:18:50	40	50	15	54	143	0	0	159	10:30:03	0.00779	673	268	193	461	212	Ba3Kha 5808
5	10:25:36	21	71	0	23	168	0	0	70	10:35:01	0.00654	565	114	239	353	212	005Kha 9502
6	9:46:25	86	158	0	73	97	0	20	85	9:59:04	0.00878	759	244	275	519	240	006Kha 2893
7	10:02:07	92	119	0	65	127	0	15	40	10:13:30	0.00791	683	197	261	458	225	Ba3Kha 5508
8	10:15:00	89	105	0	74	65	0	25	30	10:25:15	0.00712	615	193	195	388	227	006Kha 2979
9	10:18:32	83	96	0	75	98	0	0	75	10:29:26	0.00757	654	233	194	427	227	006Kha 2991
10	9:43:58	138	64	0	89	87	0	15	67	9:55:14	0.00782	676	294	166	460	216	006Kha 2571
11	9:48:23	85	138	0	62	65	0	0	45	9:58:53	0.00729	630	192	203	395	235	Ba3Kha 5120
12	9:57:44	96	145	0	55	49	0	0	40	10:08:09	0.00723	625	191	194	385	240	006Kha 2987
13	10:12:18	145	65	10	95	142	0	25	68	10:25:08	0.00891	770	318	232	550	220	006Kha 7517
14	10:19:38	106	79	20	87	119	0	20	73	10:31:43	0.00839	725	286	218	504	221	Ba4Kha 7092
15	10:23:48	86	117	0	75	85	0	15	97	10:35:28	0.0081	700	258	217	475	225	Ba5Kha 3709
16	10:29:25	64	125	0	55	82	0	0	85	10:40:20	0.00758	655	204	207	411	244	006Kha 7525
17	10:32:33	79	75	0	64	76	0	0	95	10:42:51	0.00715	618	238	151	389	229	Ba5Kha 3708
18	10:35:48	58	105	0	73	80	0	15	118	10:46:58	0.00775	670	249	200	449	221	Ba5Kha 3702
19	10:37:56	75	95	0	50	115	0	0	87	10:48:41	0.00747	645	212	210	422	223	Ba6Kha 1795
20	10:39:25	67	125	15	55	77	0	20	134	10:51:13	0.00819	708	271	222	493	215	006Kha 2977
21	9:26:58	129	87	15	63	133	15	20	93	9:39:38	00:12:40	760	315	240	555	205	006Kha 2986
22	9:28:23	98	168	0	87	68	0	0	113	9:41:11	00:12:48	768	298	236	534	234	Ba4Kha 2542
23	9:37:10	136	106	0	40	156	0	0	106	9:48:52	00:11:42	702	282	262	544	158	006Kha 7517
24	9:39:08	179	72	0	51	49	0	10	96	9:51:10	00:12:02	722	326	131	457	265	Ba5Kha 4774
25	9:44:52	93	134	0	49	125	0	0	62	9:54:59	00:10:07	607	204	259	463	144	006Kha 2980
26	9:54:20	93	66	15	20	186	20	15	100	10:05:15	00:10:55	655	248	267	515	140	Ba4Kha 2537
27	10:03:18	182	114	0	68	64	0	0	46	10:14:05	00:10:47	647	296	178	474	173	Ba5Kha 4764
28	10:09:35	142	42	0	67	81	0	15	65	10:20:13	00:10:38	638	274	138	412	226	006Kha2981
29	10:14:30	81	63	0	60	106	0	0	56	10:24:30	00:10:00	600	197	169	366	234	006Kha2995
30	10:22:18	131	113	0	54	83	0	0	76	10:33:54	00:11:36	696	261	196	457	239	Ba3Kha 9402
31	10:27:50	82	131	0	20	43	0	10	154	10:38:44	00:10:54	654	256	184	440	214	006Kha2989
32	10:32:15	82	112	0	48	105	0	20	19	10:44:20	00:12:05	725	149	237	386	339	Ba3Kha 9415
33	10:38:28	116	103	0	51	62	0	0	97	10:51:27	00:12:59	779	264	165	429	350	006Kha 2987
34	10:45:50	22	97	0	38	121	0	0	19	10:54:26	00:08:36	516	79	218	297	219	006Kha 2965
35	10:49:15	22	58	15	56	67	15	20	57	10:59:04	00:09:49	589	165	145	310	279	Ba3Kha 4838
36	9:36:10	77	83	0	71	162	0	0	111	9:48:37	00:12:27	747	259	245	504	243	006Kha 9357
37	9:44:20	55	91	0	113	72	0	20	75	9:56:44	00:12:24	744	243	183	426	318	Ba4Kha 2546
38	9:47:10	120	142	0	65	90	0	15	36	9:57:45	00:10:35	635	221	247	468	167	006Kha 2970
39	9:52:50	60	118	0	67	134	0	0	48	10:04:29	00:11:39	699	175	252	427	272	006Kha 7523

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Tinkune to Lokanthali **MORNING PEAK HOUR** **Vehicle Type: BUS**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (Sec)															Vehicle No.
		Koteswor	Koteshwor	Koteshw	Jadibuti	Jadibuti	Jadibuti	Manoharafat Intersection	Lokanthali	End Time	Total	Travel	Total	Total Delay in Intersection	Total	Uninturrepted	
40	9:57:15	35	48	0	58	55	0	0	97	10:06:08	00:08:53	533	190	103	293	240	006Kha 7505
41	10:05:18	177	118	0	20	111	0	0	48	10:16:30	00:11:12	672	245	229	474	198	Ba3Kha 6045
42	10:14:35	93	94	20	59	153	20	20	81	10:25:46	00:11:11	671	273	267	540	131	006Kha 2988
43	10:16:15	108	84	0	62	41	0	0	75	10:26:21	00:10:06	606	245	125	370	236	Ba5Kha 5073
44	10:25:10	34	127	0	129	110	0	15	51	10:35:27	00:10:17	617	214	252	466	151	006Kha 2996
45	10:28:50	78	141	0	55	112	0	0	148	10:39:50	00:11:00	660	281	253	534	126	006Kha2977
46	10:32:15	110	138	0	69	132	0	0	95	10:44:56	00:12:41	761	274	270	544	217	006Kha 2966
47	10:35:20	48	79	0	59	55	0	20	19	10:45:12	00:09:52	592	126	154	280	312	006Kha 9514
48	10:38:25	123	96	0	27	52	0	10	80	10:48:19	00:09:54	594	230	158	388	206	Ba5Kha 3703
49	10:42:05	75	118	0	92	122	0	0	50	10:53:17	00:11:12	672	217	240	457	215	006Kha 9502
50	10:45:40	90	139	15	81	114	15	20	103	10:57:30	00:11:50	710	304	273	577	133	Ba5Kha 3707
	Average	**96**	**103**	**3**	**60**	**99**	**2**	**8**	**76**	**-**	**0**	**666**	**236**	**210**	**446**	**220**	**-**

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Tinkune to Lokanthali **MORNING PEAK HOUR** **Vehicle Type: MINIBUS**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (Sec)															Vehicle No.
		Koteswor Stop	Koteshwor Intersection	Koteshwor Stop2 (Ilegal)	Jadibuti Stop	Jadibuti Intersection	Jadibuti Stop2 (Ilegal)	Manoharaf at Intersectio	Lokanthali Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersecti	Total Delay	Uninturrepted flow	
1	10:48:45	101	40	0	20	170	0	15	30	10:59:02	0.00714	617	151	225	376	241	Ba4Kha 706
2	10:48:52	226	191	0	23	10	0	0	145	11:02:28	0.00944	816	394	201	595	221	Ba3Kha 3775
3	10:08:25	135	113	0	46	84	0	25	76	10:20:42	0.00853	737	257	222	479	258	Ba2Kha 6392
4	10:13:47	95	84	10	74	79	0	35	88	10:25:42	0.00828	715	267	198	465	250	Ba3Kha 7219
5	10:19:56	110	134	0	57	98	0	25	72	10:31:59	0.00837	723	239	257	496	227	Ba3Kha 2955
6	10:29:25	84	155	0	51	75	0	15	40	10:40:23	0.00762	658	175	245	420	238	Ba 3Kha 7758
7	10:35:25	102	147	0	85	103	0	0	55	10:47:14	0.00821	709	242	250	492	217	Ba3Kha 2340
8	10:37:55	112	132	0	90	68	0	15	45	10:49:11	0.00782	676	247	215	462	214	Ba3Kha 4436
9	10:46:36	95	111	0	66	97	10	25	95	10:59:00	0.00861	744	266	233	499	245	Ba4Kha 1981
10	9:29:58	79	98	0	95	101	0	20	86	9:41:51	0.00825	713	260	219	479	234	Ba4Kha 5977
11	9:34:50	110	125	0	55	90	0	10	70	9:46:35	00:11:45	705	235	225	460	245	Ba4Kha 1988
12	9:35:20	120	115	0	65	85	0	20	75	9:47:10	00:11:50	710	260	220	480	230	Ba3Kha 4431
13	9:49:10	105	130	0	50	95	0	15	75	10:01:10	00:12:00	720	230	240	470	250	Ba2Kha 5508
14	9:53:25	125	110	10	70	80	0	20	80	10:05:20	00:11:55	715	285	210	495	220	Ba3Kha 4817
15	10:04:40	100	140	0	50	100	0	0	70	10:16:15	00:11:35	695	220	240	460	235	Ba3Kha 2424
16	10:08:18	115	120	0	60	85	0	20	72	10:20:26	00:12:08	728	247	225	472	256	Ba2Kha 5505
17	10:15:35	108	118	0	68	92	0	20	68	10:27:17	00:11:42	702	244	230	474	228	Ba3Kha 5377
18	10:18:45	130	105	0	72	78	0	20	78	10:30:45	00:12:00	720	280	203	483	237	Ba3Kha 3584
19	10:22:15	100	135	0	62	98	0	30	62	10:33:45	00:11:30	690	224	263	487	203	Ba5Kha 1980
20	10:35:55	135	100	0	75	75	0	20	85	10:48:00	00:12:05	725	295	195	490	235	Ba3Kha 2953
21	9:40:25	102	108	0	58	88	10	30	90	9:52:23	00:11:58	718	260	226	486	232	Ba2Kha 5515
22	9:43:30	118	122	0	62	87	10	0	74	9:55:22	00:11:52	712	264	209	473	239	Ba2Kha 6395
23	9:55:15	109	132	0	53	93	0	20	63	10:07:08	00:11:53	713	225	245	470	243	Ba3Kha 2349
24	10:04:45	115	112	0	68	82	0	20	77	10:16:43	00:11:58	718	260	214	474	244	Ba2Kha 4844
25	10:12:32	107	138	0	47	102	0	20	61	10:24:10	00:11:38	698	215	260	475	223	006Kha 7919
	Average	**114**	**121**	**1**	**61**	**89**	**1**	**18**	**73**	**0**	**0**	**711**	**250**	**227**	**476**	**235**	**-**

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Tinkune to Lokanthali **MORNING PEAK HOUR** **Vehicle Type: MICRO**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (Sec)															Vehicle No.
		Koteswor Stop	Koteshwor Intersection	Koteshwor Stop2 (Ilegal)	Jadibuti Stop	Jadibuti Intersection	Jadibuti Stop2 (Ilegal)	Manoharafat Intersection	Lokanthali Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	11:39:50	55	35	10	30	55	0	0	30	11:47:15	0.0052	445	125	90	215	230	Ba2Kha 2195
2	10:34:37	96	50	0	43	32	40	0	10	10:42:47	0.0057	490	189	82	271	219	Ba2Kha 4050
3	11:16:16	20	62	0	15	85	0	0	43	11:23:19	0.0049	423	78	147	225	198	Ba2Kha 4744
4	9:35:45	40	59	0	25	103	0	18	60	9:44:10	0.0058	505	125	180	305	200	Ba2Kha 2167
5	9:39:20	61	67	0	51	93	0	12	62	9:48:22	0.0063	542	174	172	346	196	Ba2Kha 2017
6	9:45:44	30	49	0	45	125	0	0	70	9:54:25	0.006	521	145	174	319	202	Ba2Kha 2615
7	9:47:36	45	72	0	55	113	0	15	65	9:56:55	0.0065	559	165	200	365	194	Ba2Kha 9324
8	9:58:24	50	37	0	41	95	0	17	78	10:07:02	0.006	518	169	149	318	200	Ba2Kha 2171
9	10:12:15	42	48	0	35	109	0	0	64	10:20:20	0.0056	485	141	157	298	187	Ba2Kha 2606
10	10:19:25	64	59	0	38	115	0	20	77	10:28:56	0.0066	571	179	194	373	198	Ba2Kha 2478
11	10:24:24	48	55	0	45	88	0	0	58	10:33:04	00:08:40	520	151	143	294	226	Ba2Kha 2167
12	10:29:46	52	58	0	38	95	0	10	52	10:38:21	00:08:35	515	142	163	305	210	Ba2Kha 2602
13	10:35:10	65	48	0	35	85	0	20	50	10:43:25	00:08:15	495	150	153	303	192	Ba2Kha2175
14	9:26:20	55	60	10	45	100	0	15	60	9:35:05	00:08:45	525	170	175	345	180	Ba2Kha 5201
15	9:33:36	40	52	0	32	90	20	0	48	9:41:41	00:08:05	485	140	142	282	203	Ba2Kha2191
16	9:44:19	50	50	0	40	92	0	0	55	9:52:44	00:08:25	505	145	142	287	218	Ba3Kha2011
17	9:56:11	47	57	0	36	88	0	10	53	10:04:31	00:08:20	500	136	155	291	209	Ba2Kha 304
18	10:08:41	53	74	0	39	98	0	0	57	10:17:21	00:08:40	520	149	172	321	199	Ba2Kha 2174
19	10:17:24	42	49	0	33	92	15	0	49	10:25:34	00:08:10	490	139	141	280	210	Ba2Kha 9739
20	10:22:46	58	62	0	48	105	0	15	62	10:31:36	00:08:50	530	168	182	350	180	Ba2Kha 4181
21	10:29:40	46	51	0	37	97	0	0	61	10:38:05	00:08:25	505	144	148	292	213	Ba2Kha2163
22	10:36:15	51	56	0	41	96	15	0	56	10:44:45	00:08:30	510	163	152	315	195	Ba3Kha2051
23	9:45:10	44	53	15	34	84	0	10	54	9:53:20	00:08:10	490	147	147	294	196	Ba2Kha2620
24	9:58:25	65	49	0	35	99	0	10	62	10:07:00	00:08:35	515	162	158	320	195	Ba2Kha2159
25	10:27:35	43	50	0	36	86	0	20	52	10:35:40	00:08:05	485	131	156	287	198	Ba2Kha2478
	Average	**50**	**54**	**1**	**38**	**93**	**4**	**8**	**56**	**-**	**0**	**506**	**149**	**155**	**304**	**202**	**-**

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Tinkune to Lokanthali **EVENING PEAK HOUR** **Vehicle Type: BUS**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (Sec)															Vehicle No.
		Koteswor Stop	Koteshwor Intersection	Koteshwor Stop2 (Ilegal)	Jadibuti Stop	Jadibuti Intersection	Jadibuti Stop2 (Ilegal)	Manoharafat Intersection	Lokanthali Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	17:07:25	60	80	0	20	50	0	35	85	17:16:13	0.006111	528	165	165	330	198	008Kha 7224
2	17:42:57	100	98	0	45	90	0	0	40	17:52:32	0.006655	575	185	188	373	202	Ba3Kha 3758
3	18:16:26	176	163	15	45	30	0	40	63	18:28:56	0.008681	750	299	233	532	218	Ba3Kha 9186
4	17:00:20	30	20	0	40	58	0	45	125	17:09:23	0.006285	543	195	123	318	225	Ba5Kha 4505
5	17:05:53	70	164	0	25	47	0	20	72	17:16:07	0.007106	614	167	231	398	216	006Kha 2974
6	17:16:25	57	70	0	40	75	0	15	105	17:26:08	0.006748	583	202	160	362	221	Ba3Kha 7324
7	17:22:35	38	58	0	102	110	25	0	20	17:32:00	0.006539	565	185	168	353	212	006Kha 9389
8	17:23:35	44	157	0	95	98	0	35	97	17:35:53	0.008542	738	236	290	526	212	Ba3Kha 4118
9	17:25:45	20	54	0	167	121	20	25	77	17:37:40	0.008275	715	284	200	484	231	Ba3Kha 2553
10	17:35:25	111	127	10	86	98	0	20	95	17:48:21	0.008981	776	302	245	547	229	006Kha 7529
11	17:37:30	107	160	0	103	87	0	0	80	17:50:05	0.008738	755	290	247	537	218	006Kha 9394
12	17:41:00	37	30	0	90	108	0	15	105	17:51:12	0.007083	612	232	153	385	227	Ba5Kha 5073
13	17:43:05	60	124	0	10	15	0	35	152	17:53:30	0.007234	625	222	174	396	229	Ba3Kha 4838
14	17:49:20	41	191	0	30	52	0	0	102	18:00:02	0.007431	642	173	243	416	226	Ba3Kha 9402
15	17:51:35	86	93	0	35	46	0	25	147	18:02:37	0.007662	662	268	164	432	230	Ba3Kha 2752
16	17:56:10	110	160	0	120	126	0	0	30	18:08:47	0.008762	757	260	286	546	211	Ba3Kha 6045
17	17:33:40	88	131	0	80	105	0	20	115	17:46:21	0.008808	761	283	256	539	222	006Kha 9357
18	17:08:20	95	126	0	113	98	10	15	85	17:20:58	0.008773	758	303	239	542	216	Ba3Kha 3830
19	17:23:30	53	120	0	75	84	0	15	103	17:34:34	0.007685	664	231	219	450	214	Ba3Kha 5011
20	18:02:14	114	85	0	90	102	0	0	90	18:13:48	0.008032	694	294	187	481	213	006Kha 9387
21	18:10:15	100	87	15	92	133	15	20	93	18:22:55	00:12:40	760	315	240	555	205	006Kha 7517
22	18:21:40	98	168	0	87	68	0	0	113	18:32:48	00:11:08	668	298	236	534	134	006Kha 2970
23	18:28:05	136	106	0	40	136	0	20	106	18:39:47	00:11:42	702	282	262	544	158	006Kha 7523
24	17:05:15	139	72	0	51	49	0	10	136	17:17:17	00:12:02	722	326	131	457	265	Ba4Kha 2546
25	17:08:50	73	134	0	49	105	0	20	82	17:18:57	00:10:07	607	204	259	463	144	Ba5Kha 4774
26	17:18:10	93	102	15	20	135	20	30	100	17:29:05	00:10:55	655	248	267	515	140	006Kha 2980
27	17:20:40	90	114	0	98	64	0	0	76	17:31:27	00:10:47	647	264	178	442	205	Ba4Kha 2537
28	17:23:05	90	42	0	99	81	0	15	85	17:33:43	00:10:38	638	274	138	412	226	Ba5Kha 9106
29	17:34:15	81	89	0	60	80	0	0	56	17:44:10	00:09:55	595	197	169	366	229	Ba3Kha 5808
30	17:37:10	90	113	0	95	83	0	0	76	17:48:46	00:11:36	696	261	196	457	239	Ba5Kha 3707
31	17:40:25	82	131	0	20	43	0	10	154	17:50:40	00:10:15	615	256	184	440	175	Ba5Kha 3711
32	17:48:45	50	112	0	48	105	0	20	51	18:00:50	00:12:05	725	149	237	386	339	006Kha 7525
33	17:54:20	116	103	0	51	62	0	0	97	18:07:19	00:12:59	779	264	165	429	350	006Kha 2977
34	17:57:35	22	118	0	38	85	0	15	19	18:06:16	00:08:41	521	79	218	297	224	006Kha 2986
35	18:07:15	22	58	0	56	67	15	20	72	18:17:04	00:09:49	589	165	145	310	279	006Kha 2893
36	18:14:10	77	123	0	71	92	0	30	111	18:24:57	00:10:47	647	259	245	504	143	Ba3Kha 5508
37	18:16:55	55	91	0	113	72	0	0	75	18:29:19	00:12:24	744	243	163	406	338	006Kha 9348
38	18:22:05	60	142	0	105	90	0	15	56	18:32:40	00:10:35	635	221	247	468	167	006Kha 2969
39	18:29:35	60	118	0	67	104	0	30	48	18:41:14	00:11:39	699	175	252	427	272	006Kha 2988
40	18:36:15	35	48	0	58	55	0	0	97	18:44:58	00:08:43	523	190	103	293	230	006Kha 4781
41	17:11:15	85	118	0	67	81	0	30	53	17:21:37	00:10:22	622	205	229	434	188	006Kha2998
42	17:18:40	93	134	10	59	103	20	30	91	17:29:51	00:11:11	671	273	267	540	131	006Kha 2987
43	17:21:10	90	84	0	80	41	0	0	75	17:31:06	00:09:56	596	245	125	370	226	006Kha 2965
44	17:29:45	34	127	0	129	95	0	30	51	17:40:02	00:10:17	617	214	252	466	151	006Kha 1586
45	17:35:25	78	141	0	55	82	0	30	148	17:46:25	00:11:00	660	281	253	534	126	Ba5Kha 3703
46	17:41:10	90	138	0	89	102	0	30	95	17:53:46	00:12:36	756	274	270	544	212	006Kha 2994
47	17:47:25	30	79	0	59	55	0	0	37	17:57:35	00:10:10	610	126	134	260	350	006Kha 7527
48	17:58:42	75	116	0	60	52	0	20	80	18:08:46	00:10:04	604	215	188	403	201	006Kha 7517

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Tinkune to Lokanthali **EVENING PEAK HOUR** **Vehicle Type: BUS**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (Sec)															Vehicle No.
		Koteswor Stop	Koteshwor Intersection	Koteshwor Stop2 (Ilegal)	Jadibuti Stop	Jadibuti Intersection	Jadibuti Stop2 (Ilegal)	Manoharafat Intersection	Lokanthali Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
49	18:05:20	75	118	0	92	92	0	30	50	18:16:19	00:10:59	659	217	240	457	202	Ba4Kha 2542
50	18:17:35	90	139	0	81	104	15	30	113	18:28:56	00:11:21	681	299	273	572	109	006Kha 2979
51	18:19:55	90	165	0	105	65	0	20	80	18:32:30	00:12:35	755	275	250	525	230	006Kha 2991
52	18:28:15	55	30	10	95	85	0	30	105	18:38:50	00:10:35	635	265	145	410	225	Ba4Kha 2542
53	18:34:30	75	115	0	25	10	0	30	150	18:45:40	00:11:10	670	250	155	405	265	006Kha 9502
54	18:39:10	40	145	0	25	95	0	0	100	18:49:52	00:10:42	642	165	240	405	237	006Kha 7525
55	17:21:18	70	85	0	40	40	0	20	145	17:32:20	00:11:02	662	255	145	400	262	006Kha 2996
56	17:27:40	70	155	0	105	90	0	40	55	17:40:17	00:12:37	757	230	285	515	242	Ba4Kha 2548
57	17:48:50	80	135	0	85	80	0	35	115	18:01:31	00:12:41	761	280	250	530	231	006Kha 2571
58	18:54:15	95	130	10	95	85	10	20	90	19:06:53	00:12:38	758	300	235	535	223	Ba4Kha 2527
59	18:12:50	50	110	0	75	75	0	10	95	18:23:54	00:11:04	664	220	195	415	249	Ba5Kha 3711
60	18:25:20	80	110	0	105	65	0	0	95	18:36:54	00:11:34	694	280	175	455	239	006Kha 2966
	Average	**75**	**111**	**1**	**71**	**80**	**3**	**18**	**89**	**-**	**0**	**666**	**239**	**209**	**447**	**219**	**-**

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Tinkune to Lokanthali **EVENING PEAK HOUR** **Vehicle Type: MINI BUS**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (Sec)															Vehicle No.
		Koteswor Stop	Koteshwor Intersection	Koteshwor Stop2 (Ilegal)	Jadibuti Stop	Jadibuti Intersection	Jadibuti Stop2 (Ilegal)	Manoharafat Intersection	Lokanthali Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	17:02:55	114	102	0	63	35	10	12	42	17:13:08	0.00709	613	229	149	378	235	Ba2Kha 5505
2	17:03:20	40	96	0	38	55	0	0	90	17:12:23	0.00628	543	168	151	319	224	Ba5Kha 4760
3	17:19:11	53	100	0	65	91	0	15	125	17:30:43	0.00801	692	243	206	449	243	Ba4kha 7058
4	17:45:35	83	125	0	75	95	0	0	140	17:58:18	0.00883	763	298	220	518	245	Ba4Kha 5832
5	17:32:20	118	135	15	88	86	10	0	97	17:45:17	0.00899	777	328	221	549	228	Ba4 Kha 7469
6	17:43:05	60	124	0	55	75	0	10	84	17:53:30	0.00723	625	199	209	408	217	Ba2Kha 4848
7	18:08:20	84	95	0	71	97	0	0	116	18:20:01	0.00811	701	271	192	463	238	Ba4 Kha 7412
8	18:13:15	119	108	0	87	86	0	0	88	18:25:21	0.0084	726	294	194	488	238	Ba2Kha 4844
9	18:28:44	98	141	0	83	97	0	0	76	18:40:42	0.00831	718	257	238	495	223	Ba2Kha 4249
10	18:35:10	90	118	0	70	82	0	0	92	18:46:30	00:11:20	680	252	200	452	228	Ba3Kha 7219
11	17:08:20	85	105	0	65	75	10	10	88	17:19:35	00:11:15	675	248	190	438	237	Ba3Kha 2985
12	17:15:05	95	120	0	75	85	0	0	100	17:26:35	00:11:30	690	270	205	475	215	Ba3Kha 3775
13	17:29:30	75	100	10	60	78	10	10	105	17:41:00	00:11:30	690	260	188	448	242	Ba3Kha 2340
14	17:34:25	80	115	0	78	80	0	0	95	17:45:50	00:11:25	685	253	195	448	237	Ba3Kha 4436
15	17:44:45	82	112	0	66	77	0	0	103	17:56:03	00:11:18	678	251	189	440	238	Ba3Kha 7226
16	17:56:05	92	120	0	72	83	0	10	98	18:07:37	00:11:32	692	262	213	475	217	006Kha 7919
17	18:05:20	78	108	10	62	74	0	0	82	18:16:45	00:11:25	685	232	182	414	271	Ba5Kha 1980
18	18:11:15	85	117	0	71	81	0	0	93	18:22:32	00:11:17	677	249	198	447	230	Ba3Kha 6228
19	18:23:50	90	122	0	76	84	0	15	99	18:35:25	00:11:35	695	265	221	486	209	Ba3Kha 2950
	Average	**85**	**114**	**2**	**69**	**80**	**2**	**4**	**95**	**-**	**0**	**684**	**254**	**198**	**452**	**232**	**-**

Onboard Survey for Travel time and Delay of Public Transportation

Approach: Tinkune to Lokanthali **MORNING PEAK HOUR** **Vehicle Type: MICRO**

Date of Data Colllection: 2025 Feb

S.N	Start Time	Delay Time (Sec)															Vehicle No.
		Koteswor Stop	Koteshwor Intersection	Koteshwor Stop2 (Ilegal)	Jadibuti Stop	Jadibuti Intersection	Jadibuti Stop2 (Ilegal)	Manoharaf at Intersection	Lokanthali Stop	End Time	Total Travel Time	Travel time in sec	Total Delay at Stop	Total Delay in Intersection	Total Delay	Uninturrepted flow	
1	16:55:05	28	83	0	25	78	0	12	53	17:03:03	0.00553	478	106	173	279	199	Ba2Kha 2168
2	17:49:55	55	72	0	20	80	0	0	20	17:57:18	0.00513	443	95	152	247	196	Ba2Kha 7008
3	17:01:53	40	54	0	64	69	0	10	125	17:11:14	0.00649	561	229	133	362	199	Ba2Kha 2610
4	17:13:42	78	80	0	45	97	0	0	75	17:23:18	0.00667	576	198	177	375	201	Ba2Kha 9323
5	17:28:00	30	40	0	30	65	0	0	105	17:35:50	0.00544	470	165	105	270	200	Ba2Kha 2170
6	17:42:25	20	30	0	47	60	0	0	65	17:49:30	0.00492	425	132	90	222	203	Ba2Kha 2606
7	17:54:40	84	57	0	48	75	0	0	78	18:03:38	0.00623	538	210	132	342	196	Ba2Kha 2478
8	17:29:35	30	125	0	65	58	0	0	75	17:38:50	0.00642	555	170	183	353	202	Ba2Kha 9739
9	18:15:22	30	84	0	45	83	0	15	45	18:23:36	0.00572	494	120	182	302	192	Ba2Kha 2014
10	18:22:13	35	65	0	35	70	0	0	65	18:30:33	00:08:20	500	135	135	270	230	Ba2Kha 2602
11	18:28:40	40	60	0	45	80	0	10	90	18:37:15	00:08:35	515	175	150	325	190	Ba2Kha 2178
12	17:05:25	30	55	0	40	60	0	0	65	17:13:25	00:08:00	480	135	115	250	230	Ba2Kha2019
13	17:12:45	52	65	0	50	70	0	10	94	17:21:35	00:08:50	530	196	145	341	189	Ba2Kha 2167
14	17:23:25	40	70	0	40	75	0	0	70	17:31:35	00:08:10	490	150	145	295	195	Ba2Kha 2017
15	17:34:10	45	75	0	45	80	0	0	75	17:42:30	00:08:20	500	165	155	320	180	Ba2Kha 2173
16	17:46:35	49	70	0	42	85	0	10	85	17:55:15	00:08:40	520	176	165	341	179	Ba2Kha2025
17	17:55:33	30	80	0	30	65	0	0	68	18:03:28	00:07:55	475	128	145	273	202	Ba2Kha 2604
18	18:05:30	65	77	0	60	75	0	10	50	18:14:25	00:08:55	535	175	162	337	198	Ba2Kha 2184
19	18:14:20	55	78	0	41	72	0	0	55	18:22:35	00:08:15	495	151	150	301	194	Ba2Kha 2612
	Average	**44**	**69**	**-**	**43**	**74**	**-**	**4**	**71**	**-**	**0**	**504**	**158**	**147**	**306**	**199**	**-**

APPENDIX C: Photographs

Figure C1: VISSIM Simulation model of traffic operations at Koteshwor Intersection

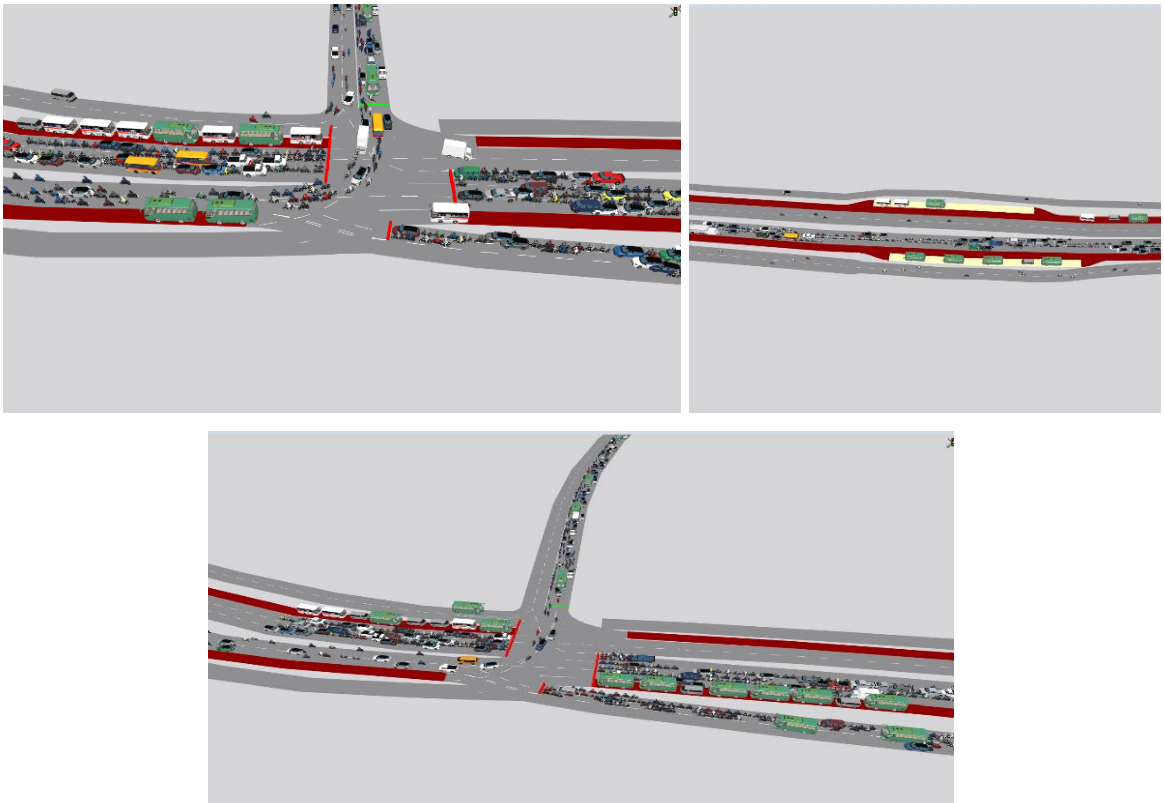

Figure C2: VISSIM Simulation model of traffic operations at Jadibuti Intersection and Lokanthali

Figure C3: Existing traffic conditions at Koteshwor and Jadibuti Intersection iThenticate

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To Whom It May Concern

This is to certify that the paper titled **"Performance Evaluation of Exclusive Bus Lane System with Signal Priority using Simulation-based Analysis - A Case Study of a Section in Kathmandu-Bhaktapur Route during Morning Peak Hour"** submitted by **Samrat Acharya** as the first author has been accepted for publication after the peer-review process. The paper was also formally presented at the LEC Conference 2026, held on 31 January 2026 at Lalitpur Engineering College.

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Performance Evaluation of Exclusive Bus Lane System using Simulation-based Analysis - A Case Study of a Section in Kathmandu-Bhaktapur Route during Morning Peak Hour

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Abstract

In developing cities with heterogeneous vehicle composition and limited road space, such as Kathmandu, urban roads are becoming highly congested, especially the major corridors like the Kathmandu-Bhaktapur Road. This study aims to examine whether exclusive bus lanes and signal priority system can be effectively implemented in such an environment. A microsimulation model was developed using PTV VISSIM replicating existing traffic conditions on which various scenarios involving exclusive bus lanes and signal priority were simulated for morning peak hour where performance indicators like queue length and travel time were analyzed. Introduction of exclusive bus lanes prioritizes public transport by providing separate lane, but it heavily penalizes general traffic by amplifying the queue in the normal lanes. Signal priority when used with EBLs eliminates queues in bus lanes to minimal level while also softening the negative impact on normal lanes. Similarly, the travel time of public transport reduces by 7-13% after the introduction of exclusive bus lanes, but delivers the biggest improvement in both directions when used in conjunction with signal priority, resulting the reduction of 20-23%. In contrast, EBL implementation increased travel time for vehicles in normal lanes; however, the increase was substantially reduced when combined with signal priority, dropping from +21% to -13% in the Tinkune-Lokanthali approach and from +98% to +67% in the Lokanthali-Tinkune approach. Hence, highlighting the effectiveness of exclusive bus lane system with signal priority for the Kathmandu-Bhaktapur Route.

Keywords: Exclusive Bus Lane, Signal Priority, Public Transport Priority, Kathmandu-Bhaktapur Route, Simulation, VISSIM

1. Introduction

The rapid growth of urban populations worldwide has led to a surge in private vehicle ownership, presenting significant challenges for cities trying to maintain efficient and sustainable transportation systems. This increasing reliance on private vehicles stresses existing road infrastructure, creating chronic traffic congestion, especially at peak hours. This congestion results in longer commute times, reduced productivity, and increased delay and queue length in intersection, and higher fuel consumption, negatively impacting both the economy and the environment.

Public transport plays a crucial role in addressing urban mobility challenges, such as traffic congestion. They can transport a large number of passengers efficiently, reducing the overall number of vehicles on the roads and the associated environmental and economic costs. The road traffic in Kathmandu Valley has increased at a very steep rate in the recent past, from 1.4 million vehicles plying on the roads of valley to 1.75 million in just a span of year, according to Kathmandu valley Traffic Police Office (Kandel et al., 2023). As a result, urban transportation systems in Kathmandu face significant challenges in providing efficient and reliable public transportation services.

Under the heterogeneous traffic-flow conditions prevailing on roads of Kathmandu Valley, the buses, being relatively larger vehicles, find it difficult to maneuver through the mixed traffic and is subjected to frequent acceleration and deceleration leading to lower speed and discomfort to both driver and passengers. This also results in enormous delay and uncertainty to bus passengers and, consequently, the travel time of buses is considerably increased making buses a less attractive mode of transport.

Under heterogeneous traffic conditions, the larger size of buses makes it difficult for them to navigate through mixed traffic efficiently. Continuous acceleration and deceleration lower operating speeds and reduce passenger comfort, resulting in higher delays and longer travel times, which negatively affect the attractiveness of public transport (Arasan & Vedagiri, 2009). Similar challenges are also observed in Kathmandu, where traffic conditions are predominantly heterogeneous.

By focusing on infrastructure upgrades like introduction of Mass Rapid Transit (MRT), Bus Rapid Transit (BRT), integration of multimodal transportation system, intelligent transportation system, the policy makers can create a more efficient, reliable, and sustainable public transport system. Nevertheless, these enhancements are expensive, and there is a need for finding alternative solutions to the problem. One way to improve the efficiency of existing road infrastructure is by prioritizing the movement of people rather than vehicles. This can be accomplished through the provision of exclusive bus lanes, which enhance bus operations and mobility (Arasan & Vedagiri, 2009). Consequently, a greater number of passengers can be transported with fewer vehicles, thereby reducing traffic congestion.

The main objective of the study is to evaluate the performance of an exclusive bus lane with bus signal priority during morning peak hour using simulation-based analysis. Specifically, this study aims to:

1. Develop a simulation model that accurately represents the characteristics of the study area, including the lane configuration, signal control, and mixed traffic conditions.
2. Assess the impacts of the exclusive bus lane and signal priority on bus travel time, and queue length during morning peak hour.

The findings of this study would contribute to the understanding of the potential benefits of implementing exclusive bus lanes, particularly in the context of Kathmandu-Bhaktapur route. The results can inform policymakers and urban planners, providing evidence-based recommendations in developing effective public transport strategies that prioritize bus operations while minimizing the impact on general traffic.

2. Literature Review

This review will focus on studies that examined the influence of EBLs and BSP systems on bus travel times, general traffic flow and the balance between bus and general traffic performance. The simulation-based analyses play an important role due to the complex interactions between buses and general traffic in various situations, thus this review will also evaluate the strengths and weaknesses of simulation models and data collection methods used for such studies previously and will eventually help to define the methodology for a case study on the Kathmandu-Bhaktapur corridor.

2.1 Exclusive Bus Lane (EBL) and its Significance

Exclusive bus lanes (EBLs), also known as dedicated bus lanes or bus-only lanes, are sections of roadways reserved solely for the use of buses and, sometimes, other high-occupancy vehicles (HOVs) like taxis or carpools. The core concept is to provide buses with a dedicated right-of-way, separating them from general traffic improving the efficiency and reliability of the public bus service by minimizing delays caused by mixed traffic. By reducing delays and improving efficiency, EBLs aim to make bus travel more attractive to commuters, potentially leading to a modal shift from private vehicles to public transport.

There are several types of exclusive bus lanes, primarily differentiated by their location within the roadway.

- Curb-side bus lanes
- Median bus lanes
- Contra-flow bus lane
- Dynamically activated exclusive bus lanes

The conditions of setting an exclusive bus lane includes:

a. Geometric conditions on the road
b. Traffic saturation level on the road
c. Bus volume on the road section
d. Public transit passenger volume on the road section

While EBLs offer significant benefits for bus transit and potentially overall traffic efficiency, the effectiveness of EBLs is highly context-dependent and requires tailored solutions for specific urban environments. Jha (2023) argues that implementing a BRT system, which includes EBLs, can significantly alleviate traffic congestion in Kathmandu valley. The study emphasizes that BRT can serve city to establish rapid, safe, comfortable, equitable, efficient, sustainable, economical, and efficient modern mass transit system that can ensure carry of a high number of passengers. Similarly, the implementation of EBLs has been recognized as a practical strategy to improve bus operations, particularly in urban areas with high congestion levels.

2.2 Bus Signal Priority and its Strategy

Bus Signal Priority (BSP), also known as Transit Signal Priority (TSP), is a traffic management strategy aimed at reducing bus delays at signalized intersections. The core concept is to adjust the normal traffic signal timing to give buses preferential treatment, allowing them to proceed through intersections more quickly than other vehicles, thereby reducing delays and improving service reliability. BSP is particularly relevant in heterogeneous traffic conditions, where buses often experience significant delays due to interactions with slower-moving vehicles.

The choice of BSP strategy depends on various factors, including traffic volume, bus frequency, intersection geometry, and the desired balance between bus priority and general traffic flow. This preferential treatment can involve various techniques such as:

- Green Extension (GE)
- Red Truncation (RT)
- Phase Insertion
- Conditional Priority
- Unconditional Priority

2.3 Exclusive Bus Lane system with Bus signal Priority

There have been various studies suggesting that the bus signal priority when used in combination with EBLs, can be effective measures in enhancing the operational performance of public transportation. For instance, study by Rahmat et al. (2013) demonstrated that the introduction of bus signal priority (BSP) in conjunction with EBLs led to a reduction in bus travel time by approximately 19% and average delays by 38% at signalized intersections. This aligns with findings from Khakimov & Tanaka (2024), who noted that exclusive bus lanes combined with signal priority could lead to a modal shift, encouraging more commuters to use public transport. Similarly, Baalaganapathy et al. (2023) evaluated the effectiveness of bus signal priority (BSP) and dedicated bus lanes (DBL) in Chennai, India, using VISSIM simulation. Their study found that the combination of BSP and DBL resulted in a significant reduction in bus travel time and delays at signalized intersections, whereas the use of DBL only resulted in reduction of travel time of buses in expense of increment in travel time of other modes.

While there is a growing body of literature on EBLs and bus priority systems globally, research specific to Kathmandu valley remains limited.

3. Methodology

3.1 Study Area Selection

For this study, about 1.75km stretch of Kathmandu-Bhaktapur route between Tinkune and Lokanthali is considered because this section consists of two major congested intersection where vehicle conflicts and intersection delays are most significant. Also, these intersections have existing signalized control system with the potential for signal priority. The selected road section consists of 6 lanes, each with a lane width of 3.5m, split into a combination of at least 3 and 3 lanes separated by a median. Figure 1 below shows the general overview of the study area.

Figure 1: Study Area Location

3.2 Data Collection

The following data were collected during the study for the comprehensive development of simulation model.

3.2.1 Road Network Data

The detailed road geometry data of the selected section was collected. This includes road configuration, no. of lanes, lane width, intersection layout, bus stop location and layout. These data are required setting up the model in simulation software. This road section consists of two major signalized intersection i.e. Koteshwor intersection and Jadibuti intersection as well as one minor unsignalized intersection i.e. Manoharafat intersection. The general layout of the study area is shown in the Figure 2 below:

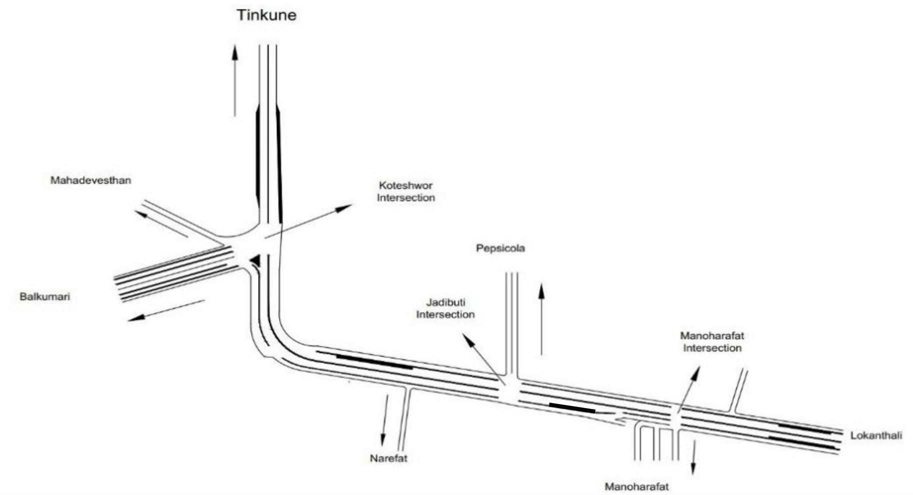

Figure 2: Study Area Road Network Layout

3.2.2 Traffic Volume Data

The traffic flow data for three consecutive week-days from 26th January 2025 to 28th January 2025 were obtained through the recordings of 11 CCTV cameras installed at various locations along the study area. The access to the video recordings was provided at Kathmandu Valley Police Office, Ranipokhari. Appropriate CCTV Camera location capturing the required traffic flow and directional movement at intersection was selected based on location, camera angle and the clarity of the video. From the recordings, classified volume count was conducted manually at 15-minute interval during morning period (9:00am to 12:00pm) which were converted into equivalent passenger car using equivalency factors from Kathmandu Sustainable Urban Transport Project (2010) as shown in Table 1, except motorcycle for which a lower equivalency factor of **0.35** (JICA, 2012) was used for effective calibration.

Table 1: Equivalency Factor as per KSUTP (2010)

S.N	Vehicle Type	Equivalency Factor	S.N	Vehicle Type	Equivalency Factor
1	Motorcycles	0.25	5	Heavy Truck	3
2	Tempo	1	6	Micro Bus	1.5
3	Cars/Taxi/Utility Vehicles	1	7	Mini Bus	2.5
4	Light Truck	1.5	8	Large Bus	3

(Source: KSUTP, 2010)

At two major intersections, the total PCU's that entered the intersection from all approaches during each 15-minute interval in the morning period were determined. By summing the successive four 15-minute period counts in PCU, hourly volumes in PCU entering the intersection from all the approaches were determined for the morning period. Thus, peak hour in the morning was observed to be at **9:30am to 10:30am.** The three-days average peak hourly traffic volume and PCU's at both of the major intersections is shown in the Table 2 below.

Table 2: Peak hourly PCU and Volume at Koteshwor and Jadibuti Intersection

Intersection	Morning (9:30-10:30am)	
	Peak hour PCU	Peak hour Volume
Koteshwor Intersection	**10203**	**17755**
Jadibuti Intersection	7988	14246

The vehicles were sorted to 10 different categories and the three-days average percentage composition was identified. Large bus, micro, minibus and tempo being the public transportation were kept under one category and constituted 3.36% of total vehicles. The most dominant vehicle type was motorcycle with 78% share followed by car/jeep/van with 14.48% share. The summary of average vehicle composition is shown in the Table 3 below:

Table 3: Average Vehicle composition in study area

S.N	Vehicle Type	Percentage Composition	S.N	Vehicle Type	Percentage Composition
1	Motorcycle	78.09%	6	Light Truck	0.65%
2	Car/Jeep/Van	14.48%	7	Heavy Truck	0.15%
3	Utility Pickup	1.85%	8	Emergency	0.07%
4	Public Transportation	3.36%	9	Cycle	0.94%
5	Private Bus/Micro	0.41%	10	Tractor	0.01%

3.2.3 Signal Timing Data

The current signal phasing and timing plans of the two selected intersection was recorded from the CCTV footage which includes cycle length and green phase for each phase. The cycle time of 442s and 480s were observed at

Koteshwor and Jadibuti intersection respectively. These existing signal timing data were vital for scenario analysis. The phasing diagram for the Koteshwor intersection is shown in the Figure 3.

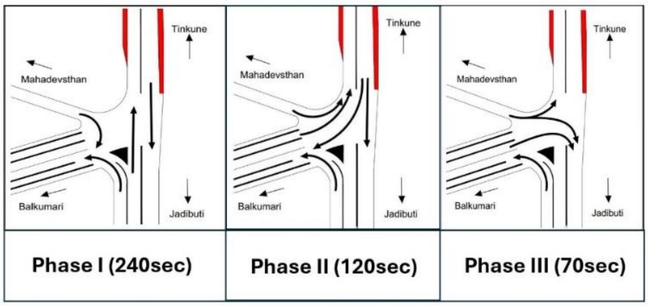

Figure 3: Phasing diagram and green time at Koteshwor intersection

Similarly, the phasing diagram at Jadibuti intersection is shown in the Figure 4.

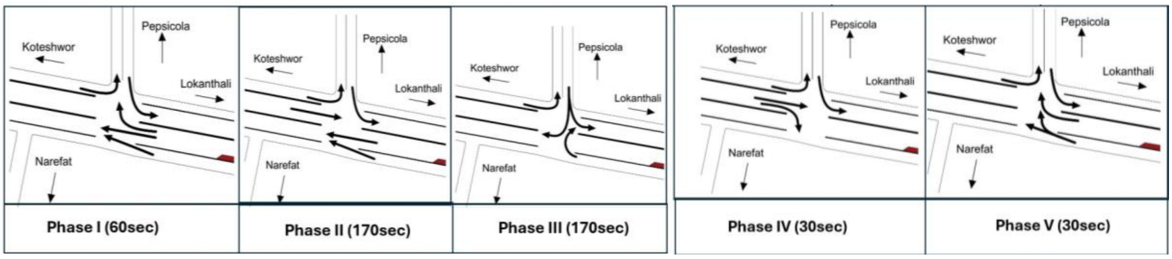

Figure 4: Phasing Diagram and green time at Jadibuti Intersection

3.2.4 Public Transportation Operational Data

The public transportation that operates on the selected route consists of large bus, minibus and micro. The operational data like travel time, dwell time at the stops, delay at intersection for all public transportation were collected using onboard survey during morning peak hour. Both the approaches Tinkune-Lokanthali and Lokanthali-Tinkune were considered for onboard survey.

4 Analysis and Results

4.1 Directional Movement

The directional volume and the directional split were calculated for two major signalized intersections (i.e Koteshwor and Jadibuti) and one minor intersection (i.e Manoharafat intersection) during morning peak hour. This directional split was used while calculating the total volume in the defined routes in VISSIM modeling. The directional split for each intersection is shown in schematic diagram in Figure 5, Figure 6 and Figure 7 below:

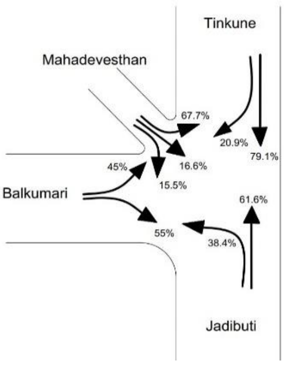

Figure 5: Directional split at Koteshwor Intersection

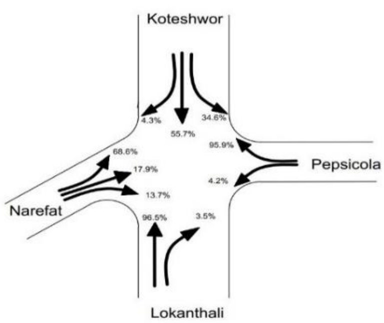

Figure 6: Directional split at Jadibuti intersection

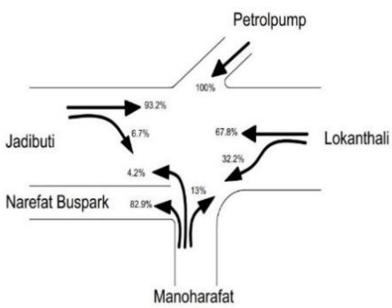

Figure 7: Directional split at Manoharafat intersection

4.2 Analysis of Public Transport Operational Data

The public transportation that operates on the selected route consists of large bus, minibus and micro. The number of samples required for each category of public transportation (Bus, minibus, micro) was determined according to their proportions and onboard survey was performed. The operational data like travel time, dwell time during boarding and alighting at the stops, no. of stops on this section, delay in intersection for the sample size was determined. The summary of those data is shown in the Table 4 for Koteshwor-Lokanthali approach and Lokanthali-Koteshwor approach:

Table 4: Average travel time and delay from onboard survey

Time	Public Transport	Average Travel time (s)	Average Delay at Stop (s)	Average Delay at intersection (s)	Average Total Delay (s)
Tinkune-Lokanthali Approach	Bus	666	236	210	446
	Minibus	711	250	227	476
	Micro	506	149	155	304
	Average (s)	**628**	**211**	**197**	**408**
	(in Minutes)	**10min 28sec**	**3min 31sec**	**3min 17 sec**	**6min 48sec**
Lokanthali-Tinkune Approach	Bus	682	229	223	452
	Minibus	666	239	206	444
	Micro	511	142	177	319
	Average (s)	**620**	**203**	**202**	**405**
	(in Minutes)	**10min 20sec**	**3min 23 sec**	**3min 22 sec**	**6min 45sec**

4.3 Simulation Analysis

Once the model was setup with links and connectors in VISSIM, it was simulated with the default value to check if there is a need for calibration. The total volume of vehicle with their composition during morning peak hour were entered in VISSIM and routes were assigned. Similarly, the signal heads with recorded signal timings were added in model at both the signalized intersection.

4.3.1 Calibration of the Model

Once the model was setup with links and connectors in VISSIM, it was simulated with the default value to check if there is a need for calibration. A comprehensive review of literatures related to VISSIM calibration under heterogenous and non-lane-based traffic was carried out. Wiedemann 74 and Lane change parameters with the recommended range from different literatures were adjusted by iteration process till the simulated output was within acceptable range. The values as shown in the Table 5 were then adopted for further study. Some snapshot of the simulation runs at three intersections are shown in the Figure 8 below:

Table 5: Average travel time and delay from onboard survey

S.N.	Parameters			VISSIM Default Values	Range tested with reference from literature	Values adopted for Calibration
1	**Following**	Look ahead distance	Min (m)	0	10-30	10
2			Max (m)	250	100-140	100
3		Look back distance	Min (m)	0	5-24	5
4			Max (m)	150	80-150	100
5	**Wiedemann 74**	Average standstill distance (m)		2	0.2-1.5	0.2
6		Additive part of safety distance		2	0.1-1.5	0.2
7		Multiplicative part of safety distance		3	0-1	0.25
8	**Lane Change**	Min. clearance (front/rear) (m)		0.5	0.11-0.8	0.2
9		Safety distance reduction factor		0.6	0.2-0.6	0.2

Literature referred: (Manandhar, 2023)*;* (Shrestha & Pradhananga, 2023)*;* (Siddharth & Ramadurai, 2013)*;* (Kunwar et al., 2025); (Chhetri, 2023); (Dutta & Ahmed, 2019)*;* (Mathew & Radhakrishnan, 2010)*;* (Jayasooriya & Bandara, 2018)*;* (Acharya & Marsani, 2020)*;* (Khan et al., 2022)*;* (Paul et al., 2019)*;* (Hussain et al., 2017)*;* (Mondal & Gupta, 2020)*;* (Mistry et al., 2022)*;* (Raju et al., 2021).

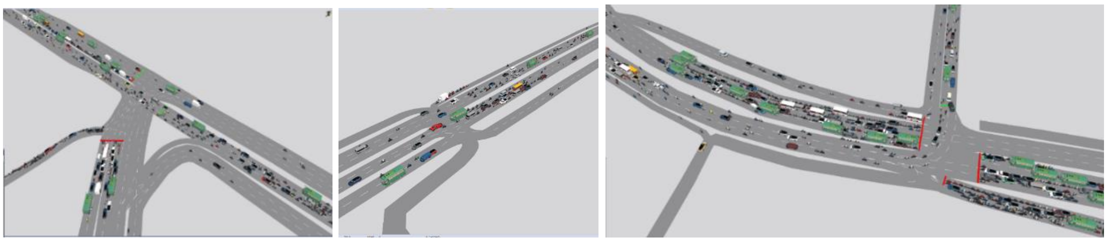

Figure 8: Simulation in VISSIM

4.3.1.1 Calibration of Model for Traffic Volume

The average field data from Day 1 and Day 2 were entered into VISSIM with the adjusted parameters and the simulation was run. For calibration of developed model, GEH (Geoffrey E. Havers) statistics was used. The GEH formula (Oregon, D. O. T, 2011) for hourly flows is shown in Equation 1.

$$GEH = \sqrt{\frac{2\ (m-c)^2}{(m+c)}} \text{ ....(Equation 1)}$$

where,
m = output traffic volume from the simulation model (vehicle per hour)
c = input traffic volume (vehicle per hour)

The simulated volume was then compared to the observed average volume. More than 85% GEH results for traffic volume of the major selected route satisfied the threshold criteria with GEH less than 5. Hence, the model was calibrated successfully for traffic volume.

4.3.1.2 Calibration of Model for Maximum Queue Length

The maximum queue length for each given approach for three days was measured from the video footage. This average of two-days observed maximum queue length was then compared with the maximum queue length generated by the VISSIM simulation. For calibrating of queue length, Root Mean Squared Normalized Error (RMSNE) as shown in Equation 2 was used, which measures the percentage deviation of the simulated data from field observed data.

$$RMSNE = \sqrt{\frac{1}{N}\sum\left(\frac{yi,sim-yi,obs}{yi,obs}\right)^{\wedge}2} \text{ ....(Equation 2)}$$

where,
N = total number of traffic measurement observations
yi,sim = simulated data
yi,obs = observed data

The RMSNE value was calculated to be 7.92% which is less than 15% hence, considered acceptable for traffic model calibration (FDOT, 2014).

4.3.2 Validation of the Model

The validation is meant to determine whether the calibrated simulation model can reproduce accurately the real-world traffic conditions beyond the calibration data. Different sets of data than the ones used in calibration of the model i.e. field data from Day 3 were used for validation of the model. Similar to calibration, more than 85% GEH results for traffic volume of the major selected route satisfied the threshold criteria with GEH less than 5 and RMSNE value was calculated to be 9.36% which is less than 15%. Hence, the model was validated successfully.

4.4 Scenario Analysis

Various scenarios involing exclusive bus lanes and signal priority were created as described below:

4.4.1 Scenario S1: Base-case Scenario

The base-case scenario model was established in the VISSIM from the previously validated model. The three-days average field data were used as input for the simulation keeping other all parameters same as in calibrated and validated model. The simulation was run and the results were obtained.

4.4.2 Scenario S2: Exclusive Bus Lane with Existing Signal

In this scenario, the curb side exclusive bus lane was introduced in the base-case model keeping all other parameters constant. The bus lanes were introduced similar to the express bus service layout carried out by Department of Roads in September 21, 2023 A.D. The layout showing the exclusive bus lanes is shown in Figure 9. The simulation was run, and the results were compared with base-case scenario.

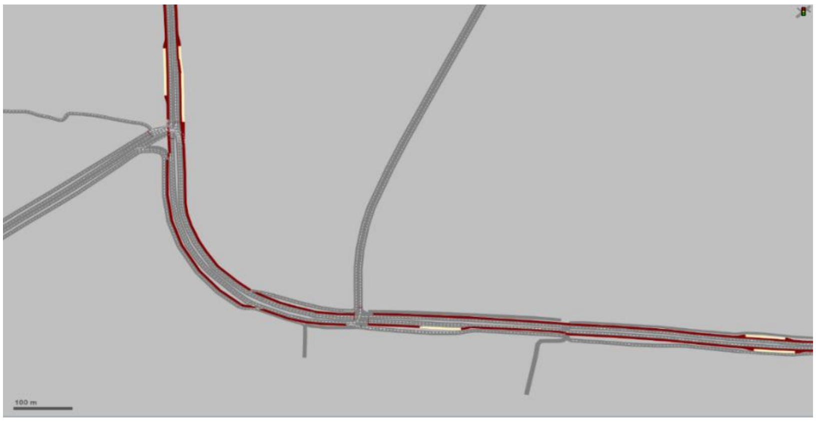

Figure 9: Layout showing the exclusive bus lanes in scenario 2

4.4.3 Scenario S3: Exclusive Bus Lane (Modified) with Existing Signal

In this scenario, minor modifications were made to the alignment of the exclusive bus lane while maintaining all other conditions consistent with scenario S2. The bus lane was rerouted between the Manoharafat and Jadibuti intersections to create additional continuous space for mixed traffic. Similarly, near the Koteshwor intersection, the bus lane was extended directly through the intersection, and the upstream bus stop was relocated downstream to reduce traffic interruptions and improve lane availability for other vehicles. The modifications are further clarified through Figure 10 below:

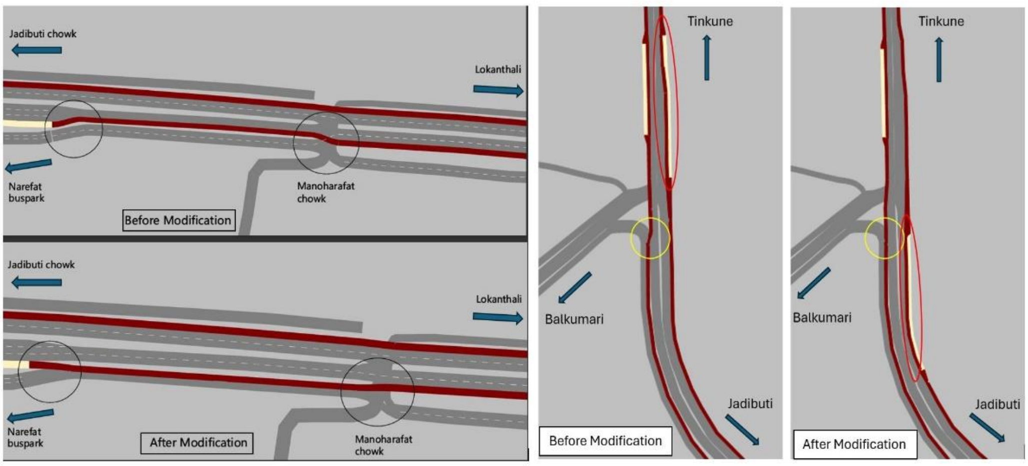

Figure 10: Modification near Jadibuti bridge and Koteshwor intersection respectively

4.4.4 Scenario S4: Exclusive Bus Lane (Modified) with Through Priority

In this scenario, the bus lane alignment remained the same as in scenario S3, while priority measures for public transport were introduced at both intersections. Public transportation was allowed uninterrupted movement through conflict-free lanes of Tinkune-Jadibuti approach at the Koteshwor intersection. Similarly, public transportations from Lokanthali were given full priority for uninterrupted flow through Jadibuti intersection against vehicle flowing from Narefat buspark approach and the resulting operational performance was evaluated through simulation.

4.4.5 Scenario S5: Exclusive Bus Lane with Signal Priority (Phase Insertion)

In this scenario, along with the priority provided to public transportation as in Scenario S4, an additional level of signal priority was introduced on the other approaches. The phase insertion technique, one of the simplest forms of signal priority, was adopted in this study. It operates by introducing an additional phase dedicated to bus movement after each existing signal phase. This can be can be implemented through minimal modifications to existing signal timing, making it a cost-effective and practically deployable near-term solution.

To apply this, the original phase that served buses in the exclusive bus lane was divided into smaller segments and inserted between each phase at both intersections. Cycle length and the timing of all other phases were kept unchanged. The new signal time after phase insertion is shown in Figure 11 below. The simulation was run with these changes and the results were compared with other two scenarios.

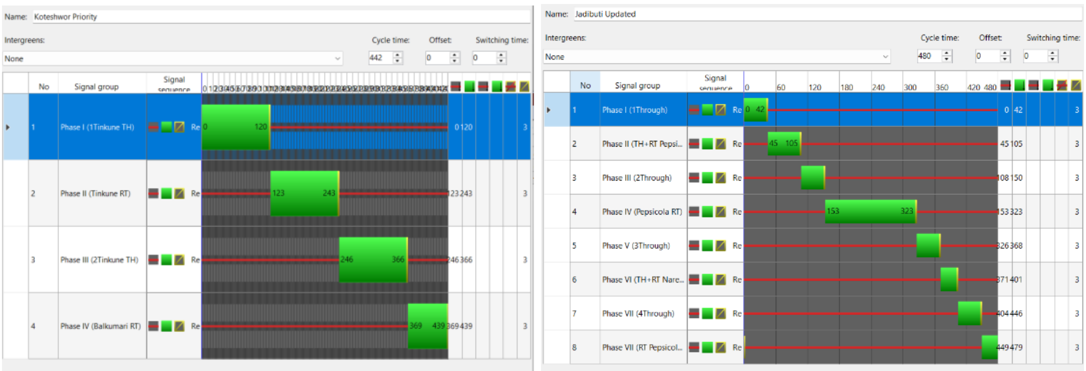

Figure 11: Updated Signal timing for signal priority (Phase insertion) at Koteshwor and Jadibuti intersection

4.4.6 Scenario Analysis Result

The results obtained after simulating all the above-mentioned scenarios in VISSIM, focusing on maximum queue length and travel time are analyzed along with their impacts on overall traffic conditions.

4.4.6.1 Maximum Queue Length Analysis

The maximum queue lengths reflecting the worst-case congestion recorded across all twelve sections for each of the five simulated scenarios during the morning peak hour, as obtained from VISSIM microsimulation is presented in Table 6. The percentage change is calculated with respect to base-case scenario where negative sign indicates reduction of queue length from the base-case scenario.

Table 6: Maximum Queue Length Results across all Scenarios

	Section No. & Name	Maximum queue length (m) & percentage change w.r.t base-case scenario								
		S1 Base Case	S2 EBL	% Change	S3 EBL Modified	% Change	S4 BSP Through	% Change	S5 BSP Phase Insertion	% Change
Normal Lanes	1: From Manoharafat chowk towards Lokanthali	158	961	508%	689	336%	675	327%	426	170%
	2: From Jadibuti chowk towards Lokanthali	252	458	82%	425	69%	433	72%	408	62%
	3: From Jadibuti chowk towards Pepsicola	1137	1405	24%	1402	23%	1405	24%	1405	23%
	4: From Jadibuti chowk towards Koteshwor	162	212	31%	162	0%	164	1%	145	-10%
	5: From Koteshwor chowk towards Jadibuti	330	609	84%	593	80%	605	83%	565	71%
	6: From Koteshwor chowk towards Balkumari	192	192	0%	192	0%	194	1%	191	-1%
	7: From Koteshwor chowk towards Tinkune	296	522	76%	300	1%	316	7%	215	-27%
Exclusive Bus Lane	8: EBL from Manoharafat chowk towards Lokanthali	158	25	-84%	26	-84%	25	-84%	21	-87%
	9: EBL from Jadibuti chowk towards Lokanthali	252	114	-55%	114	-55%	0	-100%	0	-100%
	10: EBL from Jadibuti chowk towards Koteshwor	162	141	-13%	157	-3%	156	-4%	116	-28%
	11: EBL from Koteshwor chowk towards Jadibuti	268	158	-41%	101	-62%	105	-61%	77	-71%
	12: EBL from Koteshwor chowk towards Tinkune	296	35	-88%	31	-89%	0	-100%	0	-100%

Scenario S2 shows that introducing EBL significantly worsens queue lengths on normal traffic lanes due to reduced road space, with Section 1 showing the highest increase (from 158 m to 961 m, +508%), while while section 5 increases by 84% (from 330 m to 609 m) and Section 7 by 76% (from 296 m to 522 m). In contrast, bus lanes in S2 benefit greatly, with sections 8 and 12 dropping by 84% and 88% respectively, confirming that the physical separation of bus traffic substantially improves bus flow.

Scenario S3 offers slight improvements over S2, with marginal reductions in queues on some sections, while maintaining similar or slightly better bus lane performance. Scenario S4 shows similar results on normal lanes but improves bus operations further, achieving zero queues in key bus lane sections due to uninterrupted flow.

Scenario S5 emerges as the most effective scenario. On the normal traffic lanes, section 1 sees its maximum queue fall to 426 m from 961 m in S2, an increase of 170% over base case compared to 508% in S2. More significantly, several sections show queue lengths below base case under S5: section 4 drops to 145 m (-10%), Section 6 to 191 m (-1%), and Section 7 to 215 m (-27%), indicating genuine capacity relief rather than mere redistribution. On the exclusive bus lanes, S5 consistently achieves the highest reductions, with section 8 falling 87%, section 11 by 71%, and sections 9 and 12 recording zero queues.

4.4.6.2 Travel Time Analysis

Similarly, the travel time for the different vehicle class travelling from Tinkune to Lokanthali and vice-versa along with the percentage changes with respect to the base case are presented in Table 7 which was obtained after the simulation of all five scenarios in VISSIM. The negative sign indicates reduction of travel time from the base-case scenario.

Table 7: Travel time Results across all Scenarios

Approach	Vehicle Class	Travel Time (in seconds) and % change w.r.t base-case scenario								
		S1 Base Case	S2 EBL	% Change	S3 EBL Modified	% Change	S4 BSP Through	% Change	S5 BSP Phase Insertion	% Change
Tinkune-Lokanthali	Large Bus	666	558	-16%	531	-20%	523	-21%	514	-23%
	Mini Bus	711	585	-18%	572	-20%	555	-22%	529	-26%
	Micro	506	484	-4%	474	-6%	450	-11%	450	-11%
	Average of PT	628	545	-13%	531	-16%	517	-18%	505	-20%
	All Vehicle except PT	331	400	21%	340	3%	334	1%	288	-13%
	Private Vehicles	330	399	21%	340	3%	334	1%	287	-13%
Lokanthali-Tinkune	Large Bus	682	588	-14%	580	-15%	539	-21%	489	-28%
	Mini Bus	666	629	-6%	625	-6%	562	-16%	514	-23%
	Micro	511	507	-1%	505	-1%	426	-17%	424	-17%
	Average of PT	620	579	-7%	570	-8%	509	-18%	476	-23%
	All Vehicle except PT	438	869	98%	855	95%	853	95%	731	67%
	Private Vehicles	437	870	99%	855	96%	855	95%	732	67%

The introduction of EBL in scenario S2 provides significant travel time savings for public transport, particularly in the Tinkune-Lokanthali approach, where average PT travel time decreases by 13%, while the Lokanthali-Tinkune approach records a 7% reduction. These improvements result from segregated bus lanes that reduce conflicts with mixed traffic. Scenarios S3 and S4 further enhance public transport performance, while Scenario S5 achieves the greatest improvements in both directions, reducing average PT travel time by 20% and 23% in the Tinkune-Lokanthali and Lokanthali-Tinkune approaches respectively.

However, the reduced lane availability in Scenario S2 substantially increases travel time for other vehicles, particularly in the Lokanthali-Tinkune direction, where travel time nearly doubles (+98%). Scenario S3 provides slight relief for mixed traffic, while scenario S5 achieves the best balance between public transport priority and general traffic performance. In the Tinkune-Lokanthali approach, travel time for other vehicles drops by 13% below the base case, whereas in the Lokanthali-Tinkune approach, although travel time remains 67% higher than the base case, it is still significantly improved compared to earlier scenarios. Overall, scenario S5 emerges as the most effective option, delivering the highest benefits for public transport while minimizing adverse impacts on general traffic.

Conclusion

This study aimed to evaluate the potential effectiveness of exclusive bus lanes with signal priority in heterogeneous traffic conditions, using the Kathmandu-Bhaktapur Road as a case study. The traffic data were processed to reflect actual conditions, and an appropriate simulation model was developed using those data for local traffic characteristics. The model was then calibrated and validated for traffic volume and maximum queue length and then the base model was formed. Scenarios involving exclusive bus lanes and signal priority were created and simulated using VISSIM and their performance were analyzed using queue length and travel time as performance indicator.

Looking across all scenarios, introduction of exclusive bus lanes prioritizes public transport by providing separate lane, but it heavily penalizes general traffic by amplifying the queue in the normal lanes (up to 508%). Similarly, the travel time for public transport reduces by 7-13% whereas the travel time for other vehicles in normal lanes increases by 21-99%, with greater increase in Lokanthali-Tinkune approach.

Signal priority when used with exclusive bus lanes delivers the most consistent results across every approach. It preserves the major improvements for public transportation by eliminating queues to minimal level while also softening the negative impact on normal lanes. The queues in exclusive bus lanes gets reduced by 18-100%. In normal lanes, queues previously worsen by 508% drops to 170%. Although the queue is still above base case but it still represents a notable mitigation of adverse impacts. The travel time results also show the similar pattern. Public transport gets faster after the bus lane is introduced, but signal priority when used with exclusive bus lanes delivers the biggest gains in both directions. The travel time for public transport reduces by 20-23% in both approaches, whereas the travel time for other vehicles in normal lanes drops by 13% in Tinkune-Lokanthali approach and increases by 67% in Lokanthali-Tinkune approach.

This concludes that signal priority used in conjunction with exclusive bus lanes is the most effective option among the five scenarios studied. It gives public transport the largest travel-time savings on both approaches, but it doesn't punish the other vehicles on normal lanes as severely as other scenarios.

Limitations and Future Works

- Only 1.75km section of Kathmandu-Bhaktapur Road is considered. Future works should extend the model to broader network to get more clearer picture of how bus lane and signal priority behaves.
- The model excludes pedestrian movements, crossings and pedestrian-vehicle interactions. Future works should incorporate these pedestrian flow data and crossing behaviors.
- Simple signal priority technique, in the form of phase insertion is used in the study. Future works may explore the performance evaluation using advance signal priority strategies.
- This study is limited to curb-side exclusive bus lanes only. So, further studies may perform the comparative evaluation of median-side bus lanes.

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