



**Assessment of the Effectiveness of Bus Priority Systems and Their Challenges:  
The Case of Mexico to German Roundabout, Addis Ababa.**

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**June, 2025**

**Addis Ababa, Ethiopia**



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**ADDIS ABABA UNIVERSITY**  
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### **Declaration**

I, Nyamouch Simon, registration number GSR 2832/14 do here by declare that this thesis is my original work and that it has not been submitted partially or in full by any other person for an award of a degree in other universities.

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## **Abstract**

*Bus priority systems are increasingly recognized as a key component of sustainable urban transportation, offering solutions to congestion and improving public transport efficiency. They are one solution that can help address the challenges faced by the bus transport system in Addis Ababa. This system improves public transport on the road network by providing buses with dedicated lanes, signal priority, and other elements that reduce travel times and improve reliability by looking at the challenges that affect urban mobility. A mixed-methods approach was employed, combining quantitative traffic data with qualitative input from stakeholders. The study aims to evaluate how well bus rapid transit (BRT) corridors, dedicated bus lanes, and signal prioritization may improve bus service dependability and cut down on trip times. Although concerns such as poor lane markings, enforcement gaps, and lack of public awareness persist. The study finds that well-designed bus priority schemes can reduce bus travel time by 66% and improve service reliability by 68%. Targeted recommendations emphasize improved enforcement, periodic infrastructure maintenance, enhanced public awareness, and integrated institutional collaboration.*

**Key words:** *Bus priority system, road infrastructure, Sustainable Urban Transport, Challenges*

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## Acronyms

ACCRA	Addis Ababa City Road Authority
APTA	American Public Transportation Association
ANPR	Automatic Number Plate Recognit
BRT	Bus Rapid Transit
DBL	Dedicated Bus Lane
MTA	Metropolitan Transportation Authority
NACTO	National Association of City Transportation Officials
NYC	New York City
BPS	Bus Priority System
TSP	Transit Signal Priority
WMATA	Washington Metropolitan Region Transit Authority

## **Chapter 1: Introduction**

### **1.1. Background of the Study**

Ethiopia, with over 120 million people, is the second most populous country in Africa, with Addis Ababa experiencing a 5% annual population growth (Source: Ethiopian Census, 2023). This rapid urbanization has led to severe traffic congestion, requiring innovative solutions such as bus priority system.

There has been a mass migration taking place from the rural settlements and smaller towns across the country to Addis Ababa. The main reason for this migration being mostly of economical factor but there are other factors like search of better education and others like health services. (Nattoo T, 2017)

The transport sector is an important component of the economy and a common tool used for development. This is even more so in a global economy where economic opportunities have been increasingly related to the mobility of people and freight, including information and communication technologies. (Rodrigues, 2016)

Public infrastructure in general, and in particular transport networks (such as roads, railways, airports, and waterways) have long been considered important inputs to economic and productivity growth (Afraz 2006)

The bus priority system in Addis Ababa originated as a response to the city's growing transportation challenges, including worsening traffic congestion, rapid urbanization, and the need for a more efficient public transit system. Historically, the city's public transport relied heavily on conventional road-based modes such as minibuses, Anbessa buses, and later Sheger buses, all of which operated in mixed traffic and were subject to significant delays. Recognizing the limitations of this setup, the Addis Ababa City Administration, through the Addis Ababa City Road and Transport Bureau began exploring strategies to improve public transport efficiency. (AACTA, 2019) The concept of bus priority was first introduced in city planning documents such as the 2010 Urban Transport Master Plan, which highlighted the need for dedicated bus corridors and prioritized mass transit solutions. The first practical implementation of a spatial bus priority system occurred in June 2018 with the launch of a dedicated bus lane along a 5-kilometer corridor between

Mexico and Germany roundabouts. This initiative aimed to reduce travel time for buses, improve service reliability, and encourage a shift from private vehicles to public transport. (Dawit,2020)

Ethiopia being a developing country happened to have obstacles to the provision of adequate infrastructure to accommodate and serves its rural and urban population. This limitation is mostly visible in the transportation sector which plays an important role in the daily activities of city dwellers with the increasing demand for public transportation and rapid increase in motorization and car ownership, there is need for innovative approaches to prioritize buses and ensure their timely and reliable service especially during peak hours. Consequently, travel times become prolonged, accessibility is reduced and air pollution levels increased. (Addis Ababa City Administration Road and Transport Bureau, Non-Motorized Transport Strategy November 2018)

Evidently the majority of the city population being of low-income workers solely rely on the public transportation, i.e. city bus system for their day to day mobility within the city and to nearby outskirts of the city where a lot of factories that employed them are located. (Mohammed, M. 2022)

In addition to reducing travel times and improving reliability, bus priority system can also help to improve safety on the roads. By reducing conflicts between buses and other vehicles, these schemes can help to reduce the risk of accidents and make roads safer for all users. (Goh et al. 2013)

Implementing bus priority systems requires significant investment in the road infrastructure and the development of a comprehensive plan for the design and implementation of the system. This may include the construction of dedicated bus lanes, the installation of signal priority systems, the development of new bus stops and terminals. (Deborah M,2017)

In general, bus priority system is a promising solution for improving the bus transport system in Addis Ababa. By giving priority to buses on the road network, these schemes can help to address the challenges including traffic congestion, frequent delays, lack of dedicated infrastructure and poor enforcement of traffic regulations faced by the system.

## **1.2. Statement of the Problem**

In Addis Ababa, the city bus system is one of the developed public transportation systems compared to the light railway system and others. But the efficient mobility and flow the city bus system is derailed by a lot of factors. Addis Ababa faces severe traffic congestion, with public buses experiencing frequent delays due to lack of dedicated lanes and poor infrastructure.

The increased number of automobiles both private and organizational and poorly planned roads across the city are among the foremost factors.

Hence, the goal is to come up with alternative solutions to such problems. Despite efforts to implement bus priority schemes, issues such as poor enforcement, illegal lane use, and infrastructure deterioration persist costly alternatives like expanding the pre-existing roads and building new ones. That will incur more to budget for the construction of the infrastructures and the compensation of the demolished public & private properties.

If one takes a look at the city road infrastructures, one can easily see the small ratio of the main roads to the size of the city and how narrow they tend to be in size. On the other hand, another obvious factor that's contributing the derailing the efficient functioning the city bus system is the lack of designated lanes for automobiles and buses, and a supervision of such lanes. (Minalu,2018)

The road network in Addis Ababa is inadequate, with many roads poorly maintained and congested, leading to major bottleneck of clear functioning of a city transport system with increase in vehicle population passengers spends more time in traffic jam and loses precious time which could have been utilized well. It also causes wasteful fuel expenditure which directly affects the environment through pollution that come out of it and country's exchequer. (Bogale, 2012)

The lack of proper bus stops and terminals is also a challenge, as buses often have to compete for space on the roads with other vehicles, resulting in inefficient operations and unreliable schedules. These challenges are well-documented in the Addis Ababa City Administration's Non-Motorized Transport Strategy (2018).

### **1.3. Objective of the Study**

The objectives of study are presented below as general and specific objectives.

#### **1.3.1. General Objective**

The general objective of this study is to evaluate the effectiveness and challenges of the bus priority system implemented along the corridor from Mexico to German Roundabout in Addis Ababa. The study aims to evaluate the system's impact on public transport efficiency and travel time while identifying key operational, infrastructural, and institutional challenges that affects its optimal performance.

#### **1.3.2. Specific Objectives**

- ✓ To Identify the condition of infrastructural elements of Bus Priority Systems (BPS) in the study area.
- ✓ To Assess the effectiveness of the BPS in improving public transport efficiency (travel time reduction, reliability).
- ✓ To identify the key challenges affecting the Bus Priority System along the specified corridor (Mexico to the German roundabout, Addis Ababa).

### **1.4. Research Question**

- A) What are the main observed infrastructural elements of bus priority system (BPS)?
- B) To what extent has the bus priority system improved public transport efficiency in terms of travel time and reliability?
- C) What are the observed implementation challenges of bus priority system and can these challenges be addressed through Planning, design and other interventions?

### **1.5. Significance of the Study**

The study on the Assessment of the effectiveness of bus priority systems and their challenges: The Case of Mexico to German Roundabout, Addis Ababa provides a critical insight how bus priority scheme can improve public transport systems by prioritizing buses on congested road networks. It is essential to support the implementation of bus priority system. By providing dedicated bus lanes, signal priority systems, well-designed bus stops and terminals, and using ITS and effective roadway design, the bus transport system in Addis Ababa can be made more efficient, reliable and safe for passengers.

The findings of this study will benefit key stakeholders including transport authorities who can use the insights for policy and infrastructure planning, urban planners and engineers can apply spatial design improvements. The study also contributes empirical evidence and case study analysis to researchers studying transit solutions in rapidly urbanizing African cities. Public transport users would gain from faster, more reliable services and development partners can better target investments in sustainable mobility.

### **1.6. Scope of the study**

The study focuses on a specific corridor stretching from Mexico Roundabout to German Roundabout in Addis Ababa, where the Bus Priority System (BPS) is currently being implemented. Geographically the research concentrates on the designated bus lanes, intersections, and bus stops within this corridor, examining how spatial design influences traffic flow and bus service efficiency. Thematically, the study addresses the key challenges affecting the performance and success of the Bus Priority System, including infrastructure elements, enforcement issues, and operational barriers. Temporally, the study covers the period from the initiation of the Bus Priority System in 2018 up to 2025, allowing for an evaluation of both short-term impacts and longer-term developments in public transport performance and infrastructure outcomes.

### **1.7. Limitation of the study**

This study does not comprehensively evaluate the environmental impacts of the Bus Priority System such as changes in air pollution or gas emission resulting from the system. Additionally, it does not fully address the social implications of the system, including equity and accessibility concerns for different user groups. Financial and logistical challenges such as infrastructure construction costs, maintenance expenses, and institutional capacity are also not analyzed in depth. These limitations suggest the need for further research to explore the broader economic, environmental of bus priority interventions.

## Research flow chart

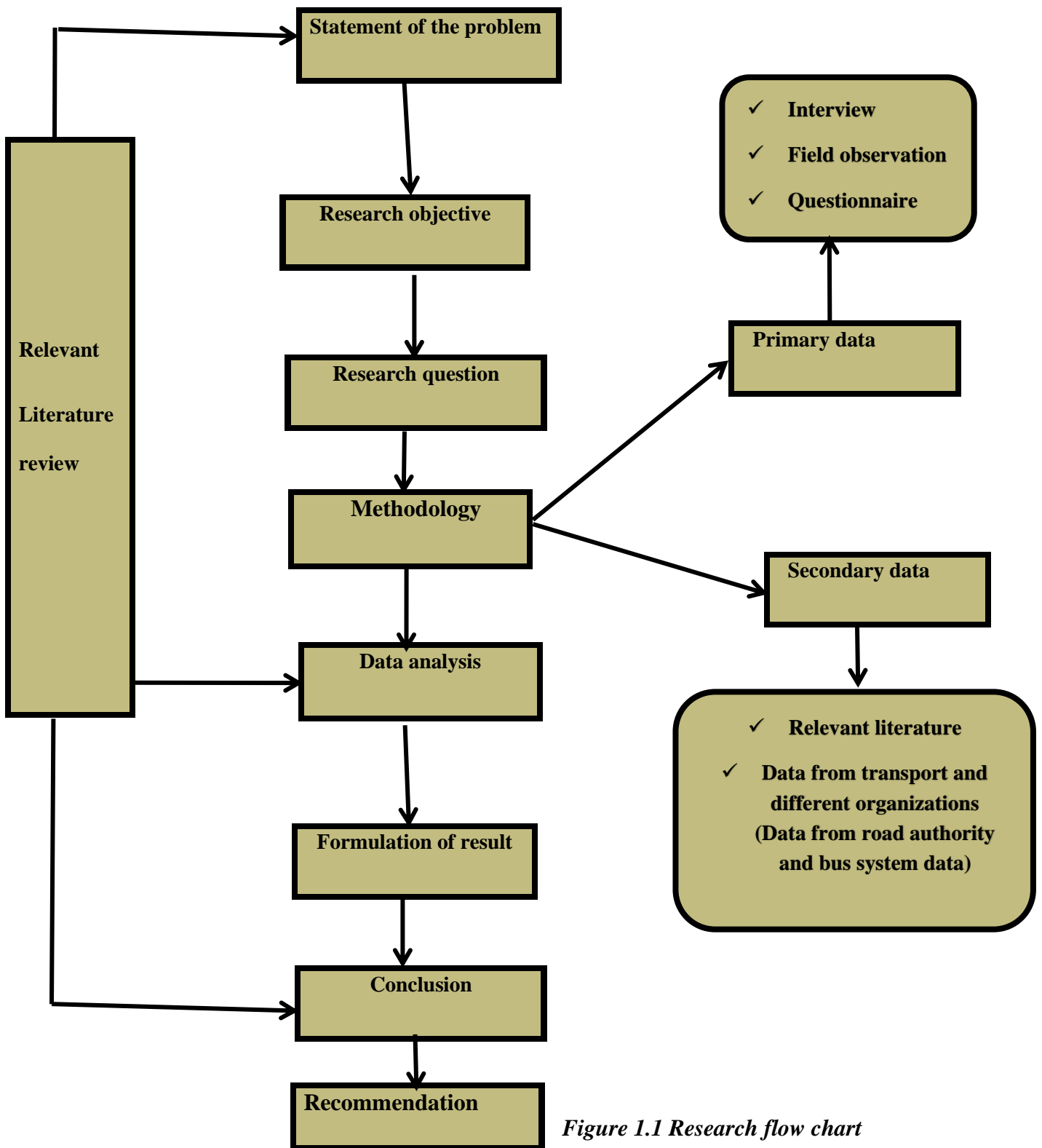


Figure 1.1 Research flow chart

## **Chapter 2: Literature Review**

### **2. Introduction**

#### **2.1. Theoretical Framework**

Rapid urbanization in many developing cities, including Addis Ababa, has led to rising private vehicle use, traffic congestion, and adverse environmental impacts (Cervero, 2013). Enhancing public transport is one way to address these problems, and bus priority schemes using dedicated lanes, signal priority, or partial corridor exclusivity have garnered increasing attention (Levinson et al., 2003).

One of the mitigating strategies is the implementation of bus priority lane, this measures are specifically designed to address urban traffic congestion, delays in public transport operations, and the decline in bus service reliability caused by mixed traffic conditions the phrase “bus priority” refers to the measures taken in time or space to ensure the priority of bus traffic on the road and to improve the efficiency of bus operation that is giving buses the right priority (Sun, Li, & Wei, 2021). In rapidly urbanizing cities like Addis Ababa, where private vehicle usage is increasing and road infrastructure is limited, these challenges have led to severe congestion, longer travel times, and reduced public transport attractiveness.

The implementation of bus-lanes aims at the improvement of the operability and reliability of the bus system by providing congestion-free conditions along main road corridors with the goal of strengthening its attractiveness in comparison to the private car (Waterson, et al. 2003).

Bus priority entails preferential treatment of buses over mixed traffic, with dedicated lanes, transit signal priority, and queue jumps commonly utilized (Wright & Hook, 2007).

### **2.1.1. Traffic Flow Theory**

Traffic Flow Theory is a branch of transportation engineering concerned with understanding and modeling the movement of vehicles on road networks. It analyzes key traffic parameters such as vehicle speed, traffic density, traffic volume and how their interaction impacts measures like travel time, delay, road capacity, and congestion.

Recent research by Drliciak (2024) has further advanced traffic flow analysis by introducing methods for vehicle congestion group identification, allowing for more precise evaluation of traffic flow parameters. Their work highlights the importance of distinguishing between congested and free-flowing traffic conditions to improve the accuracy of traffic performance assessments.

In the context of bus priority system, such insights are crucial. In cities like Addis Ababa, where chronic congestion affects major transport corridors, applying Traffic Flow Theory enhanced by modern congestion group analysis methods allows for more targeted interventions. Bus priority lanes, by separating buses from the variability of mixed traffic conditions, can maintain higher and more stable operational speeds, reduce delays, and improve overall service reliability.

By systematically applying these theoretical and analytical ideas into practice, Addis Ababa's implementation of Bus Priority System (BPS) will optimize bus performance on the roads offering a transportation choice that is resilient to traffic and tackling the city's growing urban mobility challenges.

### **2.1.2. Space Syntax Theory**

The spatial arrangement of urban settings and how it affects mobility patterns are examined by space syntax theory. It highlights how accessibility, connection, and travel behavior are impacted by the physical design of streets, intersections, and open spaces. Whereas places with inadequate connectivity frequently experience underuse and inefficiency, those with high connectivity typically draw larger movement flows (Hillier, 1996).

The planning and execution of Bus Priority System (BPS) can benefit greatly from the application of Space Syntax principles, which provide important information on the location and manner of priority measure deployment. In order to optimize accessibility and efficiency, bus lanes placed along highly integrated (well-connected) corridors can take use of natural circulation patterns.(Khalid,2001) By giving buses priority along these corridors, the public transportation system is oriented along the most important movement axes, facilitating access to business hubs, employment centers, and residential regions with high population densities.

### **2.1.3. The Sustainable Transport Framework**

The framework highlights the importance of economically feasible, socially inclusive, and ecologically benign transportation systems. Addis Ababa's reliance on buses for mass mobility (Lulit et al., 2020) aligns naturally with this framework. Strengthening bus operations through priority schemes not only enhances service quality but also encourages a modal shift from private cars to public transit, contributing to reduced emissions, lower energy consumption, and improved urban livability (Rodrigue,2020). Successful cases from Bogotá, Curitiba, and Guangzhou (Levinson et al., 2003) demonstrate how similar interventions can promote sustainable urban transformations.

## **2.2. Definition of key Terminology**

**Bus lane** - only buses are allowed to use this lane, which is designated by signs and road markings that specify the types of vehicles are allowed to use it.

These lanes are intended to ensure faster and more reliable bus travel by separating buses from general traffic. However, without proper enforcement, bus lanes are vulnerable to encroachment by unauthorized vehicles, which can significantly reduce their effectiveness. Therefore, consistent monitoring and enforcement are essential to maintain the operational integrity of bus lanes and uphold the benefits of the bus priority system.

**Road Infrastructure** - refers to road facilities such as the road network, parking lots, stopping places, drainage system, bike lanes, bridges, and sidewalks.

**Bus priority system** - is a system that prioritize buses on the road in order to reduce travel times and increase dependability. These systems may involve bus gates, bus lanes, and bus-only roads.

**Traffic signal priority** - Traffic Signal Priority is a system designed to enhance the movement of certain priority vehicles particularly buses at intersections by adjusting signal timing. This includes extending green lights or shortening red lights to reduce delays and improve overall traffic flow and road safety. As a core component of bus priority schemes, TSP helps ensure more reliable and efficient transit operations, especially in congested urban environments.

### 2.3. Brief Story about Bus Priority System

Bus priority system have been implemented throughout many countries in a world to mention some, North America, Latin, France, South East Asia, China and now it's increasing in Africa and India. (Deng N, 2011)

The bus priority was first established in the city of Chicago, USA in 1939 (APTA, 2004) In Europe, the first bus lane was introduced in Hamburg, Germany in 1963. At this time streetcars were abolished and the former tracks dedicated to streetcars were diverted for bus travel. Other large German cities soon followed, and in 1970 the introduction of bus lanes was officially authorized by the German Highway Ordinance. (N Gavanoas,2013)

On 26th February 1968, the first bus lane was opened in London. It was put into service on the Vauxhall Bridge. Britain's first reverse bus lane was introduced on King's Road in Reading as a temporary measure when the road became one-way (eastwards to Cemetery Junction) on 16th June 1968. (M,Peter 2008)

**Table 2.1: Bus Priority lane networks in case study cities, source (Agrawal et al.,2013)**

Characteristics	London	Los Angeles	Newyork	Paris	Sanfransisco	Soul	Sydney
Year of bus lanes first established	1968	1974	1963	1964	1970	1984	1992
Miles of bus priority	77	4	50	118	18	127	14
Kilometers	285	6	80	190	27	204	23

This implies that the evolution of bus priority systems is not solely dependent on the timing of first implementation, but also on ongoing commitment from governments, urban density limitations,

and policy growth. Cities like Paris and Seoul demonstrate that comprehensive and well-integrated bus lane systems can significantly enhance urban mobility over time, even if they were not among the earliest adopters.

### **2.3.1. New York**

A study by Scott (2017) identified the bus priority lane, which links developing employment centers, is also the public transportation system of the future for New York City. The fastest-growing sectors of New York City's economy, including health, education, hotel, food services, and culture, are also the most dissemination. Buses are essential to these industries' future prosperity as well as the means of livelihood for their employees, customers, and consumers.

The Metropolitan Transportation Authority's singular concentration on the NYC subway system and the reasons why New Yorkers select alternative modes of transportation has resulted in slow and inefficient routes, infrequent stops, packed bus lanes, nonexistent bus shelters, and poorly designated bus stations. To properly accommodate modern commuter patterns, the MTA is should thoroughly examine and restructure its bus network. (Agrawal et al., 2013)

### **2.3.2. Paris, France**

The road planners of Paris, France first put forward the concept of “bus priority “which is related to the historical background of French economic development. The rapid development of the French economy after the second world war led to a sharp increase in the number of motor vehicles accompanied by increasingly serious urban traffic congestion and environmental pollution. At this point the French government began to realize the importance of the development of public transport and the public transport priority policy came in to being (Sun et al.,2021)

According to Paris police guide, it's prohibited for other vehicles to use the bus lane unless on a bicycle, driving cap or an emergency vehicle otherwise there's a risk of a fine up to E135.

### **2.3.3. London**

During the past 40 years, London has developed long successful history schemes and the most comprehensive systems of bus priority lane in the world. included 1,200 segments and extended about 177 miles. (Hounsell et al.,2008)

London has an unusually decentralized approach to bus lane administration, which has been led by the metropolitan government on a network of key arterial, but by local authorities elsewhere. London's bus lane program is also notable for its comprehensive approach to enforcement. (Agrawal et al., 2013)

### **2.3.4. Washington DC**

The extensive modern transit infrastructure in Metropolitan Washington consists of several interconnected services, including bus, commuter train, and rail transit. The roads in the Washington metropolitan area are among the most congested in the country. A plan to establish 23 priority bus lines within its service region was approved by the Washington Metropolitan region Transit Authority (WMATA) in 2008. The half of WMATA's bus system ridership is served by the 23 selected corridors. (WMATA,2018)

### **2.3.5. Australia**

Australian BRT systems have been noted as being particularly diverse in design (Currie, 2012) with systems now operating in Sydney, Brisbane, Adelaide and to a lesser extent Melbourne.

**Brisbane:** The bus and rapid transit system in Brisbane, Australia, plays a vital role in connecting residents and visitors to various destinations within the city and its surrounding areas. The system is extensive, reliable, and equipped with modern amenities, making it easy for passengers to reach their destination. The busway system is also environmentally friendly and helps to reduce congestion on the city's roads. The bus and rapid transit system in Brisbane are a vital component of the city's transportation infrastructure and is an important part of the city's overall transportation network. (Zhang et al.,2019)

According to (Austroads,2017), the allocation of road space for Bus Priority System (BPS) often involves the designation of bus priority lanes to facilitate the transportation of buses through

congested areas without interference from general traffic. Bus lanes may operate on a time of day basis, corresponding to the periods of peak congestion through appropriate signing and marking. Since buses commonly stop at curbsides to drop off or pick up passengers, most bus lanes are constructed so that buses travel in the same direction as regular traffic. Under the Australian Road Rules, other vehicles may use a bus lane for a distance of 100 m if it's necessary to drive in the lane, particularly to enter or leave the road or move from one part to another.

### **2.3.6. Bus priority system in Africa**

Africa's cities are the fastest-growing in the world, with the region's urban population increasing by about 3.5% each year. While urbanization can often boost economic growth and open new opportunities, this steady influx of people is also putting tremendous pressure on cities and their transport systems. (World bank, 2022)

In African context, the first BRT system was introduced in Lagos Nigeria (2008) followed by other countries like South Africa which implemented it in Johannesburg and Cape Town (2011) and Gorge (2015); along with Tanzania, Ghana and Morocco. (ADB 2015)

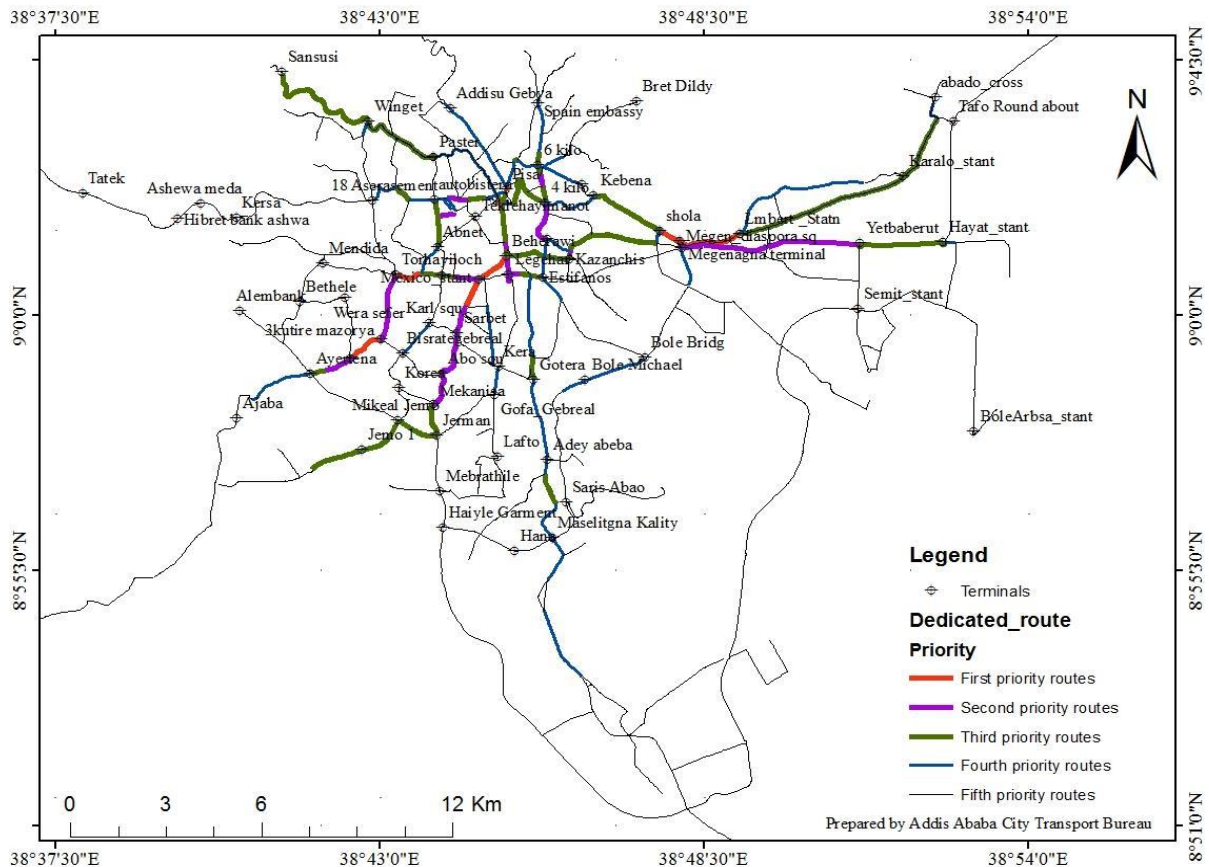
Followed by Kenya in 2019 It was implemented in Tanzania and other countries as the solution to many faced urban transport challenges which were the result of existence of unreliable and low quality urban public transport services.

### **2.3.7. Tanzania (Dar es Salaam)**

Bus priority system was implemented in 2016, in Dar es Salaam's overall transport infrastructure is relieved by the BRT by reducing traffic congestion, number of cars in the streets, separate bus lane ensure traffic flow and structure of stations increases pedestrian safety. In this city bus priority lane led to more secure livelihoods, more decent living conditions through the reduction of travel times and better accessibility of basic provision, more sales opportunities for street vendors and the creation of new jobs can also contribute to improved livelihoods. (Fred et al., 2021)

### 2.3.8. Ethiopia, Addis Ababa

Addis Ababa's density of population and economic activities exacerbates congestion. Road infrastructure remains the main transport backbone, with relatively limited support for mass transit (World Bank, 2018). A bus lane introduced along the Mexico–German corridor in 2018 was intended to reduce congestion, but subsequent field reports highlight issues such as illegal parking, lane encroachment by private vehicles, and fading lane markings (Dawit M, 2020; Gebremariam et al., 2021).



**Figure 2.1:** Bus priority routes in Addis Ababa, source (Addis Ababa City Transport Bureau, 2020)

There are two extant transport service companies that provide public transportation at the city level, namely (652) Anbessa city bus and (658) Sheger public transportation service, each having 1310 vehicles. on a typical day, there are approximately 1,227,040 users. (Addis Ababa public bus transport service)

These historical developments offer valuable insights for Addis Ababa's growing urban mobility challenges. For instance, London's approach to enforcement utilizing automatic number plate recognition (ANPR) cameras to monitor bus lane violations has been instrumental in maintaining the integrity of its bus lanes. Such technology-backed enforcement could help address the rampant encroachment issues observed in Addis Ababa's BPS

Similarly, Washington DC's focus on multimodal integration, where bus priority systems are coordinated with metro rail services, pedestrian access, and real-time passenger information, highlights the importance of designing public transport networks that are not only efficient but also interconnected. For Addis Ababa, where informal transport modes like minibuses coexist with standard buses integration of services and infrastructure can lead to a more coherent and accessible public transport system.

These global experiences underline key strategies that Addis Ababa can adopt strict enforcement, multimodal integration, legal backing, and adaptive reuse of existing infrastructure.

## 2.4. Bus Priority System Elements

Bus priority is a flexible form of rapid transit systems that combines different elements running ways, stations, vehicles, services, fare collection and intelligent transportation service elements into an integrated system with a strong identity. (Levinson, Z 2003)

*Table 2.2: The main elements of bus priority systems, Source: (Levinson, H.S., et al., 2003)*

<b>Main Elements of Bus Priority System</b>	<b>Levinson, Zimmerman (2003)</b>	<b>Canadian Urban Transit Association</b>
<b>Bus Lane</b>	Buses operate primarily in exclusive transit-ways or dedicated bus lanes.  Vehicles may also operate in general traffic	Three types of busways, including exclusive busways, dedicated lanes and mixed traffic
<b>Bus route</b>	Bus routes that are clearly identifiable, free from traffic interference wherever possible, and permit rapid and reliable service.	
<b>Fare collection</b>	Cash, pre-paid, digital fare payment systems, a combination of two or all.	

<b>Bus stations</b>	<p>Bus stations, ranging from enhanced shelters to large transit centers.</p> <p>Stations that are attractive, provide passenger protection and amenities, permit off-vehicle fare payments, and are generally spaced far apart</p>	<p>Sufficient shelter from inclement weather, seating, customer information, appropriate lighting and ample platform space for boarding, alighting and waiting are the minimum requirements.</p>
<b>Services</b>	<p>Service patterns that are clear, easy to use, and include high-frequency trunk-line operations and feeder routes</p>	<p>A variety of service alternatives, including all-stop route(s), limited-stop service, express, and trunk-feeder arrangements</p>

**2.4.1. Bus Lane**

Dedicated bus lanes are those restricted to only buses either permanently or during certain hours of the day. The lanes are usually indicated with “Bus Only” posted signs and pavement markings along the route with specific regulations. These exclusive lanes provide opportunities for buses to bypass traffic congestion and avoid vehicular conflicts in mixed travel lanes to improve bus service reliability. Implementing these lanes can help increase the attractiveness of bus transit to prospective public transit users, thereby encouraging a mode shift from using single-occupancy vehicles to buses. (Mineta Transportation Institute Publications ,2022).

Bus lanes are typically 3.35 and 3.66 meters wide. Shoulders are provided along the road where space exists. At busway stations, roadways are widened to about 15.24 meters. Busway envelopes are about 12.19 to 15.24 meters in width between stations. (Levinson,2003)

Dedicated bus lanes can make bus travel across cities more appealing to commuters and tourists alike. All it takes is clear signage, education, and enforcement so that dedicated bus lanes don’t become open space for illegal parking. When not properly enforced, bus lanes become as difficult

to navigate as any other traffic lane and they fall short in terms of on-time performance goals. (National capital region transportation planning board, June 30,2017)

The installation of a dedicated bus lane in Addis Ababa, particularly along the Mexico to Germany roundabout corridor, involved the use of a dashed road marking the line of 10–20 cm width (used in parts of the network where mixed traffic is permitted, such as right turns, parking entrances, taxi stops, etc.) and a continuous red road marking the line of 10–20 cm width (used in parts of the network where there is exclusive use of public transport). (Dawit Molla Kassa, 2020)



*Figure 2.2: Line-separated Bus lane designs Groff, M. (2019).*

There are two main types of dedicated bus lanes based on their separation from general traffic. The first type is physically separated bus lanes, where the bus lane is divided from other lanes by physical barriers such as curbs, bollards, or raised medians. These barriers prevent unauthorized vehicles from entering the bus lane ensuring a clear and consistent path for buses. The second type is line-separated bus lanes where the separation is indicated only by painted lines and road surface markings without any physical obstruction. Line-separated bus lanes are commonly marked with either a diamond symbol or with red-colored pavement to visually distinguish them from other traffic lanes. These designs rely heavily on visible markings, signage, and traffic law enforcement to keep other vehicles out of the bus lane (Groff, 2019).



*Figure 2.3: Physically separated bus lanes (source: National bus rapid transit institute)*



**Figure 2.4: Lane width (NACTO 2020)**

As shown in the picture the lane width for buses is 11 feet (3.35 meters), for private cars it ranges between 8 to 10 feet (2.44 to 3.05 meters), and for bicycles, a dedicated cycle lane should be 3 feet (0.91 meters) wide.

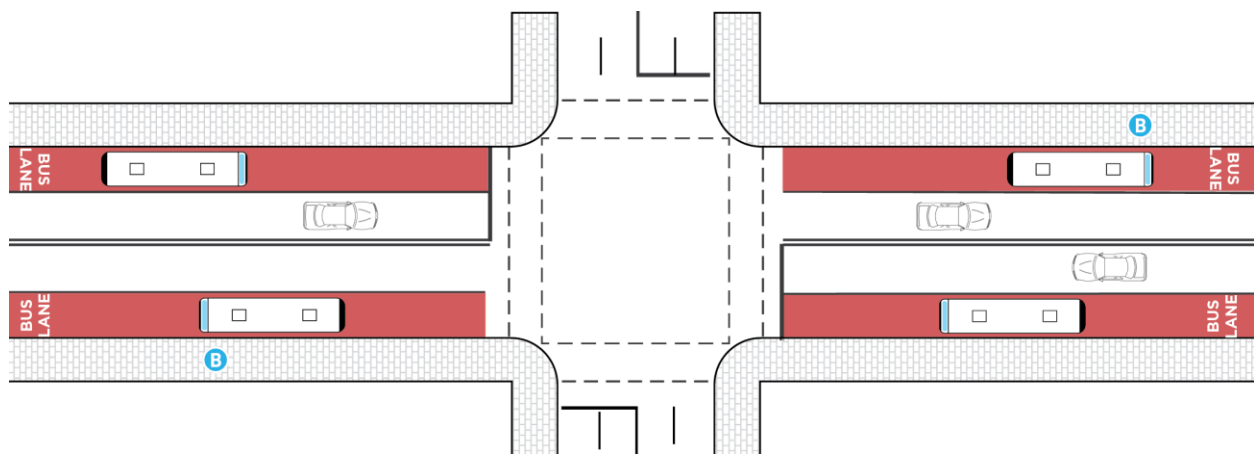
In regards to bus lane design, Levinson et al (2003) indicate that the level of service can match that of metro systems in the scenario a well-designed BRT system can reach peak capacities of

10,000 to 25,000 passengers per hour per direction when buses operate on protected or completely separated road infrastructure.

Bus lanes can be found on the road in a variety of locations, such as on the side near the curb or in the center, running in mixed traffic, using shoulder bus lanes (Cain et al,2009)

#### 2.4.1.1. Curbside bus lane

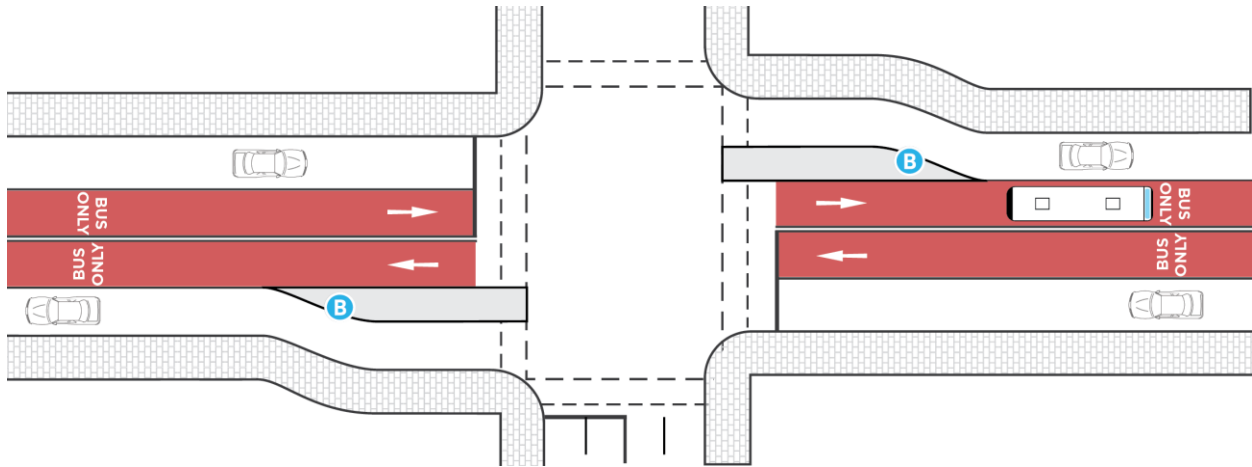
Bus lanes can be provided curbside for easier access to bus stops or as an offset lane to allow for other curbside uses and turning movements. (NACTO, 2013)



*Figure 2.5: Schematic example of Curbside bus/bus-only lane (Bus Priority Infrastructure Planning Toolbox)*

#### 2.4.1.2. Centre running bus-only lane

One of the main benefits of center running bus only lane is that it usually prevents the necessity of other cars to stop in the middle of the road for issues like parking or using it as a breakdown lane. This means that there are less cars wanting to take up space in the middle of the road and less opposition to building a physical barrier to separate the busway from the nearby general-traffic lanes, which means that there will be less enforcement challenges and the bus lane will have greater integrity.(APTA,2010)



**Figure 2.6: Schematic example of a center running bus only lane (Bus Priority Infrastructure Planning Toolbox)**

### 2.4.2. Bus routes

According to Austroads (2017) the following keys are important elements to keep in mind while allocating the necessary amount of road space for bus routes on main roads

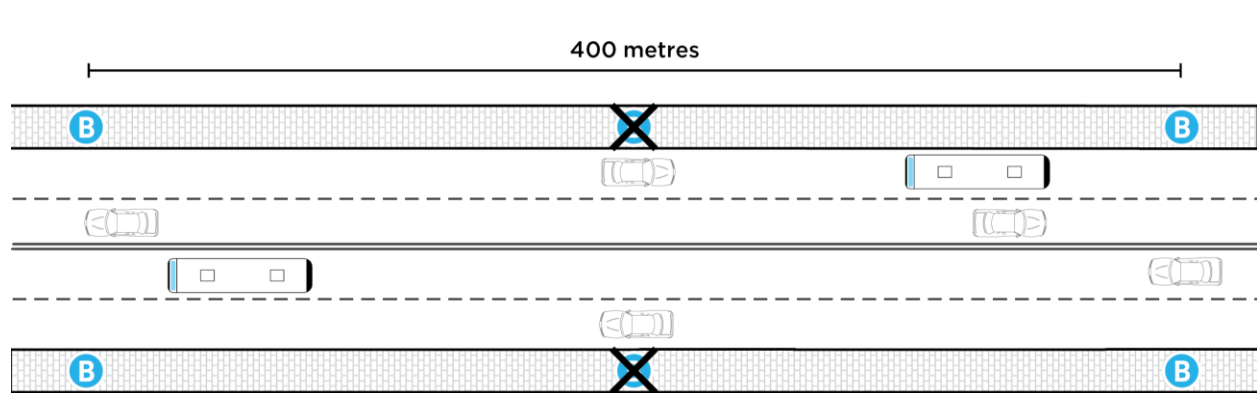
- The implementation of dedicated bus lanes on numerous major highways allows buses to share traffic lanes with other types of vehicles, perhaps resulting in an increased number of people in the lane.
- The provision of short "queue-jump lanes," which are short stretches of bus lane at an intersection for the sole use of buses enabling them to bypass congestion points, traffic signal priority, and effective bus stops (possibly located in traffic islands), as well as priority at intersections, should be taken into consideration as many of the factors affecting bus delay are located at certain road segments.
- Bus stops should be placed on the far side of a signalized intersection, following traffic signal priority; otherwise, the signal priority may be 'wasted' while the vehicle is picking up or dropping off passengers. Indented bus bays on busy arterial highways can cause buses to have trouble re-entering the traffic flow, whereas on-road bus bays can cause congestion.

- By designating particular roads as key public transportation routes, priority can be given to public transport over other modes, especially during peak hours, reducing delays for those modes.
- The ability of the bus to re-enter the traffic stream is often critical to the effectiveness of queue-jump lanes. Signal priority is often used in conjunction with queue-jump lanes for this purpose.
- At congested intersections, a bus is frequently given signal priority, allowing it to enter the intersection ahead of the usual traffic. Traffic signals can also assist the bus in performing challenging traffic maneuvers, such as turning right when crossing many lanes of traffic.
- Communication between buses and infrastructure can also enable buses that are running late to be given greater priority.

### **2.4.3. Bus stop**

Bus stops are where passenger boarding and alighting takes place and are linked together to form a route with origin and destination. Each route has different number of bus stops based on their length which is spaced at a distance of 350-500 meters unless policy and topographic restriction exists. (Addis Ababa City Bus Enterprise)

According to AACRA (2020) Bus stop should be located with regard to passenger safety and efficient traffic operations while also minimizing disruption to overall traffic operations. Ideally, bus stops should be spaced approximately 400 meters apart from each other or from major bus stations, which helps maintain a balance between accessibility for passengers and the operational speed of bus services.

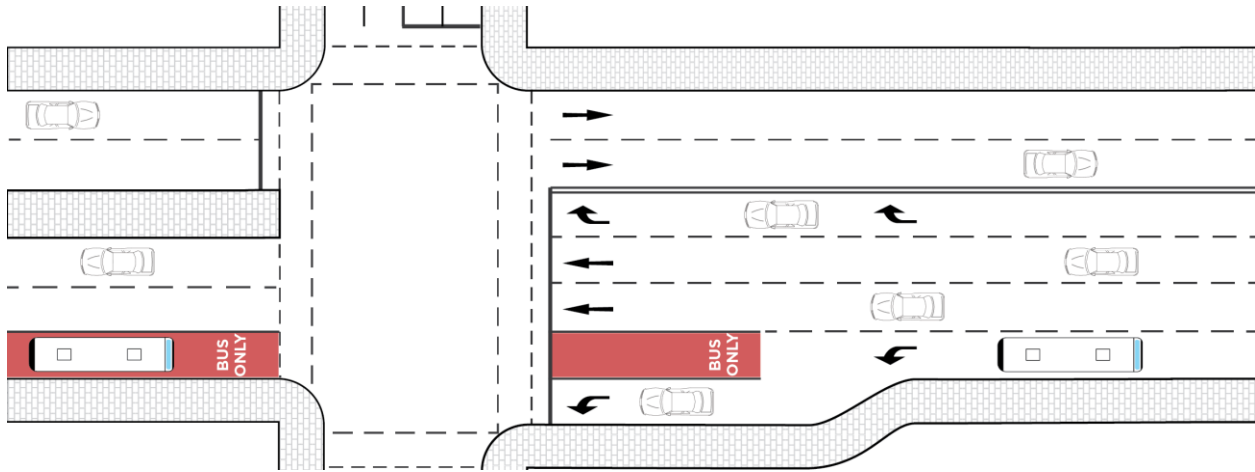


**Figure 2.7: Bus Stops**

#### **2.4.4. Queue jumps**

A queue jumps lane is a short bus lane at intersections which allows buses to go in and then move forward from a left or right turning lane depending on left-hand or right-hand Driving (Nima Dadashzadeh, Murat Ergun, 2018)

Queue Jumps lane implementation requirements may vary according to municipality, but common thresholds include routes with an average headway of 15 min or less; when traffic volumes exceed 500 vehicles/hour in the curb lane during a.m. or p.m. peak hours; when the intersection operates at a level of service or lower; and when cost and land acquisition are feasible (Townes et al. 1998).



**Figure 2.8: Schematic example of bus queue jumps and banned turn exemptions (Bus Priority Infrastructure Planning Toolbox)**

#### **2.4.5. Signage**

Street name signs shall be installed at all intersections and shall identify each street at the intersection. As per CKL-501 ‘B’ “Typical Street Name Sign Detail” the street name sign shall be 100 mm white reflective uppercase lettering on a reflective green background 150 mm in height and 610 to 915 mm in length. Signs shall be anodized aluminum, and a minimum of 2.3 mm in thickness. (City of Kawartha Lakes Infrastructure Guidelines – 2022 Roads)

Bus priority measures must be understood and followed by both pedestrians and automobiles, and this requires clear and consistent signage. At the moment, Addis Ababa's public transportation corridors lack standardized signs, and enforcement is inadequate. Putting up electronic information boards, directional signs and visible road markings may enhance bus operations visibility and compliance.

#### **2.4.6. Transit signal priority**

Transit Signal Priority (TSP) is a general term for a set of operational improvements which harness technology in order to reduce the dwell time at traffic signals for transit vehicles, by lengthening the time given for green lights or shortening to time in which red lights remain flashing. (Nima et al., 2018)

Bus delays at traffic signals account for about 10 to 20% of overall bus travel times therefore, setting signals to minimize person-delay is essential to improve BRT running times and reliability. This can be achieved by “passive” signal controls that minimize the number of phases, keep cycle lengths as short as possible, and maximize the “green” times along BRT routes. (Levinson, 2003)

Traffic signal priority for buses has not yet been implemented in the Mexico–Germany Roundabout corridor representing a significant gap in the current spatial bus priority scheme. Most intersections use fixed-time or manual signals that do not detect buses, causing delays behind private vehicles.

#### **2.5. The Condition of the Road's Width**

It would be better if dedicated roads have three or four traffic lanes in each direction to give priority to mass transport. If not, it should have at least two lanes of traffic.

Furthermore, the width of the roads allocated for buses should take into account the width of the vehicles, which is normally 3.5 meters, but the width can be reduced depending on the scenario, but it should not be less than 3 meters. (Austroads, 2017)

In the context of Addis Ababa, insufficient road width presents significant challenges to the successful implementation and operation of bus lanes. Narrow roadways can lead to conflicts between buses and general traffic, increased risk of accidents, and reduced operational speeds, thereby diminishing the intended benefits of bus priority systems. Moreover, inadequate space can result in frequent encroachment into bus lanes by other vehicles, lowering the reliability and attractiveness of public transit. Therefore, careful planning and road reallocation are essential to ensure that bus lanes in Addis Ababa not only exist but function efficiently and safely to meet the growing public transport demands.

## **2.6. Pavement Quality**

Roads must have a pavement design and drainage system well enough to prevent slippery roads for vehicles. (Nagarjun ,2019)

As it identified by (Mohammed Buhatti 2020) good-quality pavement ensures better service and operations for a longer period by minimizing the need for maintenance on the bus lane. Roadways with poor-quality pavement will need to be shut down more frequently for repairs. Buses will also have to slow down to drive carefully over damaged pavement.

No matter what type of pavement, a 40-year life span is recommended. There are several options for the pavement structure to achieve that, with advantages and disadvantages for each.

Three examples are described according to the BRT Implementation Guidelines (2003), several pavement design options can be considered for Bus Rapid Transit (BRT) systems. Asphalt pavement, when properly designed and constructed, can last over 40 years, with surface replacement typically required every 10 to 12 years. This resurfacing can be carried out without interrupting BRT services, providing a smooth and quiet ride. However, at stations where frequent braking occurs, rigid pavement is recommended to prevent damage. Jointed Plain Concrete Pavement (JPCP) is another viable option, offering a lifespan of over 30 years. To achieve this durability, the pavement must include round dowel bars at transverse joints, tied lanes using reinforcing steel, and an adequate thickness to withstand bus loads. For more demanding conditions, Continuously Reinforced Concrete Pavement (CRCP) may be considered. Though it is the most expensive option, CRCP uses continuous slab reinforcement to enhance pavement strength and longevity, making it suitable for high-stress areas within the BRT corridor.

## **2.7. Enforcement**

Effective enforcement of curb parking restrictions along BRT routes is essential, since public perceptions of violations can affect the respect and support for BRT. Enforcement should be done by jurisdictions that have primary responsibility for the BRT running ways on a sustained basis, and penalties for violations (e.g. fines, towing) should be stringent. New York City, for example, charges a \$100 fine plus towing charges for illegally parking in the Madison Avenue Dual Bus Lanes.

Several studies from the literature indicated that the perception of limited bus lane enforcement increases violation rates, diminishing the effectiveness of bus lanes and resulting in reduced bus speed although practices vary, police enforcement and automated enforcement (such as on-board cameras) are the two most common enforcement tools used to reduce violations. (N.Gavanas et al.,2013)

## 2.8. Key challenges associated with bus priority system

Careful consideration of the challenges is important in identifying suitable bus priority infrastructure. Here are some challenges that are mention by (Currie & Sarvi, 2012) and (Austroads 2020)

*Table 2.3: Key challenges associated with bus priority system*

Challenge	Explanation
Balancing competing demands for road space	Lack of precise guidelines for when and how to give buses priority over other modes of transportation on the road; possible localized delays to regular traffic as a result of reserving a general traffic lane for buses Significant land acquisition and utility relocation costs to widen roads to provide for bus priority
Integration with land use	It is important to make sure that the location and layout of the bus priority complement the intended place intensity of a street or road.
Integration with other transport modes	Need to ensure the bus priority's layout and location facilitate movements between modes and services (e.g. walking and cycling access, transfers to rail, light rail, bus, ferry, etc.)
Bus priority remains effective and consistent	Traffic flows and behaviors change over time Insufficient priority delivered, partly delivered, driver behavior or traffic growth not forecast or anticipated in strategic plans
Public/ stakeholder feedback	Strong focus on the impacts of parking loss or reduced traffic capacity; desire to keep the impacts minimal or net-zero <ul style="list-style-type: none"> <li>• Limited focus on bus customer benefits</li> <li>• Consultation focuses on affected land owners but comments from bus customers are seldom captured</li> </ul>
Long implementation timeframes	Progressing a bus priority proposal from idea to implementation requires a significant amount of planning, design, consultation and compliance with existing regulatory processes, inhibiting the ability to be proactive or to respond to challenges quickly <ul style="list-style-type: none"> <li>• Consultative and compliance requirements inhibit the agile implementation of trial bus</li> </ul>

	lanes that could deliver immediate reliability and journey time benefits
Limited road space	<p>Minimum standard of bus priority design can impede efficient bus operations e.g. bus lanes that are too short to allow for extensive priority for buses, inability for buses to get into bus lanes due to congestion, bus lanes that are too narrow or indented bus stops that require merging into a general traffic lane</p> <p>Fragmented bus priority implementation leads to sub-optimal outcomes for the whole network</p> <p>In some cases, limited road space can result in insufficient bus stop and waiting area capacity</p>
Traffic signal priority issues	<p>Congestion on intersection approaches prevents buses from accessing signal priority</p> <p>Bus detecting signal priority such as Public Transport Information and Priority System (PTIPS) and Sydney Coordinated Adaptive Traffic System (SCATS) are not widely available</p>
Compliance and enforcement	<p>Lack of enforcement (camera or police) against vehicles driving or parked in a bus lane</p> <p>Lack of enforcement normalizes non-compliant driver behavior</p>

## 2.9 Research Gap

This study addresses critical gaps in existing research on bus priority systems in Addis Ababa. While previous studies, including (Berhan et al., 2013) and (Seleshi, 2024) have examined general operational aspects of the city's bus services such as passenger satisfaction, service frequency, DBL performance, and the operational difficulties of the Anbessa and Sheger bus systems. They have not specifically analyzed the effectiveness of bus priority system and their challenges in key corridors. However, it is necessary to study the more recent perspectives on their system and challenges encountered on the lane. It is important to understand bus priority system and the elements. What are they? Bus priority system is a system that improves bus speed leading to better efficiencies, better bus services, and reduced costs. According to (Muhammed,2023) the elements can be classified into three main categories:

**Priorities for Bus Stops:** Minimize wait times at bus stops by allowing buses to move in the median lane, levelling platforms and alighting, reducing the number of bus stops, and enabling off-board ticketing.

**Junction Priorities:** By allocating a specific area for buses to wait in line and by modifying traffic signals to allow buses to proceed more quickly, junction delays can be minimized.

**Bus Lane Priorities:** Increase buses speed by allocating specific road space or by setting apart streets and lanes for them.

Implementing spatial bus priority scheme in our city can be a great force multiplier in moving towards sustainable mobility. There are examples in developed countries how these elements have helped them boost bus transport and address sustainable mobility challenges positively. In order to draw in more people and reach net zero by 2030, Transport for London (TfL) developed a long-term action plan for buses in March 2022. These measures resulted in about a 7% rise in bus demand and average reduction of 10 minutes in travel time.

Singapore is another country where bus priority procedures have been successfully implemented, as seen by the 62% reduction in passenger boarding times. Nearly 90% of people in the city-state live within 300 meters of a bus stop, making the catchment regions of the bus network vast. (Abhishek Jaiswal,2023)

While bus priority schemes have been widely researched in developed cities such as London, there is limited research on their implementation in rapidly growing African cities like Addis Ababa. This study aims to bridge this gap by evaluating the effectiveness and challenges of bus priority system in Addis Ababa.

## **Chapter 3: Research Methodology**

### **3. Introduction**

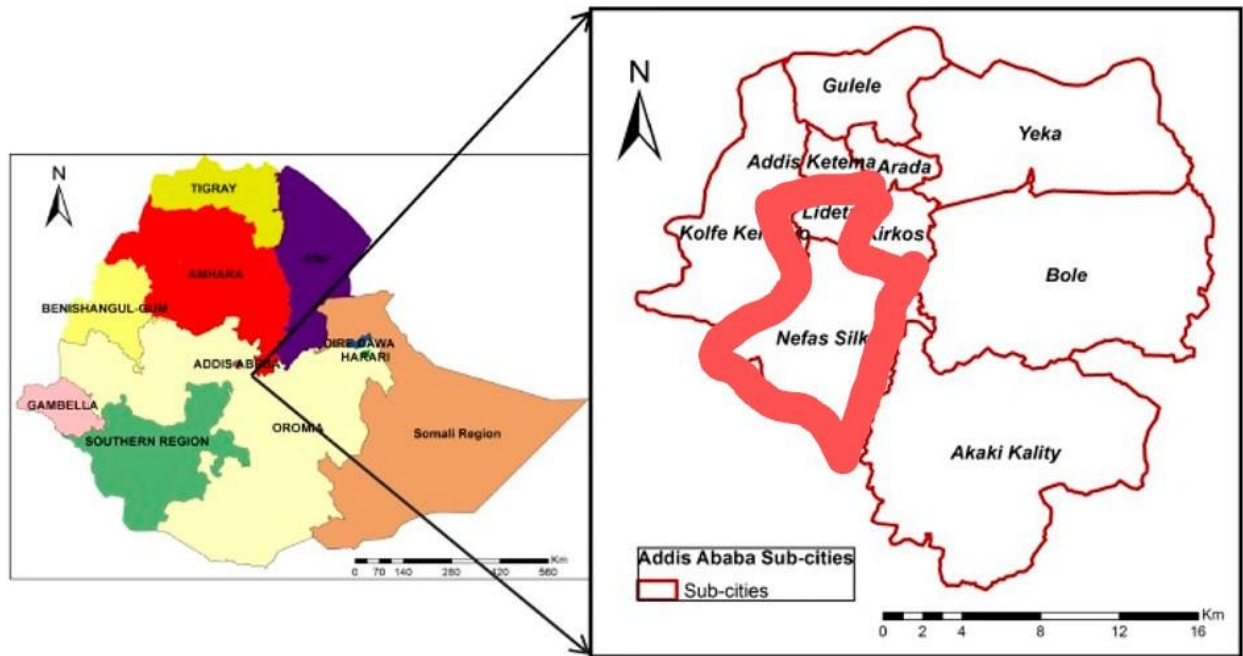
#### **3.1. Study area description**

The density of population and activity in Addis Ababa causes enormous pressure on the city's transport system which is primarily reliant on road infrastructure.

Between the sub cities of Lideta and Nifassilk in Mexico is the study area for the assessment of spatial bus priority schemes in the context of road infrastructure provision. This is a large commercial area with a variety of shopping centers, offices, and public transportation hubs that allow people to travel to any location they choose and has a total length of about 5.7 km starting from German Roundabout to Mexico square which is the city core area.

The area has a well-established public transit system that includes buses and light rail. However, like many urban areas, this area faces significant challenges related to traffic congestion and the provision of sustainable and efficient public transit services. There are many different types of vehicles on the road, such as freight trucks, private cars, taxis, city buses, minibuses, and an increasing number of motorcyclists. The necessity for efficient prioritization techniques is highlighted by the frequent lane interference, unlawful stopping, and traffic delays caused by this multimodal presence.

When a dedicated bus lane was installed, there was a dashed road and a continuous red road that marked the line of 10–20 cm width (used in network segments when public transportation is the only mode of transportation utilized). Below are maps that show where the study corridor is located in Addis Ababa. With the Lideta–Nifas Silk corridor (from Mexico to Germany roundabout) highlighted to identify its location, the first map displays the city plan. The second image provides a thorough overview of the 5.7 km bus priority corridor highlighting important landmarks such the Germany and Mexico roundabouts.



*Figure 3.1: Location map of the study area*

### **3.2 Research Design**

The research problem was brought to light following a thorough analysis of existing literature and a detailed study of real-world problems. In order to address this issue, appropriate research objectives and questions were formulated, and the necessary data was collected and prepared for analysis using the methods outlined below. A mixed methods research design was chosen for this study, as it allows for a comprehensive understanding of the problem by combining both quantitative and qualitative approaches. Various levels of analysis are conducted based on the data and the resultant findings are used to draw conclusions and make recommendations for future research.

### **3.3 Research Approach**

Mixed-methods approach followed, this ensures that both numerical patterns and the human context behind those patterns are understood. For instance, the quantitative data shows a reduction in bus delays, while the qualitative data can explain why this reduction is happening, how stakeholders view the changes, and whether there are any unintended consequences (e.g., road users still encroaching on the bus lane).

Qualitative data, was collected through interviews, focus groups to capture the perspectives of various stakeholders like the transport authority, including daily users of the road, bus drivers that have a day to day direct experience, urban planners, engineers, and policy-makers. This data can be analyzed using content analysis, perspectives, and opinions related to the implementation and effectiveness of spatial BP schemes.

To conduct a thorough analysis, some data sets was required. Additionally, map data that outlines land use, road networks, route maps, and sub cities is essential. In order to gather enough information from the transport vehicles, particularly the Anbessa bus and Sheger bus, passenger volume data and road characteristics was all collected.

### **3.4 Source of Data**

Primary and secondary data were collected to conducted the research.

#### **3.4.1. Primary Data**

The primary data (Questionnaires, interview) were collected visiting offices that involved identifying and engaging with various stakeholders who play critical roles in the implementation and management of spatial bus priority schemes.

Some of these stakeholders includes transportation authorities, the transportation engineers and local government officials.

The first visit is made to Addis Ababa City Road Authority (ACCRA) that has a responsibility for planning, designing roads and implementing roads in the city. 3 officials were interviewed.

The second visit is made to the Addis Ababa Public Bus Authority to get a firsthand understanding of the assessment of the spatial bus priority scheme, an interview was conducted to 3 officials with key responsible for its implementation and management. This included the Addis Ababa Bus

Authority Manager, as well as Planning and Design and Public Relations Officials from Anbessa Bus Organization, given that it's the city's first and most widely used bus service.

The third interview was made in Addis Ababa planning and design 2 people were interviewed. Field observation was employed to the study area to provide a detailed information about how the system practically operates. It involved observing the road infrastructure and transportation system in person. The traffic flow, bus speeds and the behavior of different road users under different bus priority schemes was observed.

Survey and Questionnaires were used to evaluate the effective way to improve bus transportation system. The question included their perception accessibility of the bus transport, road safety and pavement condition in relation to BPS and their concern before and after the implementation of the scheme. road users, passengers and drivers are also a part of the survey that is conducted their feedback is very important on the effectiveness of bus priority system.

### **3.4.2. Secondary Data Sources**

The secondary data source was collected review of relevant literature from different sources and formats including the related research documents from the offices.

## **3.5 Sampling Design**

### **3.5.1. Sample Population**

#### **Traffic Managers & Police**

- Population Size: 88 officers responsible for monitoring the bus corridor.
- Sampling Method: Purposive sampling followed by random selection.
- Final Sample Size: 43 officers were randomly selected to ensure fair representation across different shifts and responsibilities.

#### **Bus Drivers**

- Population Size: 109 drivers (72 from Anbessa Bus and 37 from Sheger Bus).
- Sampling Method: Stratified sampling, with stratification based on bus company.
- Final Sample Size: 65 drivers, proportionally representing both bus companies.

## Road Users

- Population Size: General road users, including pedestrians, passengers, and local business owners, frequenting the corridor.
- Sampling Method: Stratified sampling to include diverse perspectives.

### 3.5.2. Sampling Size

The study's sampling frame was developed from official records (for officers and drivers) and on-site recruitment (for road users). The final sample size is 205 participants, ensuring that findings accurately reflect the perspectives of key stakeholders involved in corridor traffic management.

The combination of purposive and stratified sampling ensured that expert insights and diverse user experiences were adequately captured. The sample sizes were determined based on stakeholder population sizes, ensuring proportional representation and meaningful analysis of traffic management challenges along the corridor.

$$n = \frac{N}{1 + N * (e)^2}$$

Where, n = Sample Size

N= Population Size

e=Margin Error

### 3.5.3 Sampling Technique

The concept of sampling is one of the most crucial to the entire research endeavor, stated by Kruger et al. (2001), as it is essential that a researcher comprehend before choosing, sampling, carrying out the pilot study, and doing the main research.

The target population for the study was 420 individuals, from which 205 participants were selected through the methods described below:

A combination of purposive and stratified sampling was used to ensure representation of key stakeholder groups.

### **Sampling for Traffic management professionals**

Six roadways designated as dedicated bus lanes are regularly inspected by 664 traffic management officers and traffic police. Furthermore, the Addis Ababa public bus administration manager's office is responsible for organizing and coordinating the various institutions under its authority to ensure that the transportation infrastructure is utilized for its intended purpose.

**Table 3.1: Sub-cities where bus priority lane implemented Source:(Addis Ababa Management and Traffic Police Agency,2023)**

<b>Traffic distribution</b>	<b>Lideta</b>	<b>Nifassilk</b>	<b>Arada</b>	<b>Kirkos</b>	<b>Yeka</b>	<b>Bole</b>
Traffic management	19	39	8	8	61	41
Traffic police	73	84	80	80	70	101
Total	92	123	88	88	131	142

There are 8 traffic managers and 80 traffic police on this road corridor.

### **Sampling for Drivers**

Public bus service from Mexico Square to German Square via Anbessa and Sheger, using this designated bus lane. Anbessa accounts for 72 buses, Sheger Public Bus for 37, and Sheger Support Providers for 23.

**Table 3.2 Public buses: Source: Addis Ababa public bus Administration,2020**

<b>Bus priority lanes</b>	<b>Anbessa public bus enterprise</b>	<b>Sheger mass transport service enterprise</b>	<b>Sheger support provider buses</b>
German square to Mexico square	72	37	23

**Sample for traffic management, traffic police, drivers and road users**

**Table 3.3: Sample for traffic management, traffic police, drivers and road users**

	<b>Population size</b>	<b>Percentage %</b>	<b>Sample Size</b>
Traffic managers and police	88	21	43
Bus drivers	132	31	65
Bus lane users	200	48	97
Total	420	100	205

### **3.6 Data analysis**

Traffic data analysis and road infrastructure analysis were conducted after the data collection. It could analyze the data on road condition bus speeds and travel time to identify where the challenges occur. SPSS 23 statistical analysis software is used as a major data analysis.

- **Quantitative Analysis:**
  - Traffic flow and bus travel times were assessed to identify average speeds, congestion patterns, and frequency of lane violations.
  - Descriptive statistics (percentages, frequencies) to interpret user responses.
- **Qualitative Analysis:**
  - Content analysis of interview transcripts identifying recurring themes like lane encroachment, inadequate enforcement, and infrastructure deterioration.

### **3.7 Method of validation**

Throughout the research process a number of crucial steps were taken to guarantee the quality and reliability of the data gathered. Prior to the entire data collection phase, a pilot study was first carried out. A small group of participants, comprising frequent bus customers and study area drivers, participated in a pre-test of the questionnaire. Finding any ambiguous or deceptive questions was the goal along with making sure the information was clear and pertinent. The instrument's clarity and efficacy were improved by changes made to the question's language, structure, and order in response to feedback from this pilot trial.

### **3.8 Research Ethics**

Ethical principles were strictly followed throughout the research process to ensure the protection of participants. Informed consent was obtained from all individuals involved in the interviews, with clear explanations provided regarding the purpose and use of the information collected. Participants had the right to decline or withdraw at any stage. Confidentiality and privacy were upheld at all times, and any personal or sensitive information was treated with strict confidentiality to avoid any potential harm. Overall, the study adhered to ethical guidelines to safeguard participants' rights, dignity, and autonomy during and after data collection.

## Chapter 4: Result and Discussion

### Introduction

Based on the survey conducted along the Mexico-German intersection, the number of respondents who took part in the survey were 205 people participated. Of which 65 were bus drivers and 43 were traffic police officers. The other 97 were pedestrians and commuters along the dedicated road and bus stops.

### 4.1 Demographic profile and response rate of respondents

#### 4.1.1 Demographic Profile

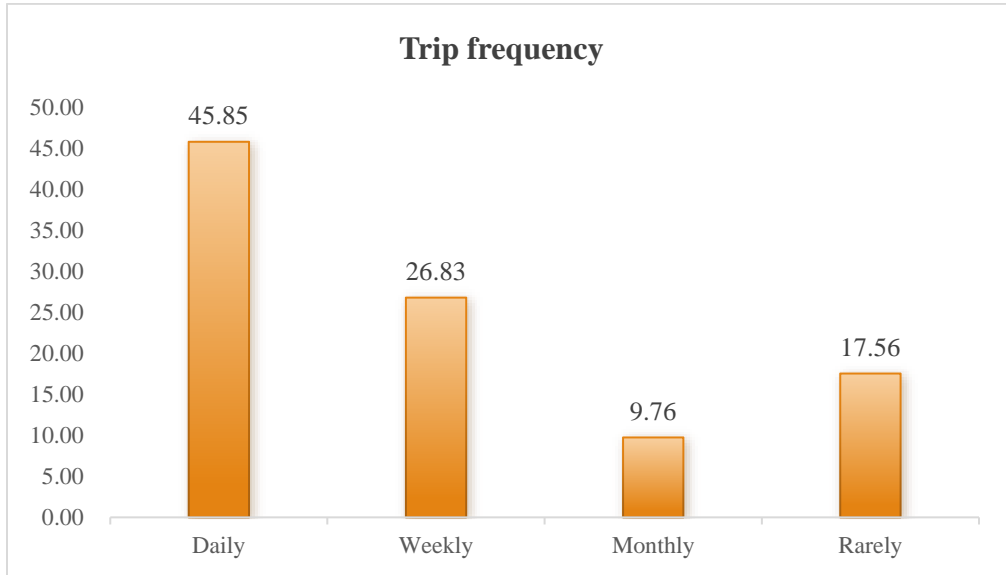
One of the variables used to discuss the demographic characteristics of the respondents is gender. As presented in table 7 among the respondents 68% were males whereas females comprise only 32%. There was more male respondent in the study than female because of most of the female respondent were inconvenient at the time of data gathering. The male respondents were found more active in this study.

*Table 4.1: Respondent Gender*

Gender	Bus drivers	Traffic offers and managers	Road users	Total	Total percent age
Female	17	9	40	66	32%
Male	48	34	57	139	68%
total	65	43	97	205	100%

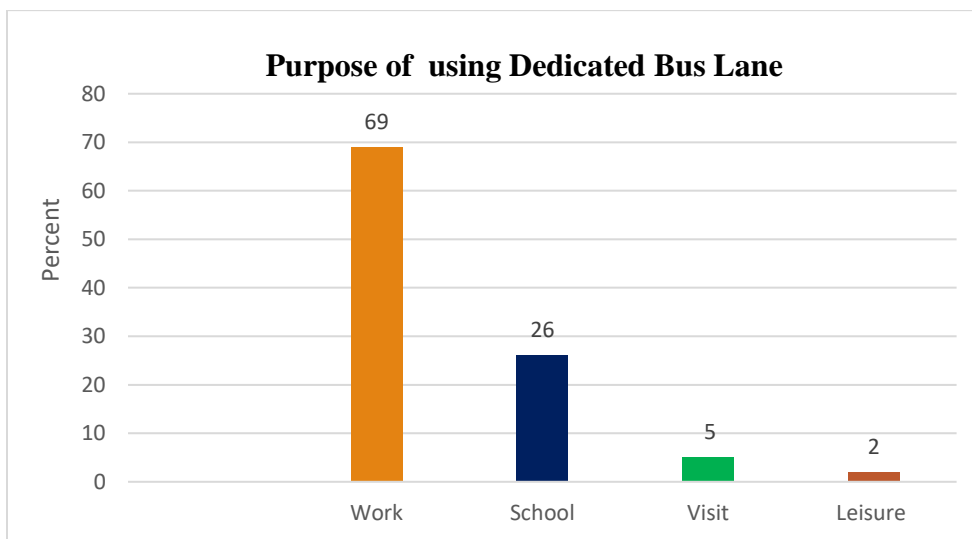
## Trip

Respondents' trip purpose and trip frequency are described on the table below



**Figure 4.1: Trip Frequency**

46% of the respondents indicated that they use the dedicated bus lane on a daily basis, while the 27% on weekly basis. this indicates that the bus lane is serving a high demand corridor and successful adoption by regular commuters which aligns with goals of reducing congestion. other 10% on a monthly basis and 17% rarely uses the lane.

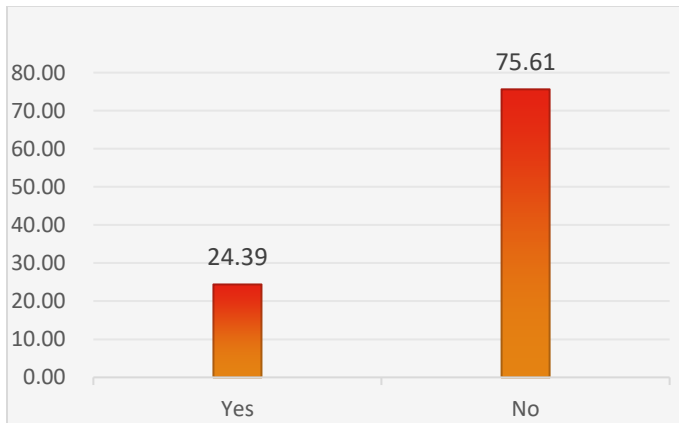


**Figure 4.2: purpose of using Dedicated Bus Lane**

69% of the respondents shown that they use the dedicated bus lane for work, while the other 26% for school, 2% of leisure and 5% for visiting. Since a significant percentage of users commute for work and school, this underscores the critical role the bus lane plays in promoting both economic activity and educational access. In these situations, the bus priority scheme's reliability and effectiveness can have a direct impact on productivity, punctuality, and general quality of life. Ineffectiveness or delays in this route could have.

#### **4.2 The condition of infrastructural elements of Bus Priority Systems (BPS) in the study area.**

##### **Road infrastructure condition**



***Figure 4.3: Road infrastructure (Road pavement)***

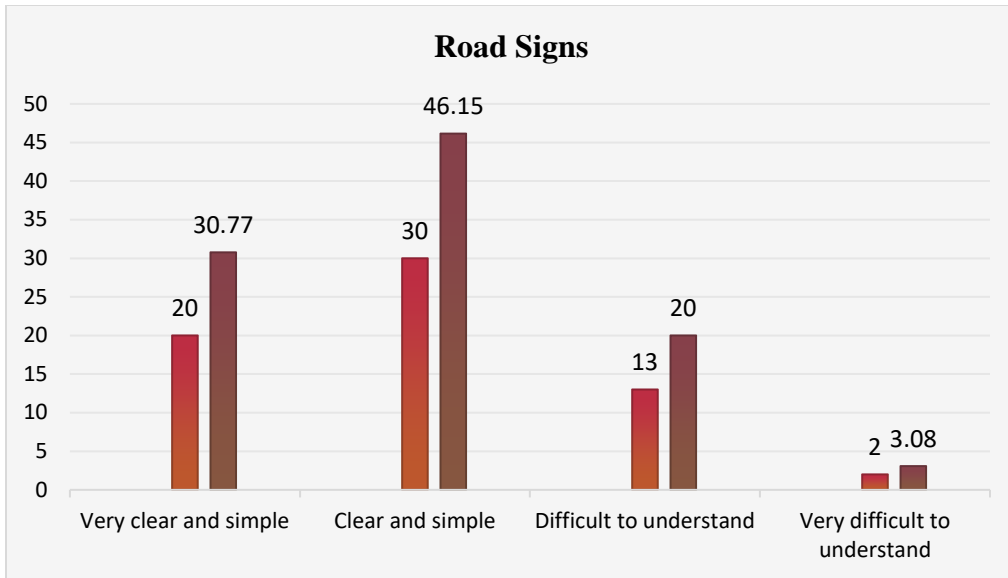
The implementation of bus priority system can have a significant impact on the road infrastructure condition, particularly the road pavement. 76% responded that bus priority system didn't affect the road condition while 24% respond that it affected the road conditions to which they explain the lane was narrow.

Passengers respond to the implementation of BPS compared to the other roads without bus priority lanes	Frequency	Percent
Good	20	30.77
Very good	19	29.23
Excellent	12	18.46
Bad	10	15.38
Very bad	4	6.15
Total	65	100

As the passengers are the direct beneficiaries of the service. Their feedback can be a reliable source to conclude whether the service is effective or not. As it's indicated by the survey 31% of the passengers rated the service has “good” ,29% as “very good” and 18% Excellent while 15% rated the service bad and 6% very bad.



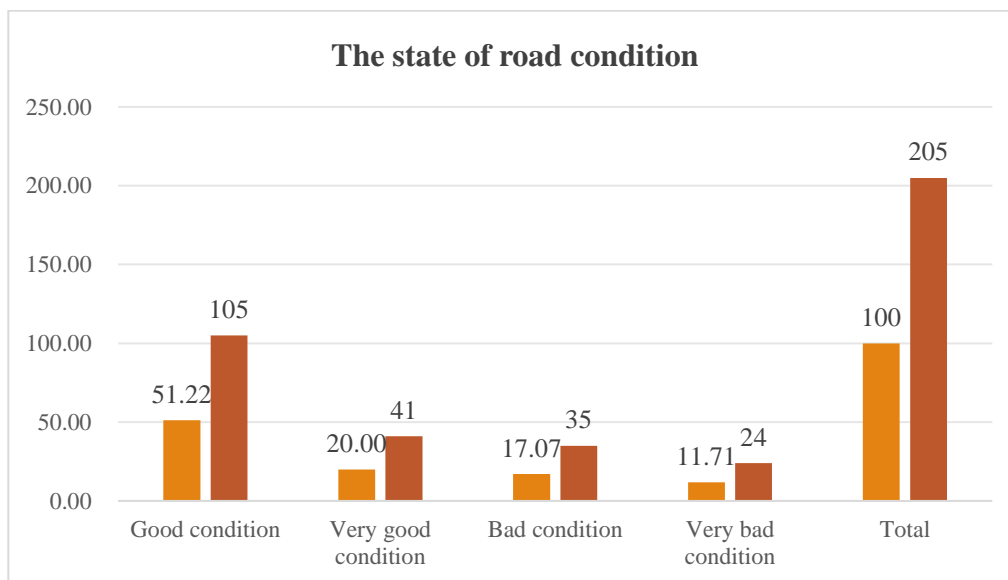
**Figure 4.4: Users satisfaction**



**Figure 4.5: Road Sign and Signals**

31% responded to “very clear and simple”, 46% to “clear and simple”, 20% responded to “difficult understand” and 3% responded to “very difficult “to which they explain the signs becomes old they request a renewal.

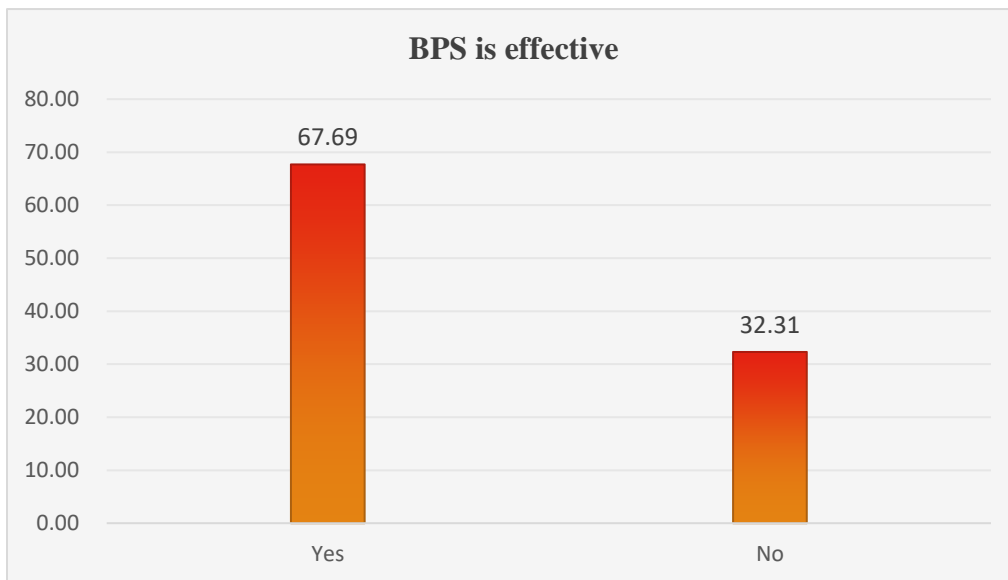
Has the implementation of the bus priority system affected the condition of the road infrastructure, such as the need for more frequent repairs or maintenance?



**Figure 4.6: The state of road condition (the need for more frequent repairs or maintenance)**

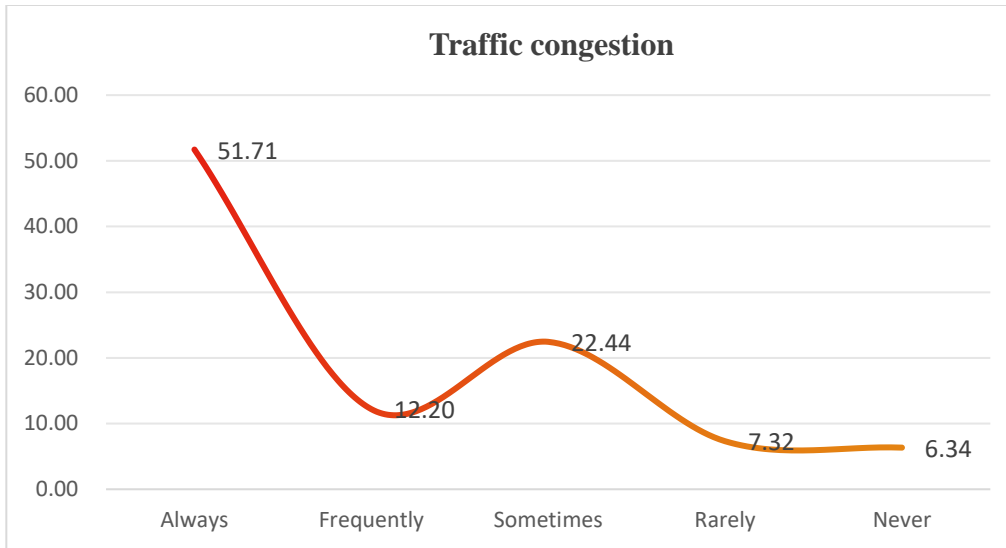
51% of the responded the road in good condition, 20% very good condition,17% bad condition and 12% very bad condition. One of the reasons given by 29% of respondents for the poor road condition in this corridor is the issue of poor pavement quality. Some bus operators have stated that they are compelled to slow down in damaged areas of the road, which causes discomfort for passengers. This is in line with the literature review's emphasis that better pavement guarantees better service. There was a close split on the comments on the state of road conditions though it's evident from the observation that it needs some maintenance.

**4.2 The effectiveness of the BPS in improving public transport efficiency (travel time reduction, reliability).**



***Figure 4.7: Effectiveness of BPS***

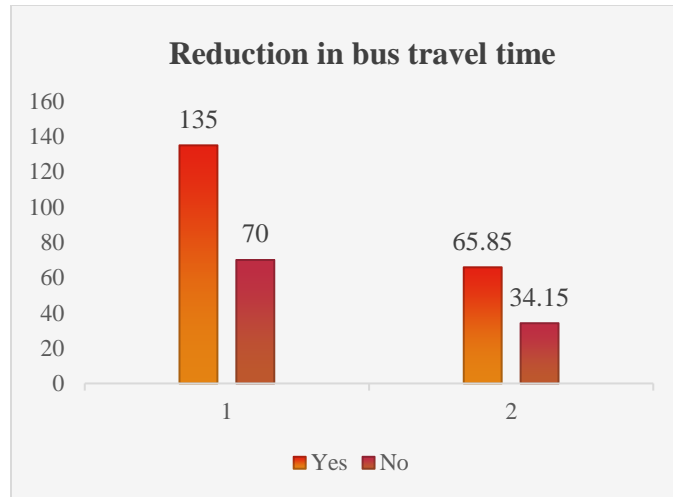
It's undeniable that the spatial bus priority lane has been very effective in reducing the congestion to which 68% of the respondents also agree, 32% disagree.



**Figure 4.8: Traffic Congestion during rush hours**

Though the service was implemented in 2018. There have been some recurring challenges. Of which congestion is a significant regardless of the fact the service was intended to tackle the very problem. Based on the survey taken 12% of the respondents indicated a frequent congestion, which the other 52% indicated occasional congestion especially during rush hours when people are leaving for work or school in the morning and returning in the evening, 23% indicated the congestion occurred sometimes, 7% indicated rarely congestion and 6% respond they never had congestion.

Have you noticed any changes in bus travel times after the implementation of DBL?	Frequency	Percent
Yes	135	65.85
No	70	34.15
Total	205	100.00



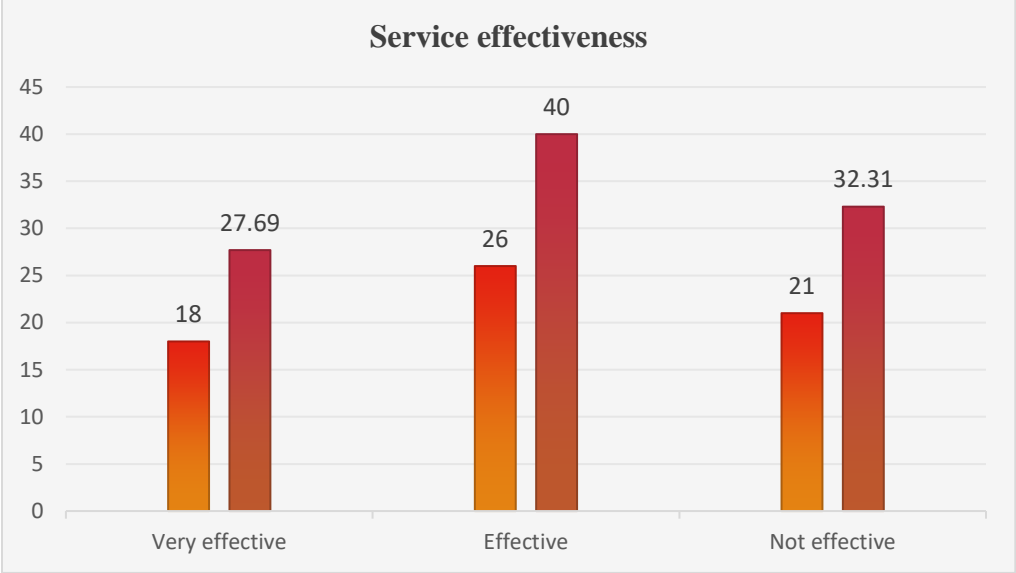
**Figure 4.9: Reduction in bus travel time**

Based on the observation made by the respondents 66% the dedicated spatial lane service has immensely brought about an undeniable change on travel time and efficiency while 34% remain the same.

However, it is also important to acknowledge that 34% of respondents did not observe any change in their travel time. This signals that the benefits of the system may not be uniformly experienced across all users or trips. Several factors could explain this, including interruptions in the continuity of the bus lane, poor enforcement leading to private vehicle encroachment, or persistent congestion at intersections and bus stops where priority is not maintained. It’s also possible that for some routes or times of day, the benefits of the bus priority system are diminished due to overlapping infrastructural or operational constraints.

Does BPS make your traveling easier and safer?	Frequency	Percent
Yes	42	64.62
No	23	35.38
Total	65	100

Based on the survey it says evident according to the respondents 65% of them have indicated that it has made driving safer and easier 35% says it's not due to the intervention of other vehicles on the lane.



**Figure 4.10: BPS service effectiveness**

	Frequency	Percent
Very effective	18	27.69
Effective	26	40
Not effective	21	32.31
Total	65	100

Compared to the time prior to when the dedicated bus lane. There used to be frequent congestion and a lot of accidents during the rush hours. This has resulted in disrupted and prolonged travel times for passengers. Which used to negatively affect their daily schedule for school or work. After it has been implemented 28% of the respondent indicated that the dedicated bus lane has been “very effective”. While on the other hand 40% of the respondent stated that the service has been “effective” while 32% responded to “not effective”.

Do you think bus priority system has improved safety for all road users?	Percent	Frequency
Yes	56.92	37
No	43.08	28
	100	65

Prior to the implementation of the dedicated bus lane along the road there used to be frequent congestion which led to a lot of accidents. Since the buses did not have a reserved lane for them. They were not an exception to the vehicles that got into accidents. According to the respondents 57% of them agreed on the approved road safety 43% disagreed.

Do you think bus priority System encourage more people to use public transportation?	Frequency	percent
Agree	50.73	104
Strongly agree	33.17	68
Disagree	9.76	20
Strongly disagree	6.34	13
Total	100.00	205

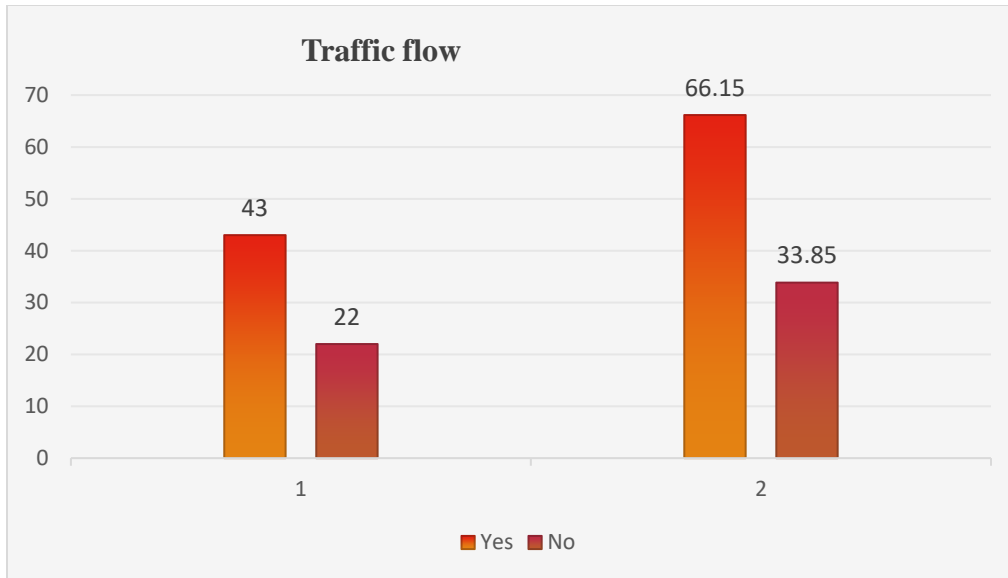
The city bus being the most affordable mode of transport for the majority of population. It's very advisable that more people use it provided that the challenges that interfered with its efficiency are being tackled. For this matter majority of the respondents agreed that more people should be encouraged to use the bus.51% agree,33% strongly agree,10% disagree and 6% strongly disagree

Any change in road infrastructure that may impact bus travel	Frequency	Percent
No	115	56.10
Yes	90	43.90
Total	205	100

56% responded it didn't make changes to road infrastructure as the dedicated bus lane service was intended to deal with the transportation problem of a city that is continuing to accommodate an ever-increasing population. 44 % responded there's, the plan is being obstructed by numerous factors like willful breaking of traffic rules from private vehicles who are equally racing against time in frequently congested roads.

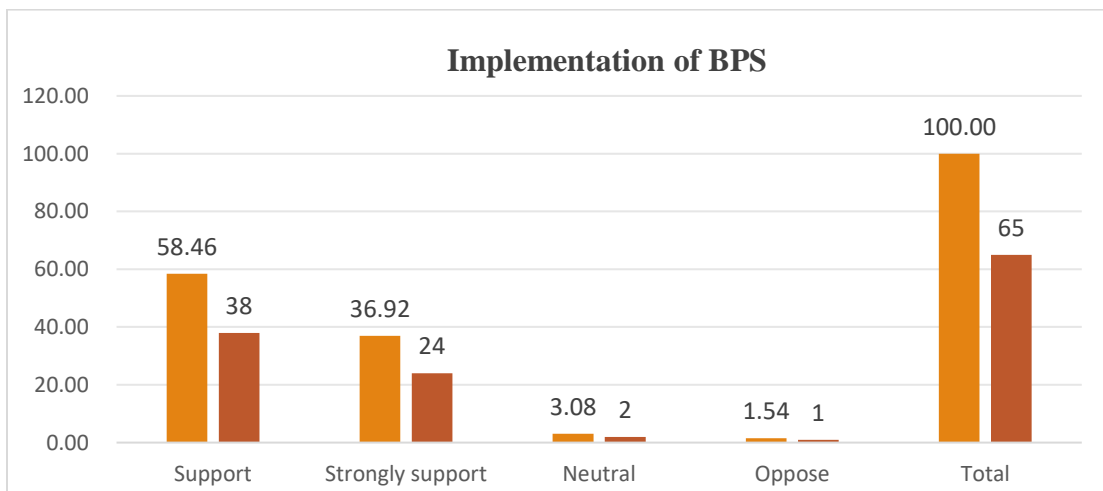
Have you experienced any negative impact on road	Frequency	Percent
Yes	30.24	62
No	69.76	143
	100.00	205

Though there are still some challenges that need to be tackled in order to reach a more satisfying efficient service. The majority of the commuters 70% shown very little dissatisfaction or have never encountered any negative experience while 30% encountered.



**Figure 4.11: Traffic Flow**

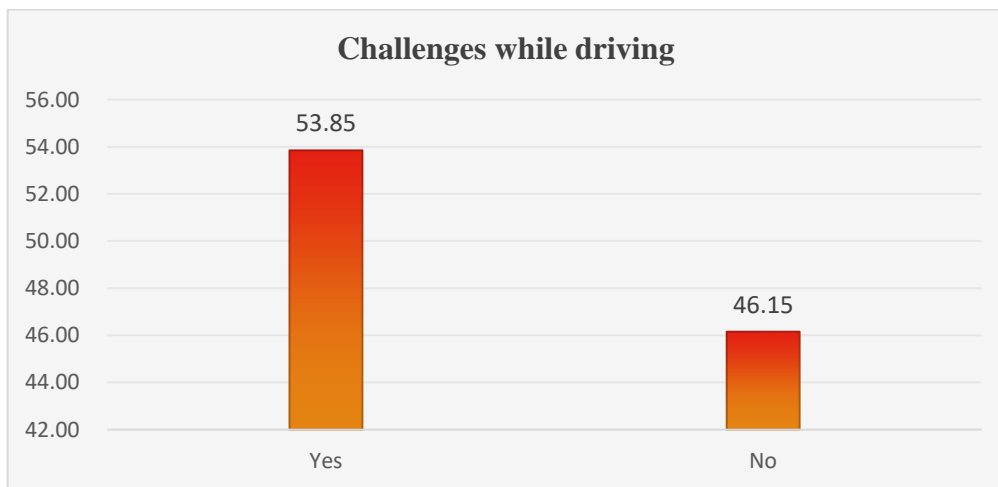
Compared to the prior time when the dedicated bus lane was implemented along the Mexico-German Adebabay Road. There used to be a lot of unregulated traffic flow due to large number of vehicles and unruly drivers. This resulted in a lot of traffic congestion and frequent accidents. However, after its implementation the dedicated spatial bus lane has positively affected the traffic flow of the road. And according to the survey 66% of your time have seen a positive impact on the traffic flow. While 34% of them have not.



**Figure 4.12: implementation of bus priority system**

In a city whose per-existed infrastructures are overcrowded by the influx of people. It is very evident dedicated bus lane is one the best ways to tackle the public transportation problem across the city. Which 58% of the respondents support its implementation,37% strongly support 5% opposed.

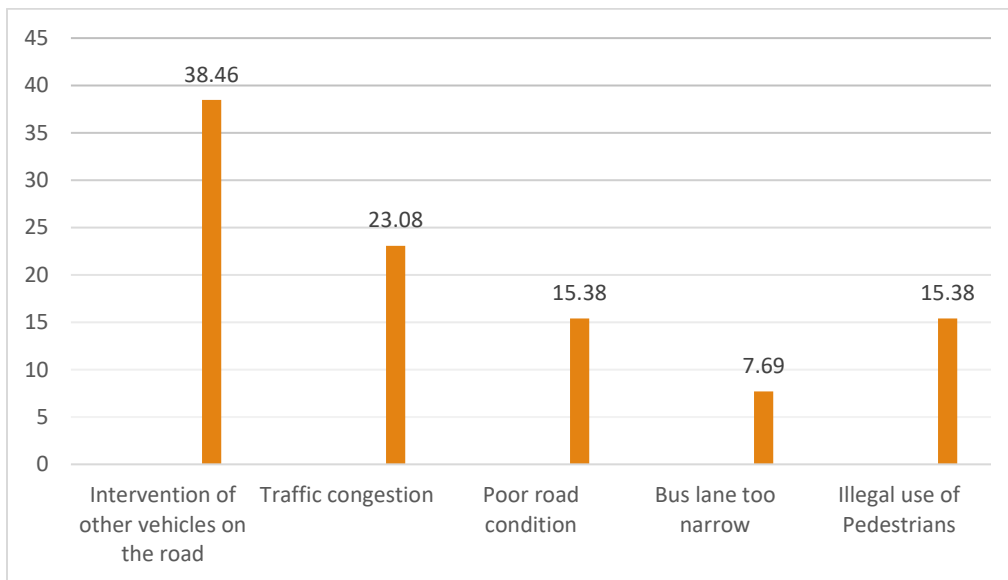
Have you encountered any challenges on the road while driving through the bus priority system?	Percent	Frequency
Yes	53.85	35
No	46.15	30
Total	100.00	65



**Figure 4.13: Challenges while driving on the lane**

54% responded to challenges while 46% didn't encounter challenges. As much as there are a lot of things that need to pragmatically dealt with. Compared to the roads where the dedicated spatial bus lane service has not implemented yet the drivers could not name a lot of concerning challenges other increased regulations and recurring breaking of traffic regulations from private vehicles.

What are Challenges of SBPS	Percent	Frequency
Intervention of other vehicles on the road	38.46	25
Traffic congestion	23.08	15
Poor road condition	15.38	10
Bus lane too narrow	7.69	5
Illegal use of Pedestrians	15.38	10
Total	100	65



**Figure 4.14: Challenges of BPS**

38% put the intervention of other vehicles as first challenge which leads to congestion.23% responded to traffic congestion,15% responded to poor road condition,8% responded to narrow road and 15% responded to the illegal use of pedestrians.

Have you ever been involved in an accident in this road?	Frequency	Percent
Yes	12	18.46
No	53	81.54
	65	100

Though there is frequent interference of private vehicles in the gaps where there are traffic regulators. Thus, according to the respondents about 18% did involve in an accident while 82% of them did not.

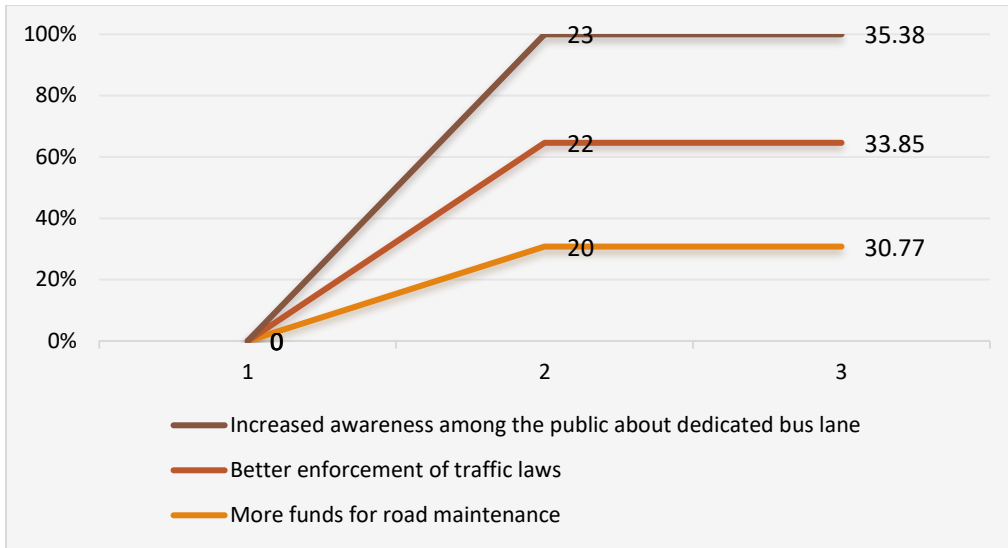
Would you recommend the implementation of similar BPS in other areas	Frequency	Percent
Agree	37	56.92
Strongly agree	20	30.77
Disagree	6	9.23
Strongly disagree	2	3.08
Total	65	100

As the city is becoming more and more populated than ever before. The city public transport system is still struggling to address its overcrowded infrastructures to accommodate the majority of its population. Hence, 57% of the respondents agree, 31% strongly agreed on recommending the dedicated spatial bus lane on other areas across the city to tackle the public transportation problem while 9% disagree, 3% strongly disagree by mentioning that the challenge on the existing BPS have to resolved first.

Did BPS made your bus driving effective	Frequency	Percent
Yes	45	69.23
No	20	30.77
Total	65	100.00

Before the dedicated bus lane was implemented the road was usually congested with unruly vehicles especially during the peak of rush-hours. It's very obvious that the dedicated bus lane as made driving more effective. Which is indicated by 69% of respondents and 31% didn't agree.

What do you think is the most essential thing that can be done to improve the quality of the bus only roads in this area?	Frequency	Percent
More funds for road maintenance	20	30.77
Better enforcement of traffic laws	22	33.85
Increased awareness among the public about dedicated bus lane	23	35.38
Total	65	100



**Figure 4.15: how to improve the observed challenges of BPS**

35% responded to “Increased awareness among the public about dedicated bus lane” 34% responded to “Better enforcement of traffic laws” and 31% responded to “more funds for road maintenance”

### **4.3. The key challenges affecting the Bus Priority System along the specified corridor (Mexico to the German roundabout, Addis Ababa).**

A list of challenges is observed in this bus lane area and these problems are supported with photographs.

#### **4.2.1. Infrastructure Challenges**

##### **Deteriorated Infrastructures**

The dedicated bus lane was introduced to Addis Ababa in 2018, which implies that it's that long the infrastructures have been in use with very little maintenance. The traffic signs are the most visible deterioration. The signs have faded and it's used as an excuse by the drivers who are intentionally abiding by the rules. The other infrastructure that's deteriorated is the sewage system that are blocked.

It makes it very hard for the buses to park at the stations, on the other hand the spaces reserved for bus station shades it's being used by public taxis. They're using it as stop station which makes it very hard for buses to efficiently carry out their daily tasks.

##### **Poor lane markings**

While 77% perceived the road as "good" or "very good" on site observations revealed Potholed roads, insufficient signage and markings, and disintegrating pavements this challenge have been also observed and mentioned by 54% of the bus drivers. not only make for an uncomfortable ride driving on them is costly since they slow down goods movement and play an important part in accidents. Allowing infrastructure assets to deteriorate to the point where maintenance costs increase is the first step towards maintaining acceptable road quality.

Red colored paint should be applied to emphasize the lane and to deter drivers from using it. Red paint has higher installation and maintenance costs, but has been shown to deter both unauthorized driving and parking in the bus lane. (NACTO,2013)

In this area from Mexico to German roundabout maintaining pavements, signage, and road markings on existing roads is required. Furthermore, by investing in novel paving materials, long-term road quality can be improved. Another way to improve road quality is to reduce damage.



***Figure 4.16: Poor lane Marking***

As shown in the picture, the red paint is less effective as a roadway management element and exhibits little signs of chipping or fading.

There are three methods for dealing with adverse road conditions introduced by

(Mohammed Buhatti 2020) First, by investing in and maintaining road infrastructure such as pavements, signage, markings, bridges, and tunnels on a regular basis. Second, by improving city design to reduce congestion and increase traffic flow. Third, by encouraging and motivating other modes of transportation such as walking, biking, and taking public transportation

Paving the roads with colors tell pedestrians and other motorists to pay attention. This contributes to the enforcement of vehicle restrictions in exclusive bus lanes and lower travel times. They also increase visibility of the bus, which not only acts as a promotion and identity tool, but also

increases safety. Audible cues can be added as well through the use of raised lane delineators, rumble strips, or different paving materials.

Placement of the signage is important consideration. Typically, most traffic signage is placed in the ground along the curb edge. Parked vehicles and traffic in general may make it difficult for drivers to see this signage. Adding signage over the lane will increase visibility of the signage in addition to clearly marking which lane the restriction applies. The use of lane markings, different lane striping, or even lane color will increase visibility of not only the restriction but also the bus service.

It's important to consider that the use of lane markings, striping or colors will also increase maintenance costs. These costs will need to be balanced against the benefits of greater visibility.



*Figure 4.17: Dedicated Bus Lane marked with red mark (Addis Ababa public transport 2013)*



*Figure 4.18: Potholes on the road, damaged road surface on the bus lane*



*Figure 4.19: Damaged bus stop shelter*

Lack of cleanliness of bus stops areas attributed to the public's demeaning perception of the system.



***Figure 4.20: Lack of cleanliness of bus stops***

15% of the respondents has put the illegal use of pedestrians as one of the challenges of BPS and this is also observed from the site, pedestrians standing on the bus lane is a serious problem that can have dangerous consequences. It can be dangerous for both pedestrians and drivers, and it can also cause traffic congestion.

### **4.2.3. Lack of Regulation**

When the dedicated bus lane was implemented in the corridor. It was such a new experience for the drivers other than the vehicles that it was dedicated for. Many drivers had to be aware of the importance of the prioritization. But still many drivers outside the buses find very hard to selflessly refrain from illegally use the lane. There are incidents where they get in the ways of buses. This has led to few accidents on the buses. To tackle this the administration deployed traffic regulators to enforce the rules. This had brought about a change. But it's only effective during the morning hours and the evening hours. But they remained an obstacle when during the noon and afternoon hours where the traffic regulators are not around. And in some instances, they would use opportunity in the spaces where there are no regulators at any hour.

### **4.2.4. Intervention of other vehicles in the Bus lane**

These behaviors highlight severe weaknesses in compliance and enforcement, as minimal police presence and a lack of automatic enforcement (e.g., cameras) have normalized illegal use of bus lanes.

38% reported that Intervention of other vehicles on the bus lane is one of the challenges,72% of bus drivers frequently encounter private cars on bus lanes. Illegal parking in bus lanes also forces buses to merge back into mixed traffic causes delay and make it difficult for them to get to their destination on time since there's no traffic light priority for buses. This is the most challenge for those who rely on public transportation to get to work and school.

Bus lanes can operate as restricted lanes round the day or at certain times of the day only, usually during rush hours, allowing all vehicles to use the lane at other times (Robert Ziolkowski, 2015)

During peak hours, the mixing of different vehicles on the bus lane causes too much congestion, air pollution which has effects on the environment. This also causes low speeds of public transport.



*Figure 4.21: Bus driver evading the rule by leaving their lane*

#### 4.2.5. Parking the private cars in the bus lane

Unlawful parking, which makes buses veer into congested traffic lanes and out of designated bus lanes. If bus lanes are to work effectively in this area, other vehicles must be prevented from driving or often a more serious obstruction parking in them. The problem is particularly acute where a bus lane operates part time, which precludes full separation from the rest of the carriageway. The traffic police and other enforcement authorities have insufficient resources constantly to patrol bus lanes, which thus need as far as possible to be self-enforcing. Self-enforcement works best when other traffic will not unintentionally tend to stray into the bus lane. Implementing enforcement measures to guarantee that other cars do not hinder buses is a crucial component of any bus priority program.



*Figure 4.22: Parking the private cars on the bus lane*

#### **4.2.6. Ineffective Campaign and Public Awareness**

As a way to implement the dedicated bus lane the responsible bodies launched a campaign to create awareness to the public. There were flyers and posters posted, TV and radio commercials aired to create an awareness. These two actually have brought some significant change but not very effective. Those who still break the rules cannot blame it on the lack of awareness. This is where the punishment gets into the picture to prevent willful breaking of the rules and selfish intentions.

As 35% responded on how to improve the challenges is to “Increased awareness among the public about dedicated bus lane” 34% responded to “Better enforcement of traffic laws” and 31% responded to “more funds for road maintenance”.

### **4.3. Discussion**

The findings echo global experiences that bus priority system can yield significant benefits but require continuous enforcement, infrastructure upgrades, and public buy-in (Wright & Hook, 2007).

The main finding of this study has been summarized as follows, the implementation of bus priority systems and their challenges from Mexico roundabout to German roundabout has immensely brought some changes to travel time but this two years it has facing many challenges where if not solving in time the bus priority will be ineffective.

A key root cause is the fragmented coordination between institutions responsible for road transport planning, implementation and enforcement. Authorities often operate in division, leading to gaps between infrastructure provision and traffic management. Inadequate and outdated road infrastructure further complicates implementation as many roads are too narrow or poorly maintained to accommodate dedicated bus lanes without affecting general traffic flow. Weak enforcement of existing regulations such as illegal parking and unauthorized use of bus lanes undermines the effectiveness of the schemes, reflecting limited institutional capacity and a lack of public compliance. Additionally, poor integration with land use planning and other transport modes leads to inefficiencies and limits accessibility. The absence of real-time traffic management tools, such as transit signal priority systems, and the limited engagement of stakeholders in the planning process further hinder the success of BPS. These underlying issues highlight the need for a holistic and coordinated approach to improve the sustainability and effectiveness of bus transport in Addis Ababa.

#### **4.3.1. The condition of infrastructural elements of Bus Priority Systems (BPS) in the study area.**

The bus priority elements along the corridor between Mexico to German roundabout reflect deliberate design considerations aimed at improving public transportation efficiency. According to one of the road planners involved, the bus lane in this corridor is 3 meters wide, which is generally sufficient to ensure the safe operation of buses.

The bus lane is strategically positioned both at the middle and along the curbside of the road, allowing flexibility in integration with existing traffic flow patterns.

Bus stops along the corridor are reported to be well-equipped after the implementation of the new corridor development, offering ample space for boarding and alighting. These stops include essential features such as shelters, seating areas, and information boards, enhancing the overall user experience.

However, the integration of bus priority measures at intersections and traffic signals remains underdeveloped. Currently, traffic signals do not offer priority to buses, and intersections have not been adapted to facilitate improved bus movement which emerged as a significant gap in the system, as established in the literature, Transit signal priority (TSP) is an operational strategy that facilitates in service transit vehicles passing through signalized intersections.( Li et al.,2011)

It can reduce transit delay at intersections and improve its on time performance or schedule adherence, roughly 52% reported occasional or frequent congestion during rush hours if traffic signals prioritized buses the congestion will be reduced during rush hours in this corridor.

Regarding road infrastructure, pavement conditions are generally favorable, with 77% of respondents indicating that the roads are in good condition. However, 23% noted that some sections still require repairs and maintenance. This suggests that while the implementation of the bus priority system has positively influenced road conditions, there remains room for improvement in terms of infrastructure upkeep and the full integration of traffic management features.

#### **4.3.2. The effectiveness of the BPS in improving public transport efficiency (travel time reduction, reliability).**

The implementation of the Bus Priority System along the Mexico–German Roundabout corridor has shown measurable improvements in public transport efficiency, particularly in reducing travel time 66% and enhancing service reliability 68%. By allocating dedicated lanes for buses and minimizing interference from mixed traffic, the bus priority system has significantly decreased bus delays at intersections and congestion-prone segments. Observations and data collected from before and after implementation indicate a reduction in average travel time, especially during peak hours. Additionally, the consistency in arrival times has improved, reducing headway variability and enhancing the overall reliability of service. Despite these benefits, full effectiveness is sometimes constrained by the lack of comprehensive signal priority systems and inconsistent enforcement, highlighting the need for further improvements in supporting infrastructure and traffic management.

The combination of high private car usage and an underdeveloped traffic management system has a direct impact on the performance of the BPS. Without strict enforcement or physical separation of lanes, private cars frequently encroach on bus lanes, leading to delays and reduced travel time benefits for bus users. Moreover, the lack of supporting infrastructure such as traffic signal priority for buses limits the overall impact of the scheme. In contrast, the sizable number of public transport users suggests a strong potential benefit from an efficient BPS, which could offer shorter travel times, reduced congestion, and improved service reliability.

The positive sentiment 84% expressed by the majority of respondents who believe that the bus priority system encourages more people to use public transport is a strong indicator of its potential to influence travel behavior and promote a shift from private to public transportation. This reflects increased public confidence in the reliability and efficiency of the bus service, which is essential for making public transit a more attractive option.

Such feedback has important implications for sustainable urban mobility in Addis Ababa. If more people are willing to switch to buses due to improved service quality and reduced travel time, this could lead to a decrease in the number of private vehicles on the road, thereby easing traffic congestion and reducing emissions.

### 4.3.3 The key challenges affecting the Bus Priority System along the specified corridor (Mexico to the German roundabout, Addis Ababa).

By personally observing the implemented bus priority lanes, the traffic committee and bus drivers identified the main challenges listed in the table.

These challenges are Engineering, Lack of awareness and Lack of law enforcement some of this problem arise from other vehicles parking in the bus lane and others from entering the road.

**Table 4.2: The observed implementation challenges**

Challenges	Engineering	Lack of Awareness	Lack of law enforcement	Who's responsible for solution
Potholes on the road/pavement issue	➤			Addis Ababa road authority
Parking the private cars in the bus lane		➤	➤	Traffic management authorities
Throwing trashes on the road and bus gate			➤	Addis Ababa public transport authority
Intervention of other vehicles at the wrong time		➤	➤	Addis Ababa traffic management and Addis Ababa Public transport authority
There's no traffic sign priority provided for bus priority	➤			Addis Ababa Road Authority

Poor Drainage system	➤			Addis Ababa Road Authority
Poor lane marking	➤			Addis Ababa Road Authority

## **Chapter 5: Conclusion and Recommendations**

### **5.1. Conclusion**

The assessment of the effectiveness of bus priority systems and their challenges has demonstrated its effectiveness in improving urban mobility by prioritizing public transportation making it more attractive option for commuters and by also reducing travel time and increasing reliability for buses. However, the study identified challenges such as enforcement issues, issues on road infrastructure and lack of awareness. Addressing these challenges through targeted policy interventions from the sectors, traffic management systems, road infrastructure sectors and public transport services. These efforts will contribute to effective and efficient bus priority systems.

The result shows that the spatial bus priority have brought changes in bus travel time in 66% with better condition of infrastructural which encourage many people to use public bus transport 51% the road requires stronger pavement structure for buses to have comfort and safe ride.

The data was used by different agencies that involves in this work Addis Ababa transport agency, traffic agency and city bus enterprises, observations and literature reviews.

Depending on the traffic conditions and the type of buses operating, the standard width of bus lane typically ranges from 3.0 to 3.5 m (10 to 12 feet) in this corridor wider lane are preferable for buses to operate in higher speed because narrower lanes are feasible in congested urban areas.

The new corridor development provides advantages to the existing road infrastructure since it has made it possible to accommodate pedestrians and cycling, which frees up space for the bus lane, which is constantly crowded.

## **5.2. Recommendations**

Based on the findings of this study on the assessment of the effectiveness of bus priority system and their challenges from Mexico to German roundabout in Addis Ababa, several focused recommendations are proposed to address the observed infrastructural, institutional, and behavioral challenges. These suggestions aim to enhance the performance and sustainability of the dedicated bus lanes.

### **Road Infrastructure Enhancement**

- **Improve Lane Design and Visibility:** Maintain and repaint the bus lane using high-visibility red pavement markings. Repair potholes, ensure proper drainage systems, expanding roads to accommodate rising traffic volumes and clearly mark bus stops.
- **Upgrade Bus Stops:** Improve shelter and security at bus stops to protect passengers and discourage misuse by private vehicles.
- **Integrate with Multimodal Infrastructure:** Align future corridor developments with multimodal strategies that incorporate pedestrian and cycling pathways alongside bus lanes.
- **Implement smart traffic signals** that offers priority for buses

### **Institutional Integration and Coordination**

- **Cross-Sector Collaboration:** Strengthen coordination between AACRA, the Public Bus Authority, Land Development Bureau, and Traffic Police for integrated planning and management.
- **Integrated Transport Infrastructure Planning:** Ensure future road designs include provisions for terminals, loading points, and parking to support effective transit operations.

### **Public Awareness and Engagement**

- **Outreach Campaigns:** Launch targeted public awareness programs through social media, radio, and local outreach to inform citizens about the benefits and regulations of bus priority schemes.
- **Penalties & Monitoring:** Systems such as camera surveillance or automated number plate recognition can deter unauthorized usage. Part-time policing is insufficient for continuous

compliance.

- Stakeholder Involvement: Engage the public and transport operators early in planning processes to improve buy-in and acceptance.

### **Law Enforcement and Monitoring**

- Strengthen Enforcement Mechanisms: Use surveillance tools such as CCTV, bus-mounted cameras, and ANPR systems to detect and deter violations.
- Promote Self-Enforcing Design: Ensure physical features (e.g., colored pavement, clear signage) help deter unauthorized access without constant police presence.

### **Scaling**

- Expand Strategically: Based on the lessons learned from the Mexico-German corridor, replicate bus priority lanes in similarly congested routes using adaptable and context sensitive strategies.

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## **Appendix 1**

### **POST GRADUATE RESEARCH PROJECT (MA THESIS)**

#### **Department of Infrastructure Technology and Management**

**Survey Questionnaire** on the Assessment of the effectiveness of bus priority systems and their challenges: case of Mexico to German roundabout, Addis Ababa.

**Dear respondents,**

First and foremost, I would like to express my deepest thanks and appreciation for your time and honest cooperation to fill this questionnaire. The questionnaire is prepared to conduct a post graduate research project (MA thesis) entitled “**Assessment of the effectiveness of bus priority systems and their challenges: case of Mexico to German roundabout, Addis Ababa**”. This survey takes approximately 15 to 25 minutes to complete. The result and success of this study will highly depend on the quality of your response and I hope you will give accurate and honest responses to the items presented. Your response will be kept confidential and used only for this academic purpose.

#### **Directions:**

- You are not required to write your name.
- Circle the letter of your choice or fill the blank spaces for the following questions. You may respond more than one answer if it is necessary.

**Thank you in advance for your cooperation!**

➤ Sex

A. Male

B. Female

➤ Occupation

A. Student

B. Employee

C. Unemployment

D. Other (specify

➤ How often do you use the roads dedicated for buses only?

A. Daily

B. Weekly

C. Monthly

D. Less than once a month

➤ How satisfied are you with the state of the bus lanes in this area?

A. Very satisfied

B. Satisfied

C. Neither satisfied nor dissatisfied

D. Dissatisfied

E. Very dissatisfied

➤ What are the most major bus priority issues you have in your area when commuting by bus?

A. Cracks

B. The holes

C. Uneven surfaces

D. Traffic congestion

E. Other (please specify)

- How has the condition of the bus lane in this area altered since bus priority was implemented?
  - A. It has gotten better
  - B. It has remained unchanged
  - C. It has gotten worse
  
- What do you think is the most essential thing that can be done to improve the quality of the bus-only roads in this area?
  - A. More funds for road maintenance
  - B. Better enforcement of traffic laws
  - C. Increased awareness among the public about road safety
  - D. Other (please describe)
  
  
  
  
  
  
  
  
  
  
- How frequently do you see road signs and signals in this neighborhood?
  - A. Always
  - B. Most of the time
  - C. Occasionally
  - D. Infrequently
  - E. Never
  
  
  
  
  
  
  
  
  
  
- How clear and simple are the road signs and signals in your area?
  - A. Very clear and simple
  - B. Clear and simple
  - C. Neither clear nor difficult to comprehend

D. Difficult to understand

E. Very difficult to understand

➤ How often do you use the bus as a mode of transportation?

A. Daily

B. Weekly

C. Monthly

D. Rarely

➤ What is the purpose of your bus travel (e.g., work, school, leisure)?

A. Work

B. School

C. Leisure

➤ Do you use the bus priority lanes in your daily commute?

A. Yes

B. No

➤ What is the road infrastructure condition look like?

A. Good

B. Very good

C. Bad

D. Very bad

➤ How frequently do you encounter traffic congestion during your bus commute?

A. Always

B. Frequently

C. Sometimes

D. Rarely

E. Never

- After the implementation of bus priority system in this area, have you noticed any changes in bus travel times or bus routes?
  - A. Yes
  - B. No
  
- Have you experienced any negative impact on your travel because of a bus priority system in this area?
  - A. Yes
  - B. No
  
- Do you think bus priority system would encourage more people to use public transportation?
  - A. Agree
  - B. Strongly agree
  - C. Disagree
  - D. Strongly disagree
  - E. Neutral

#### Road infrastructure survey

- Does the implementation of bus priority system affect the road condition, Such as road pavement?
  - A. Yes
  - B. No
  
- Have any changes been made to the infrastructure as a part of implementations of bus priority system such as installation of new bus lanes and changes to traffic signal timings?
  - A. Yes
  - B. No
  
- Are there any safety issues, such as higher chances of accidents or injuries, that are connected to the modifications made to the road infrastructure as part of the bus priority system?

A. Yes

B. No

- How has the implementation of the bus priority system affected the condition of the road infrastructure, such as the need for more frequent repairs or maintenance?

A. Good condition

B. Very good condition

C. Bad condition

D. Very bad condition

- Have you noticed any changes in road infrastructure that may impact bus travel in this area?

A. Yes

B. No

#### Bus drivers survey

- Do you support the implementation of bus priority system in this area?

A. Support

B. Strongly support

C. Neutral

D. Oppose

E. Strongly oppose

- Have you encountered any challenges on the road while driving through the bus priority lane?

A. Yes

B. No

- If yes, can you please mention the challenges?

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- How safe do you feel driving in this lane dedicated just for buses in this area?
  - A. Extremely safe
  - B. Safe
  - C. Neither safe nor unsafe
  - D. unsafe
  - E. Extremely unsafe
  
- Have you ever been involved in an accident in this road?
  - A. Yes
  - B. No
  
- Do you think bus priority system can be an effective in reducing congestion?
  - A. Yes
  - B. No
  
- Do you think bus priority system has improved safety for all road users?
  - A. Yes
  - B. No
  
- Would you recommend the implementation of similar bus priority lane in other areas?
  - A. Agree
  - B. Strongly agree
  - C. Neutral
  - D. Disagree
  - E. Strongly disagree

- Did bus priority make your bus driving effective?
  - A. Yes
  - B. No
  
- How did passengers responded to the implementation of bus priority system compared to the other roads without bus priority lanes?
  - A. Good
  - B. Very good
  - C. Excellent
  - D. Bad
  - E. Very bad
  
- How satisfied are you with the performance of bus priority system?
  - A. Satisfied
  - B. Very satisfied
  - C. Not satisfied
  
- Should the bus priority system be expanded in other areas in the city?
  - A. Yes
  - B. No
  
- Is there any intervention of other vehicles on the road?
  - A. Yes
  - B. No
  
- How is the safety of the road during driving?
  - A. Very good
  - B. Good
  - C. Bad

D. Very bad

➤ How effective do you find the bus service on the roads with bus priority systems?

A. Very effective

B. Effective

C. Not effective

➤ Do you think the implementation of bus priority system has affected the flow of traffic on the road?

A. Yes

B. No

## Appendix 2

### Interview Guide

Dear Sir/ Madam

My name is Nyamouch Simon. I am undertaking a study on the *Assessment of the effectiveness of bus priority systems and their challenges: case of Mexico to German roundabout, Addis Ababa*. I kindly request that you answer these simple questions honestly; the information you give is strictly for academic purposes and will be treated with maximum confidentiality.

Questions for the selected participants from Addis Ababa city bus enterprise, Addis Ababa Management and Traffic Police Agency and Addis Ababa City Road Authority.

The Interview questions listed below are guiding questions. There will be probing questions based on the answers that would be provided by the Interviewee to get more information associated with the study.

- ✓ These interview questions will be translated into Amharic. When the Researcher gets the permission of the interviewee the interview will be tape-recorded. Then the researcher will transcribe the interview and his field notes first in Amharic, then after will summaries /narrate the Amharic transcribed document into English.
- ✓ If the interviewee is not comfortable with tape-recording, the researcher will use his field notes to transcribe the interview.

1. What are your thoughts about bus priority system?
2. What are the challenges during the implementations of bus priority system?
3. Do you think the transport sector has become effective after implementing the bus priority system?
4. Does the implementation of bus priority system affect the road condition, such as road pavement, designs of the road?
5. What are the main infrastructure elements in this corridor?
6. Does congestion always fill the road?
7. Can you explain the key elements of implementing a bus priority scheme in urban road infrastructure?
8. What are the main challenges the users encountered with the road infrastructure?
9. What can be done to improve the challenges?
10. How do you measure the effectiveness of a bus priority scheme once implemented?
11. What are bus priority system major problems, and how could they be improved?
12. What role do government policies play in the implementation of bus priority system?
13. What is the future plan or proposal to make the system efficient?

### Appendix 3

New and Existing dedicated bus routes in Addis Ababa.

ተ.ቁ	የተመረጡ የስምሪት መስመር	የመስመሩ የተለያዩ ክፍፍሎች	በቀን አገልግሎት የሚሰጡ አማካይ አውቶቡስ ብዛት	ዕለታዊ የተሳፋሪ ብዛት	በመስመሩ ላይ የተደረገ ምልልስ	በአንድ አቅጣጫ ያለው የትራፊክ መስመር (Traffic Lane)	ምርመራ
1	1ኛ ደረጃ	ከሾላ ገበያ - መገናኛ	96	1,303,680	18,629	4	
		ከመገናኛ - ላምባረት	146	2,003,120	28,616	3	
		ከብሄራዊ - ሜክሲኮ	96	1,391,040	19,872	3	
		ሜክሲኮ - ሳር ቤት	102	1,085,280	15,504	3	የተሰራ
		ከኮከ ኮላ አደባባይ - ጦር ኃይሎች	86	993,300	14,190	3	በከፊል LRT
		ከ3 ቁጥር ማዘሪያ - ዘነበወርቅ	86	1,011,360	14,448		
2	2ኛ ደረጃ	ከዘነበ ወርቅ - አየርጤና	68	628,320	8,976		
		ከ5 ኪሎ - አንበሳ ግቢ (ፔፕሲ)	63	639,450	9,135	3	
		ከግቢ ጉባርኤል - አራት ኪሎ	64	667,520	9,536	4	
		ከብሄራዊ - ለገሃር	78	900,900	12,870	3	የተሰራ ነገር ግን የብዙሃን ትራንስፖርት የማይጠቀሙበት
		ከሳር ቤት - መካኒሳ	98	960,400	13,720	3	የተሰራ
		ከመገናኛ - መሪ /የተባበሩት/	84	846,720	12,096	4	LRT እና Tidal Flow ያለበት
		ሜክሲኮ - ልደታ	80	996,800	14,240		LRT ያለበት
		ጦርሀይሎች -3 ቁጥር ማዘሪያ	76	728,840	10,412	3	
3	3ኛ ደረጃ	ከፒያሳ - ሳንሱሲ	64	304,640	4,352	3	
		ከቀበና - ሾላ	68	514,080	7,344	4	

ተ.ቁ	የተመረጡ የስምሪት መስመር	የመስመሩ የተለያዩ ክፍሎች	በቀን አገልግሎት የሚሰጡ አማካይ አውቶብስ ብዛት	ዕለታዊ የተሳፋሪ ብዛት	በመስመሩ ላይ የተደረገ ምልልስ	በአንድ አቅጣጫ ያለው የትራፊክ መስመር (Traffic Lane)	ምርመራ
		ከላምብረት - ገደራ	86	493,640	7,052	3	ከላምብረት እስከ ካራ የተሰራ
		ካሳንቺስ - ፋልውሃ ብሄራዊ	61	538,020	7,886	3	
		ከፒያሳ - 4 ኪሎ	64	618,240	8,832	2	
		4 ኪሎ - 5 ኪሎ	57	530,670	7,581	3	
		ከፒያሳ - ጥቁር አንበሳ	47	322,290	4,747	3	የተሰራ
		ከአውቶብስ ተራ - አብነት	34	202,300	2,890	3	LRT ያለበት
		ከልደታ - ኮካ ማዞርያ	63	626,220	8,946	3	LRT ያለበት
		ከመካኒሳ - ጆሞ	72	443,520	6,336	3	በከፊል የተሰራ
		ስቴዲየም - ለገሃር	45	299,250	4,275	3	የተሰራ
		ከመሪ/የተባበሩት/ - አያት	60	436,800	6,240	4	LRT እና Tidal Flow ያለበት
4	4ኛ ደረጃ	አየር ጠ.ና -ካራ ቆሬ	32	127680	1824		
		አብነት -ጦር ሃይሎቸ	24	82320	1176	3	
		ፒያሳ-አዲሱ ገበያ	29	140070	2001		
		ፒያሳ-6 ኪሎ ምንይልክ	32	15680	2240		
		ከካርል አደባባይ- ብስራተ ገብርኤል	20	75600	1080		
		ከባሌ ድልድይ- ማሞ ድልድይ	20	58800	840		
		ከቄራ - ጎፋ-ገብርኤል	21	94080	1344		
		ከ 6 ኪሎ- ስፔን አምባሲ	30	96600	1380		
		ከግቢ ገብርኤል- በእስቲፋኖስ- ደንበል ጫፍ	20	61600	880		
		ከግቢ ገብርኤል - ካዛንቺስ	24	120960	1728		

Source: Addis Ababa City Bus Enterprise, 2020

## **Appendix 4**

### **Publishable Article**

**Assessment of the Effectiveness of Bus Priority Systems and Their Challenges: The Case of Mexico to German Roundabout, Addis Ababa.**