IMPACT OF ON-STREET PARKING ON URBAN MOBILITY IN AUTOBUS TERA, ADDIS ABABA

Alamraw Muchie Woreta

A thesis submitted to the department of architecture

School of civil engineering and architecture

Presented in partial fulfillment of the requirement for the Degree of Masters of Science in Urban planning and Design

Office of graduate studies

Adama science and Technology University

May, 2024

Adama, Ethiopia

Impact of on-street parking on urban mobility in Autobus Tera, Addis Ababa.

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DECLARATION

I hereby declare that this Master thesis entitled "**Impact of on-street parking on urban mobility in Autobus Tera, Addis Ababa**." is my original work. That is, it has not been submitted for the award of any academic degree, diploma or certificate in any other university. All sources of materials that are used for this thesis have been duly acknowledged through citation.

Name of the student	Signature	Date

RECOMMENDATION

I, the major advisor of this thesis, hereby certify that I have closely advised and read the revised version of the thesis entitled "**Impact of on-street parking on urban mobility in Autobus Tera, Addis Ababa.**" prepared under my guidance by Alamraw Muchie submitted in partial fulfillment of the requirements for the degree of Masters of Science in Urban Planning and Design. Therefore, I recommend the submission of the revised version of the thesis to the department following the applicable procedures.

Dr. Belay Zeleke	______________________	____________________
Major Advisor/supervisor	Signature	Date

APPROVAL BOARD OF REVIEWERS

I, the advisor of the thesis entitled **"Impact of on-street parking on urban mobility in Autobus Tera, Addis Ababa"** developed by Alamraw muchie Woreta, hereby certify that the recommendation and suggestions made by the board of examiners are appropriately incorporated into the final version of the thesis.

__________________________ __________________ _________________

Major Advisor/supervisor Signature Date

We, the undersigned, members of the Board of Examiners of the thesis open defense by Alamraw Muchie have read and evaluated the thesis entitled "**Impact of on-street parking on urban mobility in Autobus Tera, Addis Ababa**" and assessed the understanding of the candidate about the research. This is, therefore, to certify that the thesis is accepted for partial fulfillment of the requirement of the Degree of Master of Science in urban planning and design.

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External Examiner Signature Date

Finally, approval and acceptance of the thesis are contingent upon submission of its final copy to the Office of Postgraduate Studies (OPGS) through the Department Graduate Council (DGC) and School Graduate Committee (SGC).

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Department Head Signature Date

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School Dean Signature Date

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Office of Postgraduate Studies, Dean Signature Date

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ABSTRACT

Parking has a direct impact on traffic flow, accessibility, and livability of cities; it is an essential component of urban mobility. Parking has a direct impact on traffic flow, accessibility, and livability of cities; it is an essential component of urban mobility. Global studies show that on-street parking reduces urban mobility by decreasing road capacity, slowing traffic, and creating barriers for both vehicles and pedestrians. In Addis Ababa, on-street parking is a major cause of traffic congestion, economic degradation, and other negative impacts, but the quantitative relationships are not well understood. The study area is located in autobus tera, Addis Ababa. The roads in this study area are very crowded and busy due to the existence of high mobility. The goals of this research are to identify the mode of transportation used in the study area, to assess the impact of illegal on-street parking availability on travel time, and quantifying the relationship between on-street parking occupancy and traffic congestion in Autobus tera, Addis Ababa. To meet those objectives, the methodologies of complete and real-time data collection, field observation, parking occupancy survey, and correlation analysis were implemented. The study found that 71% of vehicles parked on the roads belonged to shop owners. This on-street parking significantly impacted traffic flow near the Autobus Tera, with average road area occupancy decreasing from 22.75% within 200m to 14.79% at 200-400m and 9.22% at 400-800m as we go from autobus tera to the four routes. Consequently, individuals lost from 762.96 to 2399.32 birr per month due to congestion. The congestion index ranged from 11.92 (on the Abune Petros to Autobus Tera route) to 7.62 (on the Kolfe Keranyo to Autobus Tera route). Therefore, proper off-street parking, standardize parking system, proper road design(dimension), development of road traffic signage, close controlling and monitoring of the transportation regulations, and spatial segregation of pedestrian and vehicle mobility should be practiced.

Keywords: *on-street parking, urban mobility impact, urban mobility, economic impact, Autobus Tera, Addis Ababa.*

LIST OF ACRONYMS AND ABBREVIATIONS

OPGS	Office of Postgraduate Studies
SGC	School Graduate Committee
DGC	Department Graduate Council
GPS	Global positioning system
GIS	Geographical information system
ETB	Ethiopian Birr
PPTT	Peak period travel time
CI	Congestion Index
FFTT	Free flow Travel time
ATT	Average travel time

CHAPTER ONE

1. INTRODUCTION

This study will focus on how on-street parking affects urban mobility in Addis Abeba's Autobus Tera. The active commercial area of Autobus Tera is characterized by the presence of two bus terminals that serve both medium and long-distance bus routes. However, the lack of a carefully constructed parking scheme makes the already congested roadways worse, creating a chaotic situation for traffic. Because there are not enough locations set out for cars, people park randomly on the streets, which inhibits traffic flow and interferes with urban mobility. The continuous flow of buses into and out of the terminals worsens this problem by adding to traffic and disorganized parking procedures. Beyond just being inconvenient, this parking-related chaos affects accessibility generally as well as traffic safety. To provide practical solutions that can reduce traffic, promote safety, and improve overall mobility in the area, it is essential to comprehend the effects of on-street parking on urban mobility in Autobus Tera. The study area will be held an 800 m radius along the four directions of the streets. After this restricted length the impact is becoming minimized due to the existence of another feeder/collector road.

The researcher's motivation to study the impact of on-street parking on urban mobility in Autobus Tera stems from concerns about safety, traffic flow, economic impact, stakeholder input, urban planning considerations, and the desire to identify best practices. With Autobus Tera being a highly commercial area, road safety and accessibility are crucial. The researcher aims to address safety concerns related to crowded parking and its effect on pedestrians and road users. Through stakeholder engagement and urban planning considerations, the researcher seeks to identify effective solutions that contribute to a vibrant and accessible commercial environment, ultimately benefitting both the local economy and the community.

1.1. Background of the Study

Parking is a crucial aspect of urban mobility, as it directly affects the flow of traffic and the overall accessibility and livability of cities. Cities need to manage parking effectively to mitigate traffic congestion, reduce environmental impacts, and improve overall urban mobility. To date, public parking spaces play a vital role in modern urban transportation systems by reducing heavy traffic loads(Piccioni et al., 2019).

However, the inadequate provision of parking facilities and unregulated on-street parking pose significant challenges to urban mobility (Bertolini, 2020).

One of the most widely seen parking prototypes is on-street parking, which includes all forms of roadside parking, including both paid and unpaid parking. It permits moving cars and parked cars to use the same amount of road width. In certain situations, though, parking may be inclined or parallel to the alignment of the road. The reason why on-street parking is so popular is that it enables drivers to park close to their destinations. It occasionally helps lessen the effects of inadequate off-street parking facilities (Biswas et al., 2017).

On-street parking, especially in cities with narrow roads and limited pedestrian lanes like Nigeria, leads to decreased road capacity and obstructed traffic flow (Onah, 2023). This results in increased travel times, frustrated drivers, and reduced overall efficiency of the transportation network. The impact of this problem is significant on traffic congestion(Conceição et al., 2023). Vehicles searching for on-street parking spaces, also known as cruising congestion, contribute to a significant proportion of daily traffic congestion in urban downtown areas. Studies indicate that cars looking for on-street parking places are responsible for almost 30% of traffic in urban areas. When there aren't enough spots available on the street, vehicles frequently turn to parking illegally, including double parking or taking spots designated for individuals with special needs. Because they impede traffic flow and constrict streets, these unlawful parking activities exacerbate traffic congestion.(Biswas et al., 2017). The negative impact of on-street parking on traffic congestion is especially noticeable in cities with narrow roads and limited pedestrian lanes(Aroloye, 2023). On-street parking not only exacerbates traffic congestion but also has serious consequences for pedestrian safety and general road safety. Pedestrians frequently have to maneuver past parked cars, which raises the possibility of collisions and makes the area dangerous (Zhang et al., 2023). In addition, parking on the street poses problems for emergency vehicles and public transportation. Because of restricted access brought on by on-street parking and obstructed streets, emergency vehicles may take longer to arrive at their locations. Congested streets can provide difficulties for public transport as well, which can cause delays and reduced effectiveness (Fadeyev, 2017).

Urban transport activities contribute significantly to negative impacts in cities with high motorization levels and automobile dependence as the dominant mode of individual travel(Le & Teng, 2023). These negative impacts include traffic congestion, reduced accessibility, and safety concerns. One of the main causes of urban mobility problems is related to the dominance of the car as the preferred transportation mode(Shafiei et al., 2023). In the case of Addis Ababa, the capital city of Ethiopia, urban mobility poses unique challenges. Addis Ababa is one of the fastest-growing cities in Africa, experiencing rapid population growth and urbanization. This growth has resulted in increased motorization and a higher demand for transportation infrastructure and services. According to a study by Gebremeskel, Addis Ababa faces issues such as rapid automobile growth, inadequate infrastructure capacity, and the incompatibility of existing transportation systems with the city's needs(Gebremeskel et al., 2023). These challenges have led to severe traffic congestion, and longer travel times.

1.2. Statement of the problem

According to a global scenario, when vehicle roads are partially blocked (On-street parking) by parked cars, urban mobility gets more difficult. Due to this, there is decreased road capacity, traffic moves more slowly and is congested. On-street parked cars create a barrier that makes it difficult for cars to move freely, which is a cause for delays and even accidents. Pedestrians encounter challenges as well because their area is limited, which hinders their safety and mobility. The problem is longer travel times, more difficult access to destinations, and ineffective parking use.

Urban mobility in Addis Ababa has been negatively impacted by on-street parking, which is a major cause of traffic congestion, economic degradation, delays, and other related negative impacts. The precise quantitative relationship between on-street parking occupancy and traffic congestion, the effect of on-street parking availability on travel time, and the relationship between on-street parking utilization and road capacity in Addis Ababa, however, are not well understood. Thus, the issue this thesis will attempt to solve is how on-street parking affects Autobus Tera's urban mobility in Addis Ababa. Most research did not address the relationship between inappropriate on-street parking with traffic congestion, travel time, and road performance on specific main roads. However, the researcher will do this to address the connection between on-street parking occupancy and traffic congestion, evaluate the effect of on-street parking availability on travel time, and look into the relationship between on-street parking utilization and road capacity. The research aims to provide empirical evidence and insights to inform parking management strategies and transportation planning efforts that mitigate the negative effects of on-street parking on urban mobility in Autobus Tera, Addis Ababa.

To provide safer and more efficient urban mobility on vehicle roads that are threatened by on-street parking, there could be effective car parking management, enforcing parking laws, promoting public mode choice, and improvement of urban design may be the solution for these difficulties.

Therefore, this paper addressed effective car parking management policies and enforcement, Promoting the use of public transportation modes, and improving urban design to better accommodate different modes of mobility.

1.3. Objective of the study

1.3.1. General objective

The general objective of this research is to assess the Impacts of on-street parking on urban mobility in Autobus Tera, Addis Ababa.

1.3.2. Specific objectives

- To identify the mode of transportation used by parked car owners in Autobus tera, Addis Ababa.
- To assess the impact of on-street parking availability on travel time in Autobus Tera, Addis Ababa.
- To quantify the relationship between on-street parking occupancy and traffic congestion in Autobus tera, Addis Ababa.

1.4. Research questions

- What is/are the predominant mode of transportation used by parked car owners in Autobus Tera, Addis Ababa?
- What is/are the impact of on-street parking availability on travel time for commuters in Autobus tera, Addis Ababa?
- What is/are the relationship between on-street parking occupancy and traffic congestion levels in Autobus tera, Addis Ababa?

1.5. Significance of the study

The significance of studying the impacts of on-street parking on urban mobility in Addis Ababa lies in its potential to address critical transportation challenges and inform evidence-based solutions. By understanding the specific impacts of on-street parking on urban mobility, this study can contribute to optimizing transportation systems, promoting sustainable transportation options, and enhancing the overall quality of life in the city. The findings can inform policy decisions and urban planning, helping to develop effective parking management strategies, reduce traffic congestion, improve travel time reliability, and create more pedestrian-friendly environments. Ultimately, this research can have practical implications for improving urban mobility, enhancing accessibility, and creating a more sustainable and livable city for residents and visitors in Addis Ababa.

The advantage of the methods used in this research is the comprehensive and multi-faceted approach to address the research objectives. The combination of observation, surveys, interviews, data analysis, and mapping provided a holistic understanding of the transportation modes and infrastructure in the Autobus Tera area. Additionally, the data collection and analyzed techniques, including GPS tracking, parking surveys, traffic data analysis, comparative analysis, and simulation models, allowed for a detailed quantification of the impacts of on-street parking on travel time and congestion levels.

1.6. Scope of the research

The study was conducted within the geographical boundaries of Addis Ababa City, located at 9°01'48"N latitude and 38°44'24"E longitude. The spatial scope of this research is limited to the area around the Autobus Tera bus terminal, within an 800 meter radius (the major affected area). The study also examines different route lengths in the four cardinal directions, keeping the bus terminal at the center. The thematic scope of this research involves Private and public vehicles, Street layout, Transport mode choice, and Pedestrian satisfaction with on-street parking in the bus terminal area. The research aims to propose solutions and mitigation measures to create a safe, accessible, and balanced walking environment through the right-of-way in this area.

1.7. Limitation of the Study

The research paper provides valuable insights into the economic impacts of on-street parking, particularly on travel time. While it examines the time-related economic costs of on-street parking, the paper does not encompass a comprehensive analysis of all the economic dimensions associated with on-street parking. It does not account for other potential economic costs, such as fuel wastage and other associated expenses. Additionally, the study did not collect data on the exact architectural parking dimensions required. this is due to the number of city buses, taxis, and other vehicles are not counted. Recognizing these limitations, further research is needed to explore the broader economic implications of on-street parking. This would provide a more comprehensive understanding of the overall economic impacts of on-street parking in the studied area.

Those limitations of the research could be expanded to include a more comprehensive economic analysis that accounts for additional costs beyond just travel time, such as fuel wastage and other vehicle operating expenses. Additionally, the researchers should collect more detailed data on the parking infrastructure, including the specific architectural dimensions and the number and types of vehicles utilizing the on-street parking facilities. By addressing these gaps and conducting further research to explore the broader economic implications of on-street parking, the study can provide a more holistic understanding of the overall economic impacts in the studied area.

1.8. Organization of the research

The research paper will consist of five chapters. Each chapter will be systematized and effectively examine the content and data of the study accordingly. The fundamental chapters in the thesis will be further demonstrated as follows.

Chapter One - Introduction to the study introduced the thesis by lighting the main topic of the study, research problems, objectives, questions, significance, scope, and research design in detail.

Chapter Two- deals with a literature review. This chapter describes the theoretical review starting from defining the key terminology to a general assessment of on-street parking, types, causing factors, and measures taken to prove the problem contextual of the global level practices and measures used to mitigate the effect of on-street parking.

Chapter Three - is about methods and materials. It explains the methods used for the study and the process of data collection and analysis in detail.

Chapter Four- Result and Discussion. It included the results of the processed and quantified relationship between on-street parking occupancy and traffic congestion, assessed the impact of on-street parking availability on travel time, the correlation between on-street parking utilization and mode choice, and the economic impact of on-street parking on the local economy.

Chapter Five- Conclusion and Recommendation. Based on the result and discussion study's recommendations and conclusions presented in the last chapter. Finally, the Reference, on-street parking checklist, and different formats of questionnaires are given in Appendixes.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Theoretical Review

2.1.1. Introduction to On-Street Parking and Urban Mobility

On-street Parking

Parking is a crucial aspect of urban mobility, as it directly affects the flow of traffic and the overall accessibility and livability of cities. It is essential for cities to manage parking effectively to mitigate traffic congestion, reduce environmental impacts, and improve overall urban mobility. To date, public parking spaces play a vital role in modern urban transportation systems by reducing heavy traffic loads (Benhayoun et al., 2019). However, the inadequate provision of parking facilities and unregulated on-street parking pose significant challenges to urban mobility.

The modern approaches to parking management, which include parking pricing and enforcement and monitoring policies in combination with the provision of integrated information tools giving access to holistic and reliable information to passengers for the traffic situation embedded in a broader framework of sustainable mobility strategy, seem to be able to contribute to the traffic and environmental relief of urban areas (Morfoulaki, 2017). Impact of On-Street Parking on Traffic Congestion One of the primary impacts of on-street parking on urban mobility is the exacerbation of traffic congestion. On-street parking, especially in cities with narrow roads and limited pedestrian lanes like Nigeria, leads to decreased road capacity and obstructed traffic flow (Owota & Aprioku, 2018).

This results in increased travel times, frustrated drivers, and reduced overall efficiency of the transportation network. The impact of this problem is significant on traffic congestion (Elashmawi, 2023). Traffic jams caused by cars looking for on-street parking spaces account for a large number of daily traffic jams in major downtown regions. Studies indicate that cars looking for on-street parking places are responsible for almost 30% of traffic in urban areas. Numerous studies, such as Shoup's, have emphasized the negative consequences of cruising congestion brought on by on-street parking. According to Shoup, the time spent looking for a place to park increases fuel consumption and carbon emissions in addition to adding to traffic congestion. In addition to lengthening commutes and aggravating drivers, cruising congestion increases the amount of pollution that vehicles release while stuck in traffic, which increases a city's carbon footprint(Arnott & Inci, 2006). Additionally, when there aren't enough spots available on the street, vehicles frequently turn to parking illegally, including double parking or taking spots designated for individuals with special needs. By obstructing traffic flow and constricting streets, these unlawful parking practices exacerbate traffic congestion. Cities with small streets and few pedestrian lanes will noticeably suffer from on-street parking's detrimental effects on traffic congestion. On-street parking not only exacerbates traffic congestion but also has serious consequences for pedestrian safety and general road safety. It is common for pedestrians to have to avoid parked cars, which raises the possibility of collisions and makes the area dangerous (Zeleke, 2022). Furthermore, on-street parking creates challenges for emergency vehicles and public transportation. Emergency vehicles may be delayed in reaching their destinations due to blocked streets and limited access caused by on-street parking. Public transportation may also face challenges navigating through congested streets, resulting in delays and decreased efficiency.

Urban mobility: It is the movement of people and things within urban regions, which includes a variety of transport modes as well as related systems and infrastructure. Cities' ability to function and grow depends on effective urban mobility. The capacity of people and things to move freely, safely, and conveniently within an urban region while utilizing a variety of transportation options is known as urban mobility (Baniste, 2017).

Urban mobility is influenced by numerous elements, such as population density, land use patterns, transportation infrastructure, travel demand, technological breakthroughs, and policy interventions. Urban mobility patterns are significantly influenced by the spatial organization of activities and the accessibility of transportation options (Levinson and Krizek, 2018).

Efforts to improve urban mobility often focus on enhancing transportation systems, promoting sustainable and active modes of transportation, and leveraging emerging technologies. highlight the role of shared mobility services, such as ride-hailing and bike-sharing, in transforming urban mobility. They argue that these services can provide flexible and convenient transportation options, reducing the need for private vehicle ownership and promoting more sustainable travel behavior (Shaheen , 2016). The difficulties presented by population development, traffic, and environmental concerns have led to a greater focus on the idea of urban mobility in recent years (Gakenheimer, 2002).

Mode Choice: Mode selection is a difficult procedure that is impacted by several variables (Machado et al., 2018). For example, the length of the trip has a major role in deciding which mode to use; shorter trips are more suited for cycling or walking, whereas longer trips frequently call for modes like cars, trains, or airplanes (Kaplan & Prato, 2019). Furthermore, the length of the trip is a significant factor in determining which mode to employ; longer trips are better served by faster modes, like trains or airplanes, while shorter trips are better served by slower modes, like cars or buses (Frusti, 2020). Cost is another crucial factor that affects the viability of various transportation options economically. This includes ticket pricing, fuel costs, parking fees, tolls, and maintenance charges (Wang., 2017). Convenience and accessibility are other important considerations; these include things like availability, scheduling, frequency, dependability, and how simple it is to get to transit terminals or stations (Gupta e, 2016). Finally, mode choice may also be influenced by the amenities and comforts that each mode offers, with trains and airplanes offering better onboard amenities and comfort (Salon, 2022).

Mode choice decisions are becoming more and more influenced by environmental concerns (Cohen et al., 2018). Due to their lower carbon emissions, modes having less of an influence on the environment—like bicycles and public transportation—are preferred over private vehicles (Iseki, 2021). Furthermore, a person's lifestyle choices, physical capabilities, and personal mode preferences are among the restrictions and personal preferences that influence mode choice (Gao, 2019). When choosing a method of transportation, people take into account their circumstances and restrictions as well as other factors like parking, bike lanes, and pedestrian infrastructure (Zhang, 2020). The promotion of sustainable and efficient mode choices is the goal of transport planning and policy initiatives. Examples of these include the development of public transit, better walking and cycling infrastructure, and the introduction of initiatives like congestion charging and carpooling (Chen, 2017). These initiatives direct mode selection towards more convenient and eco-friendly choices, resulting in a more sustainable transportation network (Li et al., 2022).

Traffic Congestion: Throughout the world, traffic congestion is a major problem that affects both urban development and transportation networks (Levinson, 2018). It happens when there is a greater demand for road space than there is available space, which results in longer travel times, more delays, and less mobility (Litman, 2019). Numerous reasons, including population expansion, rising car ownership, poor infrastructure, and traffic incidents, are contributing to traffic congestion (Wang et al., 2017). Congestion is also caused by elements including poorly timed traffic signals, poorly designed roads, and irregular land use (Le Vine, 2016). Furthermore, congestion may be made worse by the existence of large commercial cars and a dearth of efficient public transit options (Wang et al., 2020). In addition to negative effects on the environment and human health, such as elevated air pollution and noise levels, traffic congestion also has economic ramifications, including lost productivity and fuel (Cao et al., 2018).

Numerous studies have looked at the causes and potential solutions of traffic congestion in Ethiopia in the context of urban planning and design. For instance, Tulu and Demissie's (2018) study looked into how Addis Ababa's land-use patterns affected traffic congestion. Their research made clear how crucial it is to have integrated land-use planning that takes into consideration a variety of land uses and encourages the growth of compact cities to lessen traffic and travel times. The planning, building, and assessment of transport infrastructure aimed at reducing traffic in Dire Dawa (Gebre, 2021). To effectively manage traffic, this research highlighted the importance of properly planned road networks, appropriate intersection design, and effective traffic signal operations. The potential of transit-oriented development (TOD) strategies in addressing traffic congestion in urban areas of Ethiopia (Desalegn and Assefa, 2019). Their findings underscored the importance of integrating land-use planning and transportation systems to promote sustainable and efficient urban mobility, thereby alleviating congestion.

Travel Time: Travel time is a critical factor in transportation planning and has a significant impact on urban mobility. It refers to the duration required to travel between two points and is influenced by various factors (Anowar, 2019). These factors include traffic congestion, road conditions, travel distance, mode of transportation, and the efficiency of transportation systems (Wondimu, 2016). In congested urban areas, travel times tend to be longer due to increased traffic volume and delays (Mekonnen, 2020). Additionally, the availability and quality of transportation infrastructure, such as roads, public transit systems, and pedestrian facilities, also play a crucial role in determining travel times (Tadesse, 2021).

In the context of urban mobility in Ethiopia, studies have examined the impact of on-street parking on travel time. On-street parking can contribute to increased travel times and hinder urban mobility by reducing the effective capacity of roadways (Abera., 2022). Improperly managed on-street parking can lead to lane reductions, traffic flow disruptions, and increased congestion, resulting in longer travel times (Tadesse, 2020). Research by Desta. (2017) in Addis Ababa investigated the relationship between on-street parking availability and travel time. The study found that inadequate parking facilities and improper parking management contributed to increased travel times and emphasized the importance of efficient parking policies in reducing congestion and improving urban mobility. Another study by Gebremedhin and Demissie (2021) examined the impact of on-street parking on travel time in the city of Hawassa. The findings indicated that the presence of on-street parking affected traffic flow and increased travel times.

2.2. Contextual framework

Contextual Framework of On-Street Parking

Parking Demand: Parking demand is the measure of the need or desire for parking spaces in a given area, influenced by factors such as population density, land use patterns, economic activities, and transportation modes (Litman, 2018). Understanding parking demand is crucial for effective parking management and urban mobility planning, enabling the provision of adequate parking spaces to meet the needs of residents, workers, and visitors (Shoup, 2019).

Parking Management Strategies: Parking management strategies involve various approaches to efficiently manage parking resources in urban areas. Studies by Shoup (2018) and Litman (2019) discuss effective strategies, while Chen et al. (2017) examine innovative solutions such as smart parking systems.

Parking Behavior: Parking behavior refers to the actions and decisions made by drivers when searching for and utilizing parking spaces. Studies by Li et al. (2019), Zhang et al. (2017), and Wang et al. (2021) have explored various aspects of parking behavior, including parking choice factors, decision-making processes, and parking occupancy patterns.

2.2.2. Effects of On-Street Parking on Traffic Flow

Reduced Road Capacity: Reduced road capacity due to on-street parking refers to the limitation of available travel lanes caused by vehicles parked along the curb (Konduri et al., 2018). The paper also examined the impact of on-street parking on road capacity and congestion levels. It has an effect on on-street parking on traffic flow, travel times, and overall transportation efficiency (Wang et al, 2019 Cervero et al, 2017).

Lane Reductions: Lane reductions due to on-street parking occur when travel lanes are reduced or narrowed to accommodate parked vehicles along the curb. Research by Noland et al. (2016) examines the impact of lane reductions on traffic flow and congestion. Studies by Litman (2019) and Cao et al. (2021) analyze the effects of on-street parking on roadway capacity, travel times, and overall traffic operations. Understanding the implications of lane reductions is essential for effective transportation planning and management.

Traffic Delays: Traffic delays due to on-street parking refer to increased congestion and travel time caused by vehicles parked along the roadside. Research by Guo et al. (2019) examines the impact of on-street parking on traffic flow and delays. Studies by Wang et al. (2017) and Zhang et al. (2021) investigate the effects of on-street parking on travel time reliability, intersection capacity, and overall traffic operations. Understanding the relationship between on-street parking and traffic delays is crucial for effective transportation planning and congestion management.

Disrupted traffic flow: On-street parking significantly reduces traffic flow efficiency, increases travel times, and exacerbates congestion. The presence of parked vehicles for extended periods or in violation of parking regulations can create disruptions and congestion hotspots (Chen et al., 2020). Disrupted traffic flow due to on-street parking refers to the disturbances or interruptions in the smooth movement of vehicles caused by parked cars along the roadside.

2.2.3. Review of Literature on Urban Mobility Challenges

A review of literature on urban mobility challenges reveals insights from various researchers. Wang et al. (2017) examine the impact of transportation infrastructure on urban mobility, focusing on the relationship between road network characteristics and traffic congestion. Zhang et al. (2018) investigate the role of public transportation in addressing urban mobility challenges, emphasizing the importance of integrated and sustainable transit systems. Li et al. (2019) explore the impact of emerging technologies, such as ride-sharing and autonomous vehicles, on urban mobility, highlighting their potential to transform transportation systems. Additionally, studies by Cao et al. (2020) and Chen et al. (2021) analyze the challenges posed by population growth and urbanization on urban mobility, discussing strategies for efficient transportation planning and management. The review of the literature provides valuable insights for understanding and addressing the complexities of urban mobility challenges.

2.2.4. Impact of On-Street Parking on Pedestrian Movement

The impact of on-street parking on pedestrian movement has been explored in several studies. Zhang et al. (2017) investigate the effects of on-street parking on pedestrian behavior, focusing on factors such as sidewalk width, vehicle encroachment, and pedestrian comfort. Li et al. (2018) examine the relationship between on-street parking availability and pedestrian activity, highlighting how parking supply influences pedestrian movement patterns. Furthermore, Gao et al. (2021) analyze the impact of on-street parking on pedestrian safety, considering factors such as visibility, crossing distances, and conflicts with vehicles. These studies collectively emphasize the importance of considering on-street parking in urban planning to ensure safe and efficient pedestrian movement. Understanding the impact of on-street parking on pedestrian behavior and safety is crucial for creating pedestrian-friendly environments in cities.

2.2.5. Parking Policies and Urban Mobility

Parking policies play a crucial role in shaping urban mobility, as highlighted in a range of studies. In their examination of parking management strategies, Garcia-Palomares and Gutierrez (2017) emphasize the importance of efficient parking policies in reducing traffic congestion and promoting sustainable transportation options. The study by Sanchez-Diaz et al. (2019) explores the impact of parking pricing mechanisms on travel behavior, highlighting the effectiveness of demand-based pricing in reducing private vehicle usage and encouraging alternative modes of transport. Moreover, Chen et al. (2018) investigate the role of parking regulations in managing parking supply and demand, emphasizing the need for flexible policies tailored to the specific characteristics of urban areas. These studies collectively underscore the significance of well-designed parking policies in promoting efficient urban mobility and encouraging sustainable transportation choices.

2.2.6. Environmental Implications of On-Street Parking

The environmental implications of on-street parking have been the subject of several studies. Research by Yang et al. (2016) explores the impact of on-street parking on air quality, demonstrating that emissions from idling vehicles near parking spaces contribute to air pollution. Soltani. (2018) investigate the effects of on-street parking on the urban heat island phenomenon, highlighting how parked cars absorb and radiate heat, exacerbating temperature increases in urban areas. Additionally, the study conducted by Zeng et al. (2020) examines the environmental impacts of on-street parking in terms of energy consumption and greenhouse gas emissions, emphasizing the need for sustainable parking policies and alternative transportation options. These studies collectively shed light on the significant environmental consequences of on-street parking and underscore the importance of mitigating its negative effects through appropriate planning and management strategies.

2.2.7. Strategies for Improving Urban Mobility

Enhanced Public Transportation Systems: A great deal of research has been done on enhanced public transportation systems, emphasising their significance in advancing effective and sustainable urban mobility. The advantages of integrated public transport networks are examined in a study by DA.Hensher (2017), highlights the possibility of seamless multimodal connection in drawing in more people and decreasing dependency on private vehicles. The effects of transit-oriented development (TOD) on the use of public transportation, show how attractive and accessible public transportation networks can be made through well-planned urban environments and supporting land-use laws (Y Chang Chen, 2018). Additionally, Jianguo Xia al's research from 2019 looks at how new technologies like mobile apps and intelligent transportation systems might enhance the functionality and user experience of public transit. These studies collectively underscore the importance of investing in and improving public transportation systems to alleviate congestion, reduce emissions, and enhance overall urban mobility.

Multi-Modal Integration: Multi-modal integration has received significant attention in transportation research, highlighting its potential to enhance urban mobility and improve overall transportation efficiency. Chen et al. (2017) examine the benefits of integrating various modes of transportation, such as buses, trains, and cycling, in creating seamless and convenient travel experiences. The role of transportation hubs and intermodal connectivity in facilitating multi-modal integration, emphasizing the importance of well-designed transfer facilities and coordinated schedules (Zhang, 2018). Furthermore, research conducted by Wang et al. (2020) investigates the impact of information and communication technologies on multi-modal integration, demonstrating how real-time data and mobile applications can facilitate trip planning and improve the integration of different modes of transportation. These studies collectively emphasize the significance of multi-modal integration in promoting sustainable and efficient urban transportation systems.

Transportation Infrastructure Development: Transportation infrastructure development plays a crucial role in shaping urban mobility and accessibility (Rui & Othengrafen, 2023). Studies have shown that investing in robust transportation infrastructure, such as roads, bridges, and public transit systems, can enhance connectivity and reduce travel times (Kuo et al., 2023). Additionally, effective transportation infrastructure planning and development can support economic growth and improve the overall quality of life for residents (Basciftci & Hentenryck, 2022). It is essential to consider sustainable and resilient infrastructure solutions to meet the evolving needs of growing cities (Mosissa et al., 2023). By integrating innovative technologies and considering multi-modal transportation networks, cities can create efficient and sustainable transportation systems that cater to diverse user needs (Levinson, 2016).

Traffic Demand Management: Traffic demand management is an essential approach to address transportation challenges and optimize the use of existing infrastructure (Bie, 2017). Research has highlighted the effectiveness of strategies such as congestion pricing in reducing traffic congestion and promoting sustainable transportation modes (Wu, 2019). By implementing intelligent transportation systems and advanced traffic management technologies, cities can efficiently manage traffic demand and improve overall mobility (Kang, 2020). Furthermore, studies have shown that integrating land use planning and transportation policies can help shape travel behavior and reduce reliance on private vehicles (Guo, 2018). Effective traffic demand management strategies can lead to improved traffic flow, reduced emissions, and enhanced urban livability (Meng, 2021).

Technology-Based Solutions: Technology-based solutions have transformed urban mobility by offering innovative approaches to address transportation challenges. Real-time traffic monitoring and adaptive signal control systems improve traffic flow (Yang, 2017), mobile applications and smart routing algorithms provide real-time information (Chen et al., 2020), and electric and autonomous vehicles reduce emissions and enhance safety (Zhao, 2019).

Active Transportation Promotion: Promoting active transportation has proven to be instrumental in addressing the impact of on-street parking on urban mobility. Research has shown that implementing policies that prioritize pedestrian and cycling infrastructure can encourage a mode shift toward sustainable transportation options (Oja, 2018). Creating dedicated bike lanes and pedestrian-friendly streets has been shown to enhance safety and accessibility for active commuters (Buehler., 2016). Implementing bike-sharing programs and providing secure bike parking facilities have also contributed to increasing the adoption of active transportation modes (Shaheen, 2019). These active transportation promotion strategies not only reduce the reliance on on-street parking but also contribute to improved air quality, reduced traffic congestion, and healthier urban environments.

Urban design and land-use planning: Urban design and land-use planning play a crucial role in shaping the impact of on-street parking on urban mobility. Studies have shown that compact, mixed-use developments with well-connected street networks can reduce the need for extensive on-street parking (Ewing, 2016). Designing vibrant public spaces and prioritizing pedestrian-friendly environments can encourage walking and cycling, reducing the reliance on private vehicles (Cervero, 2018).

2.3. Empirical Literature Review

An empirical literature review is a type of research review that focuses on summarizing the existing empirical studies on the impact of on-street parking on urban mobility. It involves systematically searching for and analyzing published research articles to gain insights into the current state of knowledge on the above topic.

The table below describes the most recent papers that were done and their gap in addressing the impact of on-street parking on urban mobility.

Table 2.1: the table shows the empirical literature review

Roll. No	Author	Year	Key Findings, main ideas, and addressed Solutions	Research Gap
1	Clark, Robert	2021	Assessed the effectiveness of smart parking technologies in optimizing on-street parking occupancy and improving urban mobility.	Gap: Did not evaluate the economic impact of on-street parking due to high travel time.
2	Seid Endrie	2021	Major findings: Importance of transportation, development of a mathematical tool to analyze public transport capacity in Addis Ababa, presence of multiple urban transport service providers.(Endrie et al., 2021).	Unresolved issues include the relationship between parking utilization and road capacity, the effect of unlawful parking on travel times, and the congestion caused by on-street parking.

3	Jessica Nguyen	2020	Observed a negative correlation between on-street parking availability and journey time. Recommended developing efficient parking guidance systems and improving parking infrastructure.	Gap: Did not examine the correlation between on-street parking utilization and mode choice.
4	Kim, Andrew	2019	Examined the economic benefits of efficient on-street parking management, highlighting increased revenue potential and reduced congestion.	Gap: Did not quantify the relationship between on-street parking occupancy and traffic congestion.
5	Andrea Martinez	2018	Highlighted the economic benefits of on-street parking, such as revenue generation and business vitality. Proposed implementing performance-based parking pricing mechanisms.	Determine the financial influence of on-street parking on the neighborhood economy in a specific urban area.
6	Carlos Sanchez	2018	Explored the economic benefits of efficient on-street parking management for local businesses, highlighting increased customer turnover and revenue.	Gap: Did not examine the correlation between on-street parking utilization and analysis of on-street parking.
7	Rodriguez, Carlos	2018	Assessed the impact of parking pricing strategies on on-street parking utilization and urban mobility, emphasizing the effectiveness of demand-based pricing.	Gap: Did not examine the correlation between on-street parking utilization and mode choice.
8	Biruk Mulu	2018	Major findings: Insufficient parking spaces, the disparity between actual and ITE demand rates, lack of supplies, policies, signage, and user knowledge. (Mulu, 2018)	Unaddressed gaps: On-street parking's impact on traffic, illegal parking's travel time impact, parking

				utilization, and on street parking occupancy.
9	Patel, Ravi	2017	Investigated the relationship between on-street parking availability and traffic congestion, finding that increased availability leads to reduced congestion levels.	Gap: Did not evaluate the economic impact of on-street parking on the local economy.
10	John Smith	2015	Found a positive correlation between on-street parking occupancy and traffic congestion. Suggested implementing dynamic pricing and smart parking systems to manage parking demand.	Gap: Did not assess the impact of on-street parking availability on travel time.
11	Garcia, Miguel	2014	Examined the relationship between on-street parking occupancy and traffic flow, finding that higher occupancy is associated with reduced traffic speed	Gap: Did not quantify the relationship between on-street parking occupancy and traffic congestion.
12	Shiferaw Ashenafi	2014	The study found that car parking in Addis Ababa is a significant problem affecting traffic flow and city development. It has major social, political, and economic impacts. Recommendations include a clear parking strategy and policy aligned with city objectives, as well as further research on the topic. (Shiferaw, 2014)	Unaddressed research gaps: on-street parking's correlation with traffic congestion.

2.4. Summary of Literature Review and Research Gaps

On-street parking is vital for urban mobility, but issues like insufficient provision and unregulated parking contribute to traffic congestion and transportation inefficiency. Cruising congestion, caused by drivers searching for parking, worsens traffic and affects pedestrians, safety, emergency services, and public transportation. Urban mobility involves moving people and goods in cities, influenced by factors like population density, infrastructure, and policies. Mode choice, affected by distance, time, cost, convenience, and environmental factors, shapes urban mobility. Traffic congestion, resulting from population growth and inadequate infrastructure, has economic, environmental, and health impacts. Enhancing transportation systems, promoting sustainable modes, and utilizing emerging technologies are key to improving urban mobility.

On-street parking encompasses parking demand, management strategies, and behavior, influenced by factors like population density and land use patterns. Understanding parking demand is vital for effective management and urban mobility planning. Parking behavior affects traffic flow, road capacity, and pedestrian movement. Parking policies play a crucial role in shaping urban mobility and addressing environmental concerns like air pollution and energy consumption. Efficient parking policies and sustainable transportation options are emphasized to tackle urban mobility challenges and promote environmentally friendly practices.

Strategies for improving urban mobility encompass enhancing public transportation systems, integrating multiple modes of transportation, developing robust infrastructure, managing traffic demand, utilizing technology-based solutions, promoting active transportation, and implementing effective urban design and land-use planning. These approaches aim to create sustainable and efficient transportation systems by reducing reliance on private vehicles, optimizing existing infrastructure, improving safety, reducing congestion, promoting active modes of transportation, and creating accessible urban spaces. Collectively, these strategies contribute to enhancing urban mobility and fostering a more sustainable and livable urban environment.

The empirical literature review on the impact of on-street parking on urban mobility revealed several recent papers that identified key findings and addressed various solutions. However, a common gap among the papers was their failure to address the objectives of quantifying the relationship between parking occupancy and traffic congestion, assessing the impact of illegal parking on travel time, and examining the correlation between parking utilization and road capacity. These gaps indicate a need for further research to understand the specific impacts of on-street parking on urban mobility.

2.5. Conceptual Framework

A theoretical or conceptual framework that directs the course of a study is known as a conceptual framework in research. It serves as a framework for arranging and interpreting data and reflects the researcher's understanding of the relationships between various variables or concepts. Key ideas are identified and defined, together with the connections between them and the claims or theories that will be put to the test. The following diagram shows the relationship of dependent and independent variables for the thesis proposal entitled “Impact of on-street parking on urban mobility in Autobus Tera, Addis Ababa.”

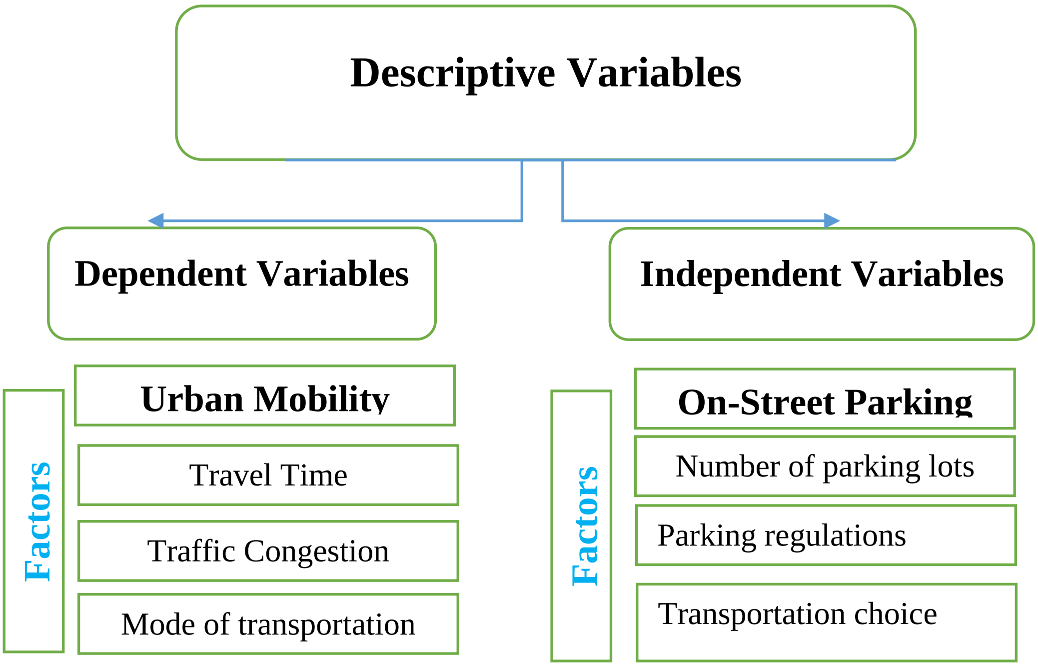

Figure 2.1: conceptual framework for variables

A. **Dependent Variables:** Dependent variables are the observed, measured, or recorded variables in research that are influenced by the independent variables being studied.

Urban Mobility: represents the extent and quality of movement within urban areas, influenced by transportation infrastructure, policies, and modes of transportation.

Travel Time: Travel time, as a dependent variable, refers to the duration it takes to travel between two points and is influenced by factors such as distance, transportation mode, traffic conditions, and road infrastructure.

Traffic Volume: Traffic volume is the number of vehicles passing through a road segment over a period of time.

Traffic Congestion: Traffic congestion, as a dependent variable, represents the level of congestion or obstruction in the flow of vehicles on roadways and is influenced by factors like traffic volume, road capacity, and transportation infrastructure.

Mode of transportation: Mode of transportation, as a dependent variable, refers to the specific type or means of transportation chosen by individuals for their travel needs, influenced by factors such as accessibility, cost, convenience, and infrastructure availability.

B. **Independent Variables**: Independent variables in research are variables that are manipulated or selected by the researcher to assess their influence on the dependent variables being studied.

On-Street Parking: refers to the availability, pricing, and management of parking spaces along public streets, which can be manipulated and studied for its impact on various outcomes.

Number of parking spaces: represents the quantity or availability of designated parking spots, which can be manipulated and studied for its influence on various outcomes and behaviors.

Parking regulations: encompass rules and restrictions imposed on parking, such as time limits, permit requirements, and enforcement policies, which can be manipulated and studied for their effects on parking behavior and outcomes.

Effect of on-street parking on traffic: refers to the impact or influence that on-street parking has on the flow and congestion of vehicular traffic in a given area.

Effect of on-street parking on transportation choice: refers to how the availability, cost, and convenience of on-street parking influence individuals' decisions regarding their chosen mode of transportation.

2.6. Expected outcome of the study

The study attempts to investigate the challenges caused by on-street parking and how it impacts various aspects of city mobility. The goal of the research is to identify the issues related to on-street parking, including greater traffic congestion, longer travel times, and less room for roadways. By analysis of Autobus Tera's on-street parking issue, the study will show that there is a direct and negative relationship between on-street parking and road capacity. The data will demonstrate how parked cars on the streets obstruct traffic flow, causing congestion and delays for those utilizing the roads. The researcher intends to improve the understanding of the difficulties caused by on-street parking in Autobus Tera, Addis Abeba, by conducting this research. The results will highlight how critical it is to put in place efficient parking management plans and regulations to mitigate the adverse impacts on travel times and road capacity. Finally, the researcher will provide transportation authorities, policymakers, and urban planners with useful information that will help them improve urban mobility and lessen the negative effects of on-street parking in this particular location.

2.7. Operational Definitions

Operational definitions provide clarity on the specific concepts and variables under investigation in the study, ensuring that researchers and readers will have a common understanding of the terms used in the study. the following are the operational definitions for this research.

On-street parking: is the practice of parking cars along the sides of public roads, taking up space meant for traffic flow and momentarily obstructing or limiting it.

Urban mobility: is the flow of people and products through an urban area using a variety of transportation methods, including driving, walking, cycling, and public transportation.

Impact: The quantifiable results or impacts of on-street parking on metrics related to urban mobility, such as travel time, capacity of the road, and traffic congestion.

Travel Time: The amount of time it takes a person or car to go from one location in the study area to another, taking into account any delays or hiccups brought on by on-street parking.

Road capacity: the greatest number of cars that a street or road can handle in a certain amount of time, taking into account the available lanes and any physical restrictions.

Traffic congestion: a condition that is characterized by a large number of vehicles causing a loss in traffic flow and a significant increase in travel time. This is typically the result of on-street parking blocking traffic flow.

CHAPTER THREE

3. METHODS AND MATERIALS

3.1. Description of Study Area

The study area is in Addis Ababa, Autobus Tera. Addis Ababa, the capital of the Federal Democratic Republic of Ethiopia, is situated in the middle of the nation. Since its founding in 1886, the city has undergone several planning modifications that have impacted both its social and physical development. Addis Ababa is recognized as a state as well as a city. It is the home base of both the African Union and the AU. Because of Addis Ababa's historical, diplomatic, and political significance for the continent, it is frequently referred to as the political capital of Africa.

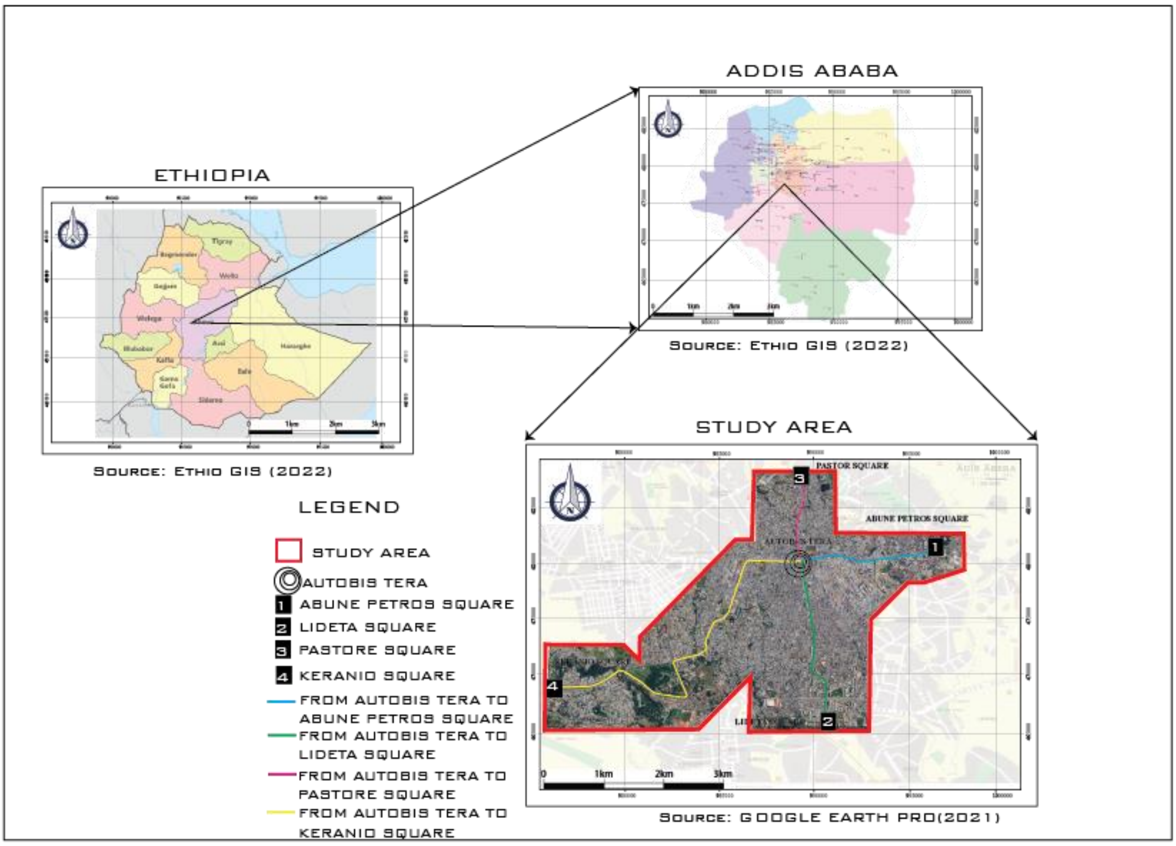

Figure 3.1: location of the study area, Autobus tera, Addis Ababa

This thesis focuses on the Autobus Terra because of the city's size. This site is extremely busy, especially in the morning (8:00 pm to 2:30 pm), lunchtime, and afternoon (after 4:30 pm) due to the existence of illegal on-street parking vehicles. Due to their involvement in business-related operations, residential settlements, and various sites merchants, governmental organizations, Autobus Tera short and long distance terminals, and buildings available located it. The study will cover asphalt roads of Autobus tera itself and 800-meter radius encompassing all directions.

3.2. Data Type and Sources

The study will focus on primary and secondary sources of data. Primary sources of data necessarily require an on-site survey of the problem or issue to obtain accurate information about the real-study area phenomena. Secondary data, such as census data and traffic data from the sub-city that are relevant to the study will be collected. To collect data wisely, the necessary method and technique should have to be established. For example, survey data will be obtained by distributing formal questionnaire papers, and observation for the representative target population.

3.2.1. Primary data

Primary data from face-to-face interviews, systematic observations, questionnaire surveys, and various recording formats used in the study. GPS-equipped automobiles can also be useful for gathering real-time traffic data by using GPS and distance measurement programs (Tang et al., 2017). The information required for TTI computations is provided by the cab GPS data used in this study. The information will be gathered from various target audiences at various times and places, triangulated, and analyzed.

3.2.1.1. Interviews

The researcher will Interview the targeted population which will make the research feasible. Since the research is going to be conducted for the users, they have to be interviewed randomly and purposively.

3.2.1.2. Questions

The researcher will prepare questions for the targeted population with understandable language and words that will enable the research will achieve excellent results. Since the research is going to study the users, they have to be questioned randomly and purposively.

3.2.1.3. Observation

To see the existing situation of the study, the researcher will collect the data directly from the study area. Through this methodology, the researcher is going to define the study area, determine observation criteria, develop an observation plan, conduct observations, analyze the data, and interpret the findings.

3.2.2. Secondary data

3.2.2.1. Published papers

Information gathered from documents such as books, researched papers, journals, magazines, and other related published documents. It has several benefits. First of all, it gives users access to thoroughly investigated and verified knowledge from subject matter specialists. Second, examining many viewpoints and evaluating empirical data, enables a thorough grasp of a subject. Finally, using published materials can improve the information's validity and dependability, making it appropriate for use in academic or professional contexts.

3.2.2.2. Documents at the concerned bodies/ Office

Office documents can offer further details that support the main information gathered from observations, questionnaires, and interviews. They can provide official records, reports, policies, historical context, policies, and other pertinent papers that fulfill and address the objective of the research. It will have advantages like unbiased and authentic information, accessibility and convenience, time efficiency, and comparative analysis.

3.3. Study approaches

A deductive research approach will focus on quantitative and qualitative and begins with theory to realize a global scenario for the study. In this study, statistical data is relevant, which will describe the objective of the study. Therefore, the research approach will clearly describe the quantity of on-street parked vehicles that are the cause of increasing obstructions to mobility. Qualitative data from the questionnaire, observation, and secondary data will also be used to determine whether the impact on the city of Addis Ababa is significant or not. Whenever the researcher will study the parameters such as Travel time and delay, congestion levels, mode choice, Parking infrastructure quality, and Parking duration. The following terms express the dependent and dependent variables.

3.4. Study design (Research Design)

Using a mixed-methods approach, the research strategy for the "Impact of On-Street Parking on Urban Mobility in Autobus Tera, Addis Ababa" study combines quantitative and qualitative data collection and analysis. The purpose of the study is to look into the relationship between urban mobility metrics including travel time, road capacity, traffic congestion, and on-street parking. The following elements comprised the research design:

Determine the Research Goals: Clearly state the goals of the study, including how much traffic congestion is affected by unlawful on-street parking, how much on-street parking occupancy is related to it, and how on-street parking utilization is related to road capacity. This is developed from the problems that are identified, literature reviewed, and case studies.

Data Collection Methods:

A. Quantitative Data Collection

On-Street Parking Occupancy: on street parked cars were counted and quantified to know what amount of space they occupied. This was conducted through five days, different times and locations (road segments) of the four selected routes in Autobus Tera.

Table 4.1: selected routes for impact analyses.

Roll no	Routes	length(km)	Average design speed as per City Adm.	FFTT(minute)
1	From Abune petros to autobus tera	2.4	40	3.60
2	From Lideta to Autobus tera	3	40	4.50
3	From Pastor square to Autobus tera	1.3	40	1.95
4	From Keranio square to Autobus tera	5.6	40	8.40

Traffic Congestion: gather quantitative data on traffic congestion indicators, such as travel time, travel time index, congestion index, and delays. This was taken by collecting a GPS data's from feres Ride Company and calculating the average speed, travel time index, delay, and congestion index.

Simulation Models: Utilized transportation simulation models to simulate different scenarios of on-street parking availability and evaluate their impact on travel time.

The following formulas are used to simulate the congestion level, travel time, and time loss with the on street parking conditions.

$$Speed(v) = \frac{Distance\ traveled}{Time\ taken\ to\ travel} = \frac{S}{T} ----Fundamental\ equation\ of\ physics(1)$$

From the equation 1, we can calculate the time as follows.

$$FFTT = \frac{Distance\ traveled}{design\ Speed} = \frac{S}{Vd} ----Fundamental\ equation\ of\ physics --(2)$$

$$Time\ loss = ATT(Average\ time\ travel) - FFTT(Free\ flow\ travel\ time) - (3)$$

Where:-

S, distance traveled by vehicles.

V_d, design speed that is sated by Addis Ababa City Structure Plan, 2017.

ATT, average time traveled,

FFTT, free flow travel time

B. Qualitative Data Collection

Interviews: To obtain qualitative information on the perceived effects of on-street parking on urban mobility, conduct interviews with important stakeholders, including urban planners, transportation officials, and members of the community.

Observation: Visit Autobus Tera in person and observe the transportation activities. Take note of the types of vehicles you see, such as buses, minibusses, taxis, or other modes of transportation.

Surveys: Conduct surveys with passengers or staff at Autobus Tera. Prepare a questionnaire that asks about the mode of transportation they use and their frequency of travel.

Interviews: Conduct interviews with users, and officials to know the mode of transportation used frequently in the study area(autobus tera).

Survey and Questionnaires: Administer surveys or questionnaires to collect additional information from drivers, residents, or stakeholders in the study area. The surveys can include questions about parking behavior, travel patterns, and perceptions of congestion. This qualitative data can complement the quantitative analysis and provide a more comprehensive understanding of the relationship between on-street parking and traffic congestion.

Traffic Data Collection: Gather data on traffic congestion levels in the Autobus Tera area. This can be done using manual traffic count techniques. The data collected should include vehicle speeds, and congestion levels during different periods.

Data processing

The collected data are processed using different soft wares, and tools and techniques such as Adobe Illustrator, Excel, and GIS.

Data Analysis

A. Quantitative Analysis

On-Street Parking Occupancy: the researcher calculated metrics like the average number of parked cars, the peak occupancy times, the percentage of curb space utilized, and the variability in occupancy across different road segments and time periods. This data could be used to identify areas with high parking demand, understand utilization patterns, and inform decisions around parking management strategies.

Traffic Congestion: The total time taken to traverse a specific route or road segment.

Travel time index: The ratio of the actual travel time to the free-flow travel time.

Congestion index: A measure of how much longer the actual travel time is compared to the free-flow travel time.

Delays: The difference between the actual travel time and the free-flow travel time. The researcher calculated these metrics for different time periods, road segments, and routes to identify patterns and hotspots of traffic congestion. This data could be used to understand the severity and causes of traffic congestion, informing strategies to improve traffic flow, such as adjusting signal timings, managing access, or implementing other transportation demand management measures.

B. Qualitative Analysis

To determine themes, viewpoints, and experiences about on-street parking and urban mobility, transcribe and interview data.

Combining the Results/ Findings: Combine the quantitative and qualitative data to present a thorough picture of how on-street parking affects urban mobility in Addis Abeba's Autobus Tera. To find consistency and disparity, compare and contrast the findings from the two data sources.

Interpretation and Conclusion: Evaluate the results in the context of the study's goals. Based on the relationship between parking occupancy and traffic congestion, the effect of unlawful parking on journey time, and the relationship between parking utilization and road capacity, conclude the effects of on-street parking on urban mobility in Autobus Tera.

Recommendations: To maximize on-street parking management and enhance urban mobility, policymakers, urban planners, and transportation authorities in Autobus Tera should be given practical recommendations based on the research findings.

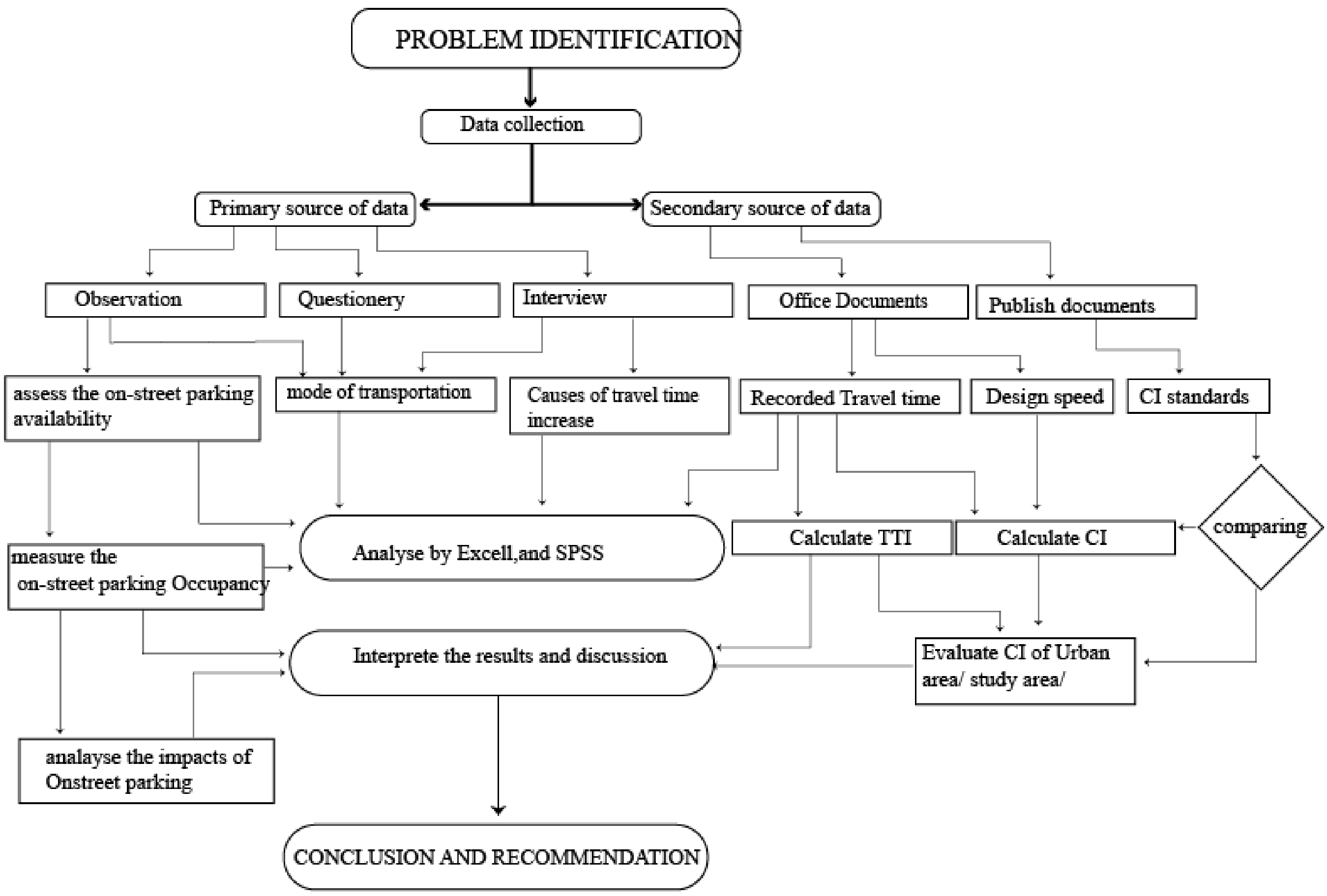

Figure 3.2: research design diagram

3.5. Sample size

Since the selected corridor (study area) is used by an undetermined population size, the research will use the following formula according to (Bernard, 1995) formula.

$$\boldsymbol{n} = \frac{Z^2\ \mathbf{p(q)}}{e^2} = \boldsymbol{n} = \frac{Z^2\ \mathbf{p(1-p)}}{e^2} = \ \boldsymbol{n} = \frac{\mathbf{1.96^2\ 0.5(1-0.5)}}{\mathbf{0.05^2}} = 384$$

384 persons will be questioned and interviewed for the research in a random sampling technique.

Where:

n represents the required sample size.

Z is the Z-score corresponding to the desired level of confidence. For a 95% confidence level, the Z-score would be approximately 1.96.

p is the estimated proportion or probability of an event occurring in the population. If there is no estimate available, it is common to use 0.5 to ensure a conservative estimate. However, the study also uses a purposive sampling technique we can use the value of e (acceptable margin error) = 5%=0.05. This is because the population that uses the area is continuously changing.

q is the complement of p, so q = 1 - p.

E is the acceptable margin of error, which represents the maximum allowable difference between the sample estimate and the true population parameter.

3.6. Sampling techniques

The research used both purposive sampling techniques and simple random sampling techniques. From this type of sampling the population should be experienced and should know the situation that happened and happening. Participants chosen based on their first-hand experiences and knowledge of the parking situation, including drivers, commuters, local business owners, and traffic management officials. Therefore, to filter those targeted populations, the researcher prepared a questionnaire under personal information that can differentiate the inexperienced and experienced before the research questions directly begin.

The purposive sampling technique: this technique used to extract high level information from those who have knowledge about. It was utilized to select specific areas that are known to experience high levels of on-street parking, urban planners, transport authorities, and parked car owners.

Qualitative data collection methods, such as interviews and focus groups, employed to gather in-depth information on participants' experiences and perceptions.

A simple random sampling approach ensures that Participants randomly selected from the chosen roads (study area), encompassing commuters, and pedestrians. The random sampling technique minimized bias and provide an equal chance of inclusion for each road and participant. This enhances the generalizability of the findings to similar urban areas confronted with high traffic congestion challenges.

3.6.1 Research population

The target groups of the survey are pedestrians, drivers, and dwellers or workers around. Populations are selected by researcher based on their interest in pedestrians, the most affected group in the area. In addition, government officials and street vendors are interviewed as key informants.

3.7. Study instruments (Data collection tools)

To study and address the objectives, the researcher is going to use different tools/instruments, and techniques.

1. Traffic Counters: Traffic counters in Addis Ababa measure on-street parking occupancy and traffic congestion by quantifying vehicle volume and flow at specific points.

2. Parking Surveys: Parking surveys assess the impact of illegal on-street parking on travel time, collecting data on availability and occupancy to analyze effects on transportation.

3. Travel Time Surveys: Conducting travel time surveys involve tracking the time it takes for vehicles to travel between specific points in Autobus Tera, Addis Ababa. By comparing travel times under different parking conditions (e.g., with and without illegal on-street parking), the impact of parking availability on travel time can be assessed.

4. GPS Tracking: GPS devices track travel routes, speeds, and delays to analyze the correlation between on-street parking and road capacity. This helps examine their relationship by comparing utilization rates with travel speeds and congestion.

5. Video Surveillance: Installing video surveillance cameras at selected locations can provide visual data on on-street parking occupancy and its impact on traffic congestion. Video footage can be analyzed to quantify the relationship between parking utilization and congestion levels.

6. Interviews and Surveys: Interviews and surveys gather insights on parking, congestion, travel time, and road capacity from various stakeholders.

7. Geographic Information System (GIS) Analysis: GIS tools analyze spatial data on parking occupancy, congestion, travel times, and road capacity, revealing correlations and patterns for valuable insights.

CHAPTER FOUR

4. RESULT AND DISCUSSION

4.1 Introduction

A comprehensive analysis and discussion of the research findings are presented, focusing on the description of data, results obtained, and subsequent discussions. The chapter is structured by the specific objectives and research questions of the study. To accomplish the research goals, a combination of quantitative and qualitative data was required. The quantitative data encompassed field measurements and questionnaires, which gathered information pertaining to various aspects such as workstation locations, travel time to reach workstations (considering both congested and non-congested scenarios), commute time back home (under congested and non-congested conditions), daily working hours, and actual hours worked per day, and the assessment of the on street parking occupancy percentage and its association effect. The researcher employed a general formula, utilizing the travel time index, to assess time delays. The quantitative data analysis involved considering parameters such as travel time during congestion(due to on-street parking) for reaching workstations, travel time during congestion for commuting back home, average road speed limits (for calculating free-flow travel time without congestion), and the distance from origin to destination (for calculating free-flow travel time without congestion). The research utilized both primary and secondary data sources, collecting data of both qualitative and quantitative nature.

4.2. Profile Analysis of Participants

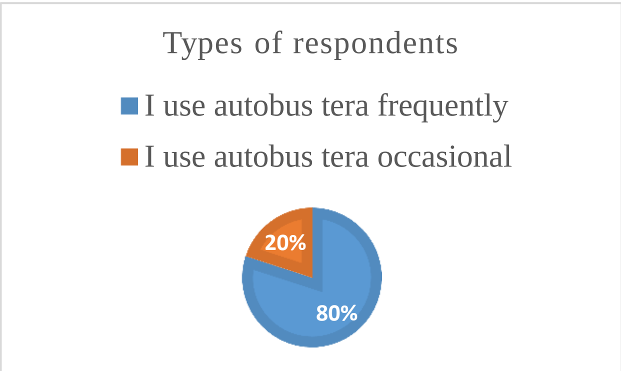

Figure 4.1: respondent’s level of experience with the study area

Most of the respondents are experiencing the study area frequently. This had a positive effect on collecting the right data. They experienced the impact that occurred due to on-street parking what is happened there. 80 % of the respondents are working, and experiencing the corridor frequently.

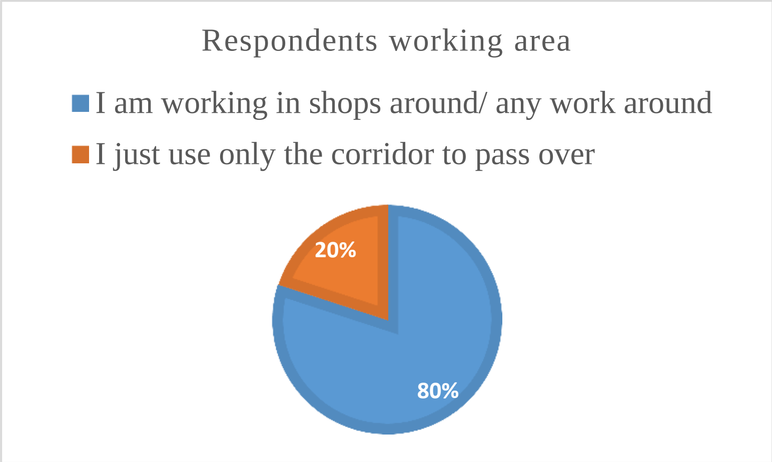

Figure 4.2: respondents working area

Most of the respondent's work area is in the study area. 80% of the respondents are experiencing the study area frequently due to their work location. Therefore, they are experiencing the impacts from the congestion of vehicles due to on street parking of their and others vehicles.

4.2.1 Sex profile respondent

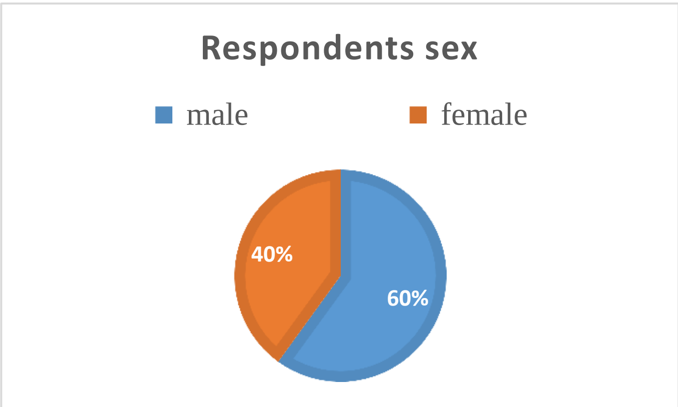

Figure 4.3: respondents sex profile

Let individuals participate without discriminating in age, and sex is very important for successfulness of the study. From here the researcher tried to gather information from both females and males without discrimination. Since most drivers and shop owners are males, their number was more than females.

4.2.2 Age profile of respondents

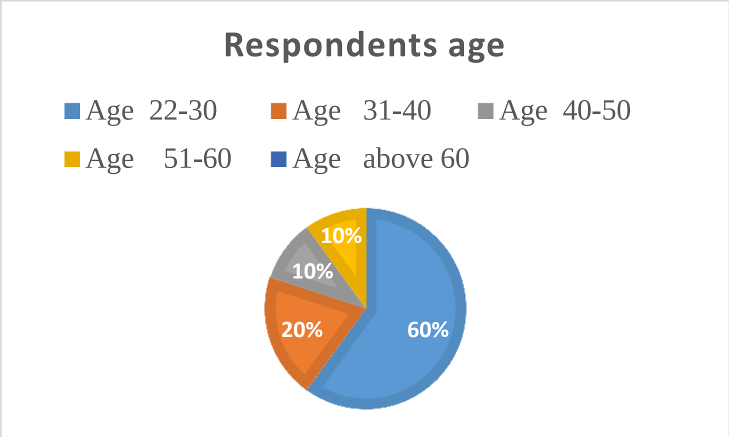

Figure 4.4: respondent's age profile

The study encompasses almost all age groups of the respondents. From the research, 60 % of the respondents are in the age group of 22-30, 20 % of the respondents are ages 31-40, 10% of the respondents are ages 40-50, and 10% of the respondents are ages 51-60. Around the work place young age group parked their own car. Therefore, the respondents are in age of 22-40. However the impact is for all groups of the respondents, the researcher tried to cover all the age groups to gather valuable data for the research.

4.3. Urban mode of transport

Urban transportation modes can be categorized into private vehicles, public transit, active transportation, and shared mobility. Private vehicles offer flexibility but contribute to congestion and pollution, while public transit is more efficient but requires significant investment. Active modes like walking and cycling promote sustainability but rely on infrastructure. Shared mobility services provide alternatives to private car ownership and can help reduce single-occupancy trips, while freight and commercial transportation support the local economy but also impact traffic and the environment.

4.3.1 Type of mode of transport

As shown in figure 4.5, most respondents use their car to move. 40% of the respondents used their private cars, 30% of the respondents used public cars, and 30% of the respondents used their feet to move. From this data, we can gather information, their feeling, and satisfaction from all types of modes of transport users.

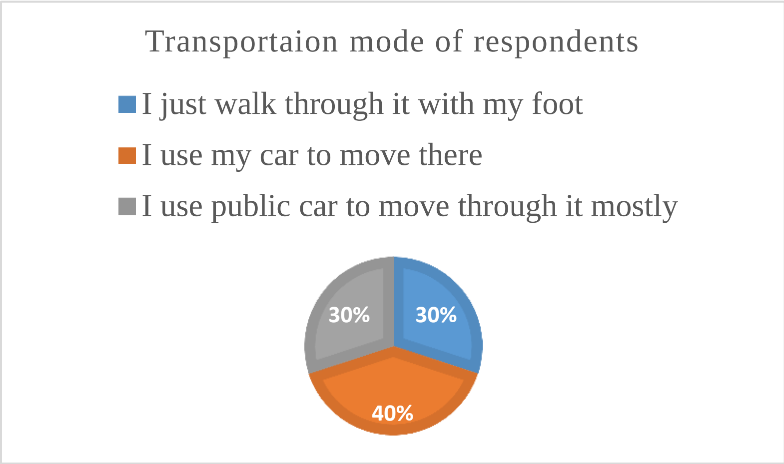

Figure 4.5: respondent’s general mode of transportation

On figure 4.6, on day 1, It was analyzed in the study that most of the parked vehicle owners (47%) and shop owners (81%) use private vehicles, and most of the commuters (52 %) rely on public cars. This indicates that most of the shop owners and parked vehicle owners use their private cars as a means of transportation. This results in a high demand for off-street or proper on-street parking.

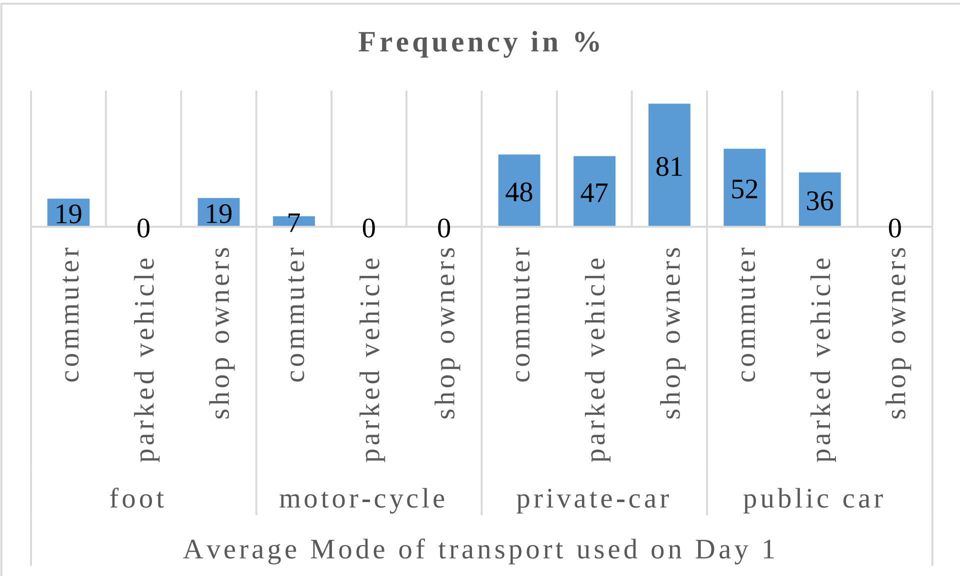

Figure 4.6: Average mode of transportation on day 1 source: author’s field survey, 2024.

On figure 4.7, on day 2, It was analyzed that most of the parked vehicle owners (41%) and shop owners (79%) use private vehicles, and most of the commuters (53 %) rely on public cars. This indicates that most of the shop owners and parked vehicle owners use their private cars as a means of transportation. This results in a high demand for off-street or proper on-street parking.

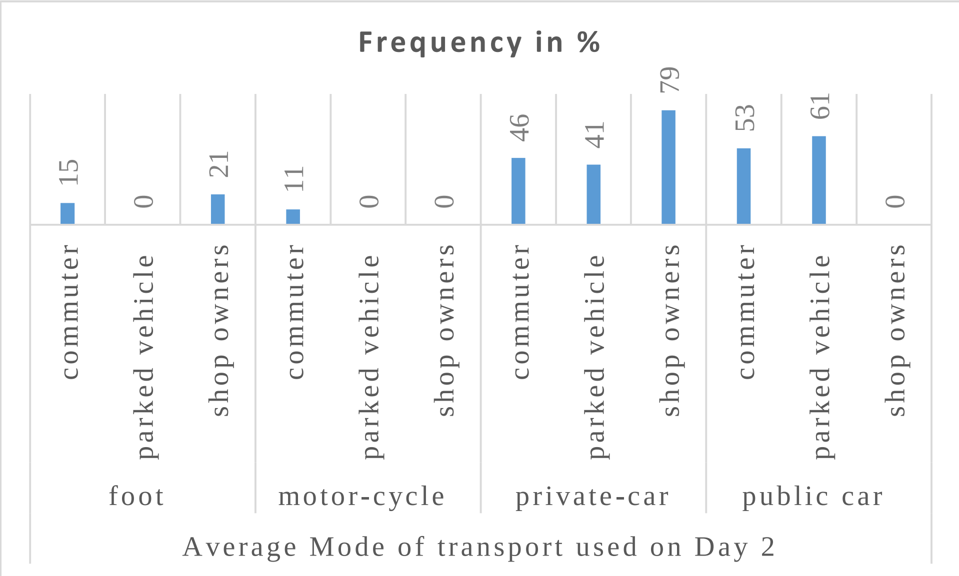

Figure 4.7: Average mode of transportation on day 2 source: author's field survey, 2024.

On figure 4.8, on day 3, It was analyzed that most of the parked vehicle owners (47%) and shop owners (83%) use private vehicles, and most of the commuters (49 %) rely on public cars. This indicates that most of the shop owners and parked vehicle owners use their private cars as a means of transportation. This results in a high demand for off-street or proper on-street parking.

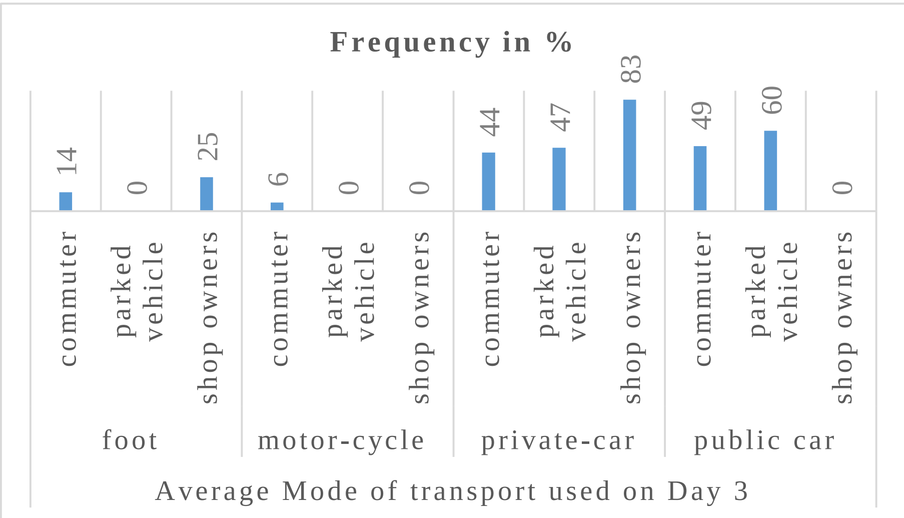

Figure 4.8: Average mode of transportation on day 3 source: author's field survey, 2024.

On figure 4.9, on day 4, It was analyzed that most of the parked vehicle owners (51%) and shop owners (83%) use private vehicle, and most of the commuters (53 %) rely on public cars. This indicates that most of the shop owners and parked vehicle owners use their private cars as a means of transportation. This results in a high demand for off-street or proper on-street parking.

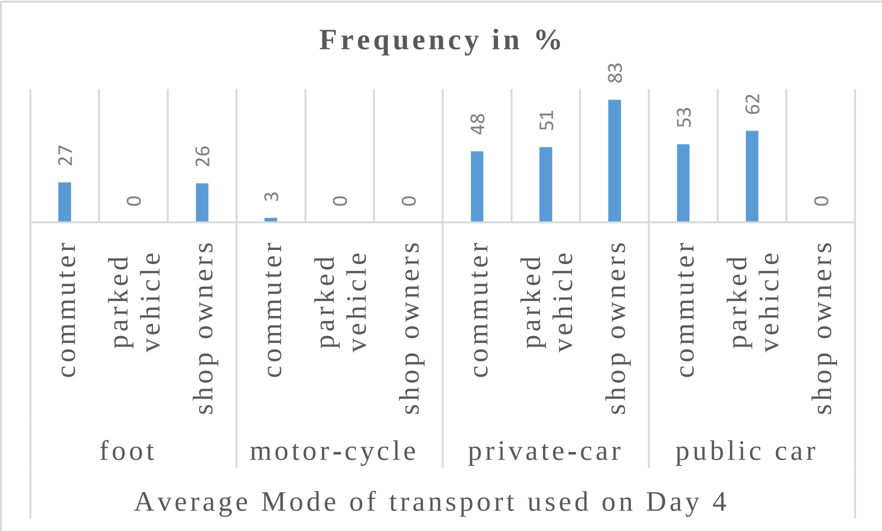

Figure 4.9: Average of the three peak hours mode transportation on day 4 source: author's field survey, 2024.

On figure 4.10, on day 5, It was analyzed that most of the parked vehicle owners (60%) and commuters (35%) use private vehicles, and most of the commuters (52%) rely on public cars. This indicates that most of the shop owners and parked vehicle owners use their private cars as a means of transportation. This results in a high demand for off-street or proper on-street parking.

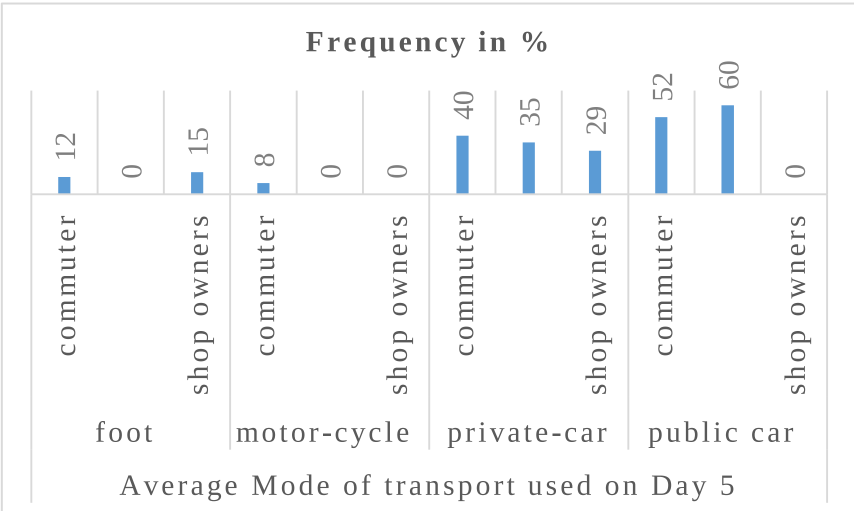

Figure 4.10: Average of the three peak hours mode of transportation on day 5 source: author's field survey, 2024.

It was analyzed that most of the parked vehicles are privately owned. From the privately owned cars 71 percent are belonged to the shop owners. Most vehicles from the shop owners are parked in front of their shops and on main road.

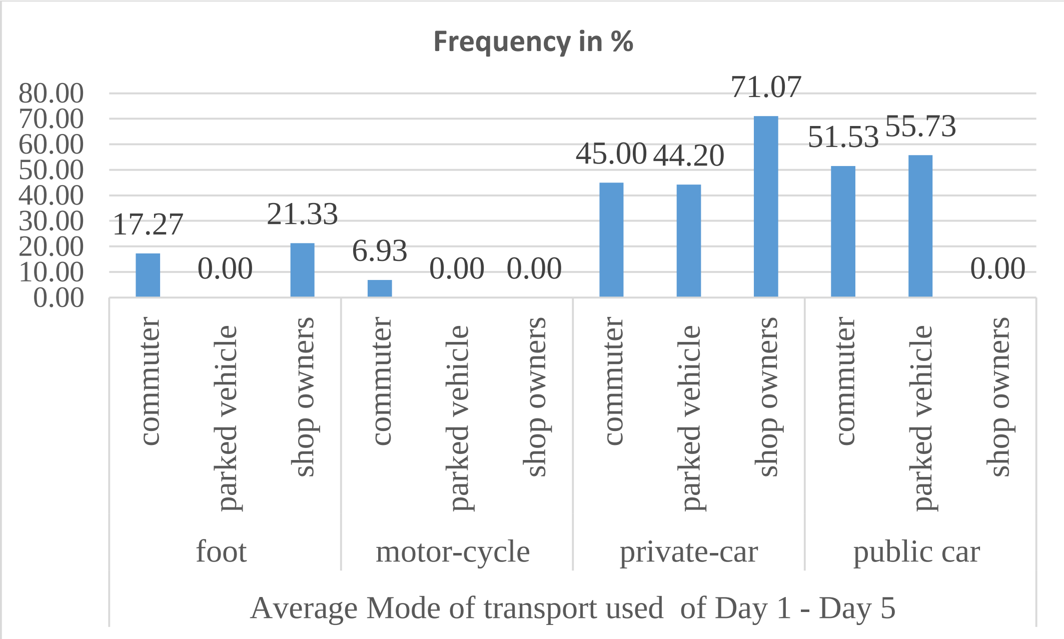

Figure 4.11: Average mode of transportation of the Day 1 to Day 5 source: author's field survey, 2024.

4.4. Impact of on-street parking availability

4.4.1. Effects on travel time

This research analyzed basically on four different routes that are in four different directions with different lengths. They all have different traffic characteristics and it is important to know the effect as well. The absence of pre-designed On-street parking availability in the study area is making traffic mobility difficult. In this research, the following main routes are selected to analyze their impact level on the economy, environmental, and social aspects.

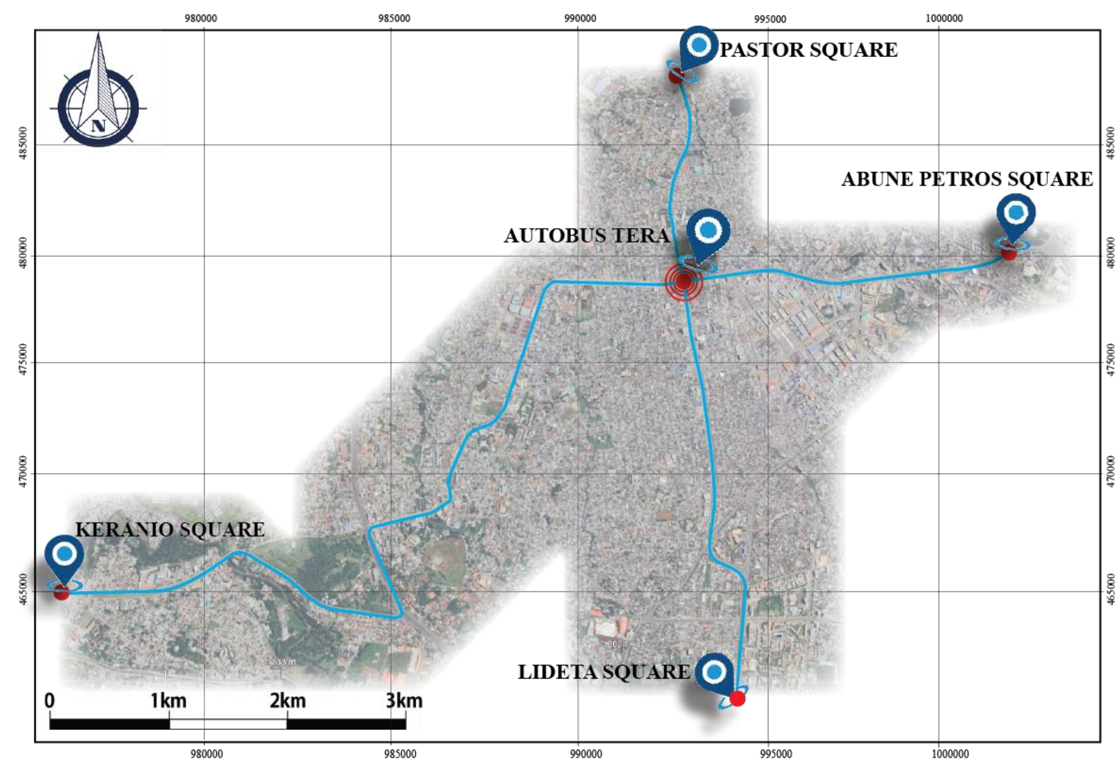

Figure 4.12: selected routes

A. Abune petros to autobus tera

This portion of the road spans a distance of 2.4 kilometers, extending from Abune Petros Square to Autobis Tera and then back from Autobis Tera to Abune Petros Square. It serves as a route for both the traffic originating from Abune Petros Square and the residential areas. The provided figure illustrates the flow of traffic during peak hours in the morning and evening, when employed individuals commute to and from their workplaces (as indicated in Table 4.2).

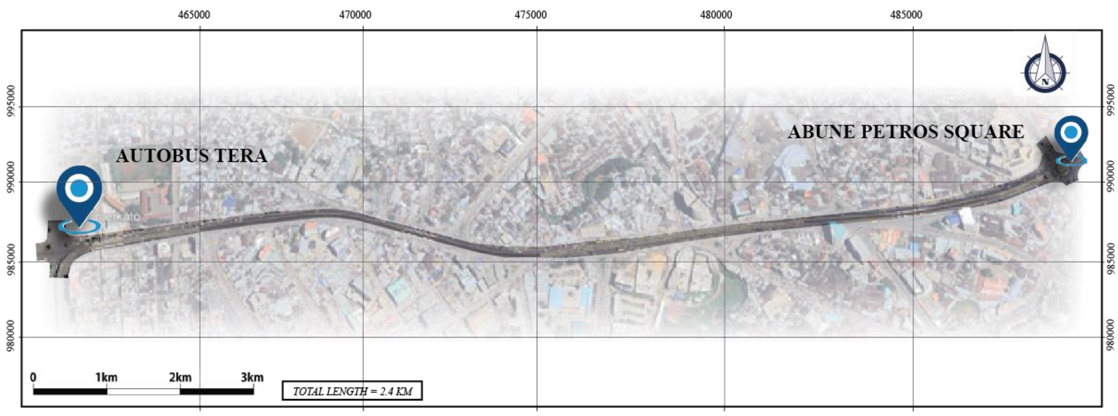

Figure 4.13: From Abune petros to autobus tera route

The table 4.2 below illustrated the peak period travel time, average kilometers, average speed, and free flow travel time of route from Abune petros to autobus tera.

Table 4.2: Peak period travel time from abune petros to autobus tera and vice versa.

From Abune petros to autobus tera									
From home to work place	Average time it takes(minute)	Average km	Average speed km/hr	From work place to home	Average time it takes(hr)	Average km	Average speed km/hr	design speed	FFTT(minute)
7:00 am-7:33 am	33	2.4	4.40	6:45 pm-7:20 pm	35	2.4	4.11	40	3.6
7:10 am-7:40 am	30	2.4	4.80	5:05 pm-6:00 pm	55	2.4	2.62	40	3.6
7:30 am-8:10 am	40	2.4	3.60	4:25 pm-5:00 pm	35	2.4	4.11	40	3.6
8:00 am-8:45 am	45	2.4	3.20	6:40 pm - 7:30 pm	50	2.4	2.88	40	3.6
8:30 am -8:13 am	43	2.4	3.35	6:50pm - 7:45 pm	55	2.4	2.62	40	3.6
8:15 am-9:10 am	55	2.4	2.62	4:00 pm-5:57 pm	57	2.4	2.53	40	3.6
7:20 am-7:52 am	32	2.4	4.50	6:40 pm-7:20 pm	40	2.4	3.60	40	3.6
8:15 am-9:00 am	45	2.4	3.20	4:45 pm-5:18 pm	33	2.4	4.36	40	3.6
7:00 am-7:30 am	30	2.4	4.80	5:00 pm - 5:55 pm	55	2.4	2.62	40	3.6
7:45 am-8:20 am	35	2.4	4.11	5:30 pm - 6:20 pm	50	2.4	2.88	40	3.6

Free-flow travel time is considered based on the Addis Ababa Transport Programs Management Office ranges between 30 to 50 km/hr and the average speed is considered 40 km/hr (Addis Ababa City Structure Plan, 2017). Since the average length from Abune Petros to Autobis Tera is 2.4 km, so according to the basic equation of physics the free flow travel time from Abune Petros square to Autobis Tera is 3.6 minutes. The total free flow time the workers commute from home to their work station and back from work station to home it takes 7.2 minutes. However, this is not practically worked. The actual travel time is calculated by the following basic equation of formula (Engineering Mechanics, by Russell C. Hibbeler).

$$Speed(v) = \frac{Distance\ traveled}{Time\ taken\ to\ travel} = \frac{S}{T} - -Engineering\ Mechanics, by\ Russell\ C. Hibbeler (1)$$

From the equation 1, we can calculate the time as follows.

$$Time(T) = \frac{Distance\ traveled}{design\ Speed}$$
$$= \frac{S}{V} --- Engineering\ Mechanics, by\ Russell\ C.Hibbeler(2)$$

$$Time(T) = \frac{2.4\ km}{40\ KPH} = 3.6\ minute$$

Table: 4.3: Total average time lost from work to home and vise versa of Abune Petros to autobus tera

Routes	ATT from home to work(minute)	ATT from work to home (minute)	FFTT (minute)	Time Loss from home to work (minute) / ATT - FFTT	Time Loss from work to hone(minute)/ ATT - FFTT	Time value in ETB/hr.	Total time loss due to congestion (hr.)	Total ETB lost due to total time loss per day
From Abune petros to autobus tera	38.8	46.5	3.6	35.2	42.9	51	1.30	66.39

From the above formula, we get a FFTT (free flow travel time) by using the design speed of the urban area that is sated by the Addis Ababa City Structure Plan, 2017. The total FFTT becomes the round trip which is 7.2 minutes. However, as per the collected data from surveying the total average time travel is 85.3 minutes (1.42 hr.). From here every individual is wasting their time on transportation due to the congestion through on-street parking.

$$Time\ loss = ATT(Average\ time\ travel) - FFTT(Free\ flow\ time\ travel) --- (3)$$

$$Time\ loss = 85.3\,\text{min} - 7.2\ min = 78.1\ minutes\ lost$$

Time loss <u>1 hour and 18.1 minutes</u>.

Generally, every individual spent an additional 78.1 minutes on transportation. It makes them deduct on average 78.1 minutes from their active work time per day. This intern impacts their work in different dimensions.

B. Lideta square to autobus tera

This particular stretch of road covers a distance of 3.00 kilometers and connects Lideta Square to Autobis Tera, forming a roundtrip route. It serves as a crucial pathway for both the traffic coming from Lideta Square and the nearby residential areas.

The accompanying figure provides a visual representation of the traffic patterns during the busiest hours of the day, specifically in the morning and evening. This is when employed individuals typically travel to and from their workplaces. The data presented in Table 4.3 further supports this analysis.

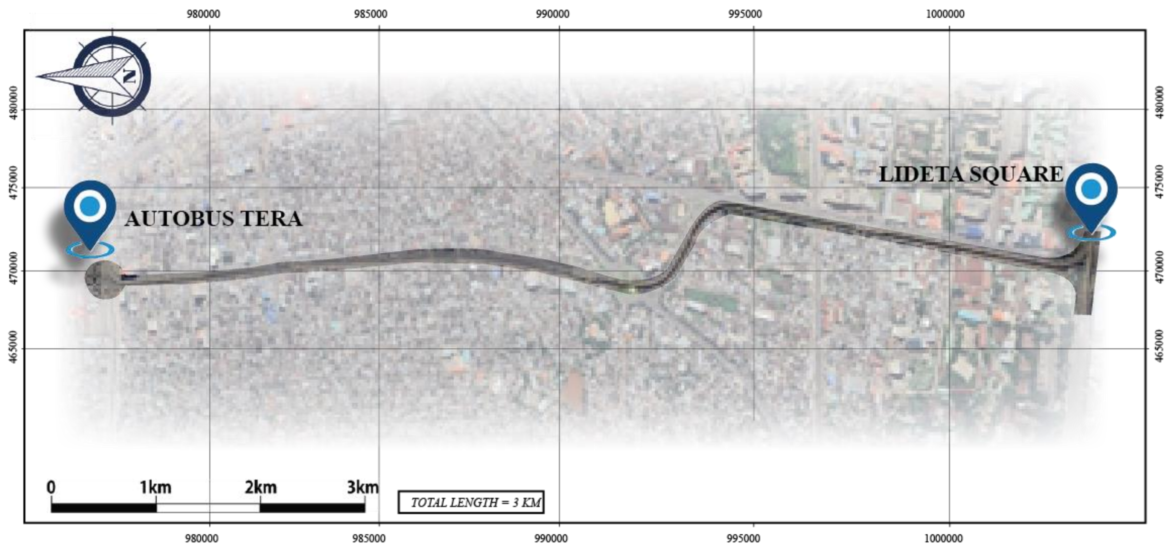

Figure 4.14: From Lideta square to autobus tera route

Table 4.4: Peak period travel time from Lideta square to autobus tera and vice versa.

Lideta to Autobus tera									
From home to work place	Average time it takes(minute)	Average km	Average speed km/hr	From work place to home	Average time it takes(hr)	Average km	Average speed km/hr	design speed(km/hr.)	FFTT(minute)
7:00 am- 7:42 am	42	3	4.29	6:45 pm- 7:30 pm	45	3	4.00	40	4.5
7:05 am- 7:40 am	35	3	5.14	5:05 pm- 5:40 pm	45	3	4.00	40	4.5
7:30 am- 8:15 am	45	3	4.00	4:25 pm- 5:00 pm	35	3	5.14	40	4.5
8:00 am- 8:50 am	50	3	3.60	6:40 pm - 7:20 pm	40	3	4.50	40	4.5
8:30 am - 8:15 am	45	3	4.00	6:30 pm - 7:00 pm	30	3	6.00	40	4.5
8:20 am- 9:15 am	55	3	3.27	4:00 pm- 5:40 pm	40	3	4.50	40	4.5
7:20 am- 8:00 am	40	3	4.50	6:40 pm- 7:15 pm	35	3	5.14	40	4.5
8:15 am- 9:05 am	50	3	3.60	4:50 pm- 5:22 pm	32	3	5.63	40	4.5
7:00 am-	30	3	6.00	5:00 pm -	34	3	5.29	40	4.5

7:30 am				5:34 pm					
7:45 am- 8:15 am	30	3	6.00	5:30 pm - 6:10 pm	40	3	4.50	40	4.5

Free-flow travel time is considered as based on Addis Ababa Transport Programs Management Office range between 30 to 50 km/hr and the average speed is considers 40 km/hr (Addis Ababa City Structure Plan, 2017). Since the average length from Lideta square to Autobis Tera is 2.4 km, so according to basic equation of physics the free flow travel time from Lideta square to Autobis Tera is 4.5 minute. The total free flow time the workers commute from home to their work station and back work station to home it takes 9.00 minutes.

$$Speed(v) = \frac{Distance\ traveled}{Time\ taken\ to\ travel}$$
$$= \frac{S}{T} - -Engineering\ Mechanics, by\ Russell\ C. Hibbeler(4)$$

From the equation 1, we can calculate the time as follows.

$$Time(T) = \frac{Distance\ traveled}{design\ Speed}$$
$$= \frac{S}{V} - - - Engineering\ Mechanics, by\ Russell\ C. Hibbeler(5)$$

$$Time(T) = \frac{3.0\ km}{40\ KPH} = 4.5\ minute$$

Table:4.5: Total average time lost from work to home and vise versa of Lideta to autobus tera

Routes	ATT from home to work(minute)	ATT from work to home (minute)	FFTT (minute)	Time Loss from home to work (minute) / ATT - FFTT	Time Loss from work to hone(minute)/ ATT - FFTT	Time value in ETB/hr.	Total time loss due to congestion (hr.)	Total ETB lost due to total time loss per day
Lideta to Autobus tera	42.2	43.2	4.5	37.7	38.7	51	1.27	64.94

From the above formula we get a FFTT (free flow travel time) by using the design speed of the urban area that is sated by Addis Ababa City Structure Plan, 2017. The total FFTT is becomes the round trip which is 9 minutes. However, as per the collected data from surveying the total average time travel is 85.4 minutes (1.42 hr.)

From here every individual is wasting their time on transportation due to the congestion through on-street parking.

$$Time\ loss = ATT(Average\ time\ travel) - FFTT(Free\ flow\ time\ travel) - - - (6)$$

$$Time\ loss = 85.4\,\text{min} - 9\ min = 76.4\ minutes\ lost$$

Time loss = 1 hour and 16.4 minutes.

Generally, every individual spent an additional 76.4 minutes on transportation.

It makes them to deduct at average 76.4 minutes from their active work time per day. This intern impacts their work in different dimensions.

C. Pastor square to autobus tera

In this specific area, there is a road that covers a length of 1.30 kilometers. This road connects Pastor Square to Autobis Tera and forms a roundtrip route. It plays a vital role in facilitating traffic flow from both Pastor Square and the nearby residential areas. During peak hours in the morning and evening, when people are commuting to and from work, this road experiences heavy traffic. The accompanying figure visually represents this traffic pattern, and the data presented in Table 4.4 further supports this observation.

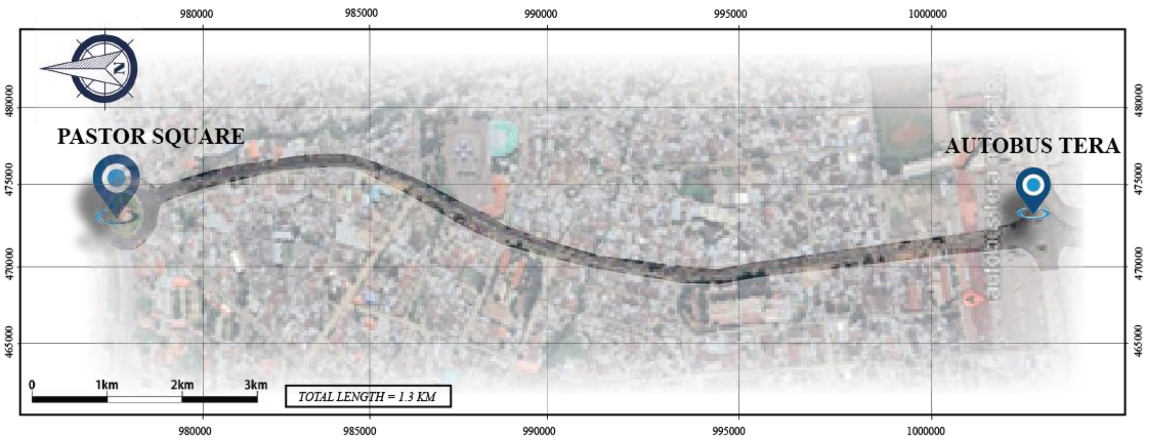

Figure 4.15: From pastor square to autobus tera route

Table 4.6: Peak period travel time from Pastor square to autobus tera and vice versa.

Pastor square to Autobus tera									
From home to work place	Average time it takes(minute)	Average km	Average speed km/hr	From work place to home	Average time it takes(minute)	Average km	Average speed km/hr	design speed	FFTT(minute)
7:00 am-7:20 am	20	1.3	3.9	6:45 pm-7:10 pm	25	1.3	3.12	40	1.95
7:15 am- 7:40 am	25	1.3	3.12	5:05 pm-5:31 pm	26	1.3	3.00	40	1.95
7:40 am- 8:04 am	24	1.3	3.25	4:40 pm-5:05 pm	25	1.3	3.12	40	1.95
8:00 am-8:18 am	18	1.3	4.33	6:50 pm -7:10 pm	20	1.3	3.90	40	1.95
8:30 am -8:51 am	21	1.3	3.71	6:50pm -7:10 pm	20	1.3	3.90	40	1.95
8:40am-9:05 am	25	1.3	3.12	4:00 pm-5:26 pm	26	1.3	3.00	40	1.95
7:30 am-7:48 am	18	1.3	4.33	6:40 pm-7:00 pm	20	1.3	3.90	40	1.95
8:15 am-8:05 am	20	1.3	3.9	4:05 pm-5:27 pm	22	1.3	3.55	40	1.95
7:05 am-7:30 am	25	1.3	3.12	5:00 pm - 5:27 pm	27	1.3	2.89	40	1.95
7:40 am-8:00 am	20	1.3	3.9	5:00 pm -6:20 pm	20	1.3	3.90	40	1.95

Free-flow travel time considers as based on Addis Ababa Transport Programs Management Office range between 30 to 50 km/hr and the average speed is considers 40 km/hr (Addis Ababa City Structure Plan, 2017). Since the average length from Pastor square to Autobis Tera is 1.3 km, so according to the basic equation of physics the free flow travel time from Pastor square to Autobis Tera is 1.95 minutes. The total free flow time the workers commute from home to their work station and back from work station to home it takes 3.9 minutes.

$$Speed(v) = \frac{Distance\ traveled}{Time\ taken\ to\ travel} = \frac{S}{T} ----Fundamental\ equation\ of\ physics(7)$$

From the equation 1, we can calculate the time as follows.

$$Time(T) = \frac{Distance\ traveled}{design\ Speed} = \frac{S}{V} ----Fundamental\ equation\ of\ physics(8)$$

$$Time(T) = \frac{1.3\ km}{40\ KPH} = 1.95\ minute$$

Table:4.7: Total average time lost from work to home and vice versa of Pastor to autobus tera

Routes	ATT from home to work(minute)	ATT from work to home (minute)	FFTT (minute)	Time Loss from home to work (minute) / ATT - FFTT	Time Loss from work to hone(minute)/ ATT - FFTT	Time value in ETB/hr.	Total time loss due to congestion (hr.)	Total ETB lost due to total time loss per day
Pastor square to Autobus tera	21.6	23.1	1.95	19.65	21.15	51	0.68	34.68

From the above formula we get a FFTT (free flow travel time) by using the design speed of the urban area that is sated by Addis Ababa City Structure Plan, 2017. The total FFTT is becomes the round trip which is 3.9 minutes. However, as per the collected data from surveying the total average time travel is 44.7 minutes (0.75 hr.).

From here every individuals are wasting their time on transportation due to the congestion through on-street parking.

$$Time\ loss = ATT(Average\ time\ travel) - FFTT(Free\ flow\ time\ travel) --- (9)$$

$$Time\ loss = 44.7\ \text{min} - 3.9\ min = 40.8\ minutes\ lost$$

Time loss= 0 hours and 40.8 minutes.

Generally, each and every individuals spent additional 76.4 minutes on transportation. It makes them to deduct at average 40.8 minutes from their active work time per day. This intern impacts their work in different dimensions.

D. Keranio square to autobus tera

This segment of the road covers a length of 5.60 kilometers, connecting Keranio Square to Autobis Tera and forming a roundtrip route. It plays a crucial role as a pathway for both the traffic coming from Keranio Square and the nearby residential areas. The figure provided offers a visual representation of the traffic patterns during the busiest hours of the day, specifically in the morning and evening. These peak hours correspond to the times when employed individuals typically travel to and from their workplaces, as indicated in Table 4.5.The road serves as a vital transportation link within the city, facilitating the daily commute for many residents.

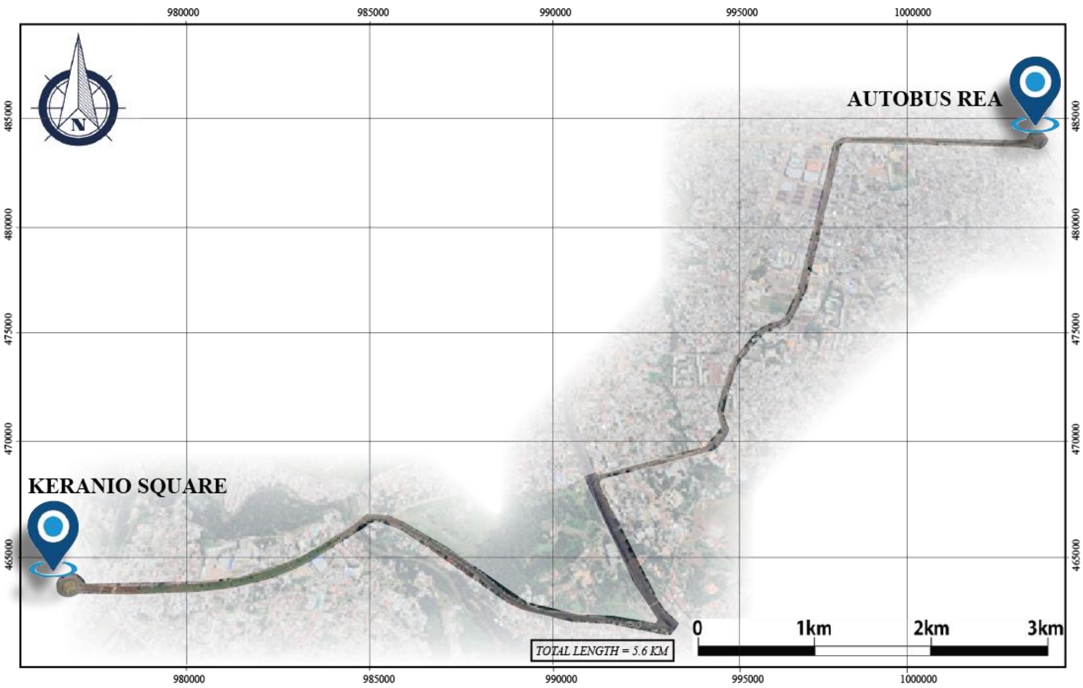

Figure 4.16: From Keranio square to autobus tera route

Table:4.8: Peak period travel time from keranio square to autobus tera and vice versa.

Keranio square to Autobus tera									
From home to work place	Average time it takes(minute)	Average km	Average speed km/hr	From work place to home	Average time it takes(minute)	Average km	Average speed km/hr	design speed	FFTT(minute)
7:10 am-8:35 am	75	5.6	4.48	6:45 pm-8:15 pm	80	5.6	4.20	40	8.4
7:00 am-8:12 am	72	5.6	4.67	5:05 pm-6:19 pm	74	5.6	4.54	40	8.4
7:30 am- 8:40 am	70	5.6	4.8	4:25 pm-5:45 pm	70	5.6	4.80	40	8.4
8:00 am-9:15 am	75	5.6	4.48	6:30 pm -7:48 pm	78	5.6	4.31	40	8.4
8:30 am -9:50 am	70	5.6	4.8	6:50pm -8:05 pm	75	5.6	4.48	40	8.4
8:15 am-9:20 am	65	5.6	5.17	4:00 pm-5:22 pm	72	5.6	4.67	40	8.4
7:10 am-8:37 am	77	5.6	4.36	6:40 pm-7:50 pm	70	5.6	4.80	40	8.4
8:15 am-9:30 am	75	5.6	4.48	4:45 pm-5:50 pm	65	5.6	5.17	40	8.4
7:00 am-8:15 am	75	5.6	4.48	4:50 pm - 6:13 pm	73	5.6	4.60	40	8.4
7:40 am-8:50 am	70	5.6	4.8	5:30 pm -6:40 pm	70	5.6	4.80	40	8.4

Free-flow travel time considers as based on Addis Ababa Transport Programs Management Office range between 30 to 50 km/hr and the average speed is considers 40 km/hr (Addis Ababa City Structure Plan, 2017). Since the average length from Keranio square to Autobis

Tera is 5.6 km, so according to basic equation of physics the free flow travel time from Keranio square to Autobis Tera is 8.4 minute. The total free flow time the workers commute from home to their work station and back work station to home it takes 16.8 minutes.

$$Speed(v) = \frac{Distance\ traveled}{Time\ taken\ to\ travel} = \frac{S}{T} - - - - Fundamental\ equation\ of\ physics (10)$$

From the equation 1, we can calculate the time as follows.

$$Time(T) = \frac{Distance\ traveled}{design\ Speed} = \frac{S}{V} - - - - Fundamental\ equation\ of\ physics (11)$$

$$Time(T) = \frac{5.6\ km}{40\ KPH} = 8.4\ minute$$

Table:4.9: Total average time lost from work to home and vice versa of Keranio to autobus tera

Routes	ATT from home to work(minute)	ATT from work to home (minute)	FFTT (minute)	Time Loss from home to work (minute) / ATT - FFTT	Time Loss from work to hone(minute)/ ATT - FFTT	Time value in ETB/hr.	Total time loss due to congestion (hr.)	Total ETB lost due to total time loss per day
Keranio square to Autobus tera	72.4	72.7	8.4	64	64.3	51	2.14	109.06

From the above formula we get a FFTT (free flow travel time) by using the design speed of the urban area that is sated by Addis Ababa City Structure Plan, 2017. The total FFTT is becomes the round trip which is 16.8 minutes. However, as per the collected data from surveying the total average time travel is 145.1 minutes (2.42 hr.).

From here every individuals are wasting their time on transportation due to the congestion through on-street parking.

$$Time\ loss = ATT(Average\ time\ travel) - FFTT(Free\ flow\ time\ travel) - - - (12)$$

$$Time\ loss = 145.1\ \mathrm{min} - 16.8\ min = 128.3\ minutes\ lost$$

Time loss = 2 hour and 8.3 minutes.

Generally, each and every individuals spent additional 128.3 minutes on transportation. It makes them to deduct at average 128.3 minutes from their active work time per day. This intern impacts their work in different dimensions.

Economic Impact

The congestion caused by the lack of parking leads to increased travel time, resulting in reduced efficiency for employed individuals. To further illustrate the impact of this congestion, Table 4.6 provides a summary of the financial losses in Birr per day for selected routes due to traffic congestion.

As per salary explorer 2017 in Ethiopia, the average ETB paid per hour for the employed is 51 birr. Each individual are expected to do 22 days per month (salary explorer, 2017). The following table showed the time lost in each routes and corresponding money loss. The total money lost per day was calculated by multiplying 51 ETB with its associated time lost.

Table 4.10: Impact summery on Economy of individuals due to congestion

Impact summery on Economy of individuals by congestion due to on-street parking								
Routes	ATT from home to work(minute)	ATT from work to home (minute)	FFTT (minute)	Time Loss from home to work (minute) / ATT - FFTT	Time Loss from work to hone(minute)/ ATT - FFTT	Time value in ETB/hr.	Total time loss due to congestion (hr.)	Total ETB lost due to total time loss per day
From Abune petros to autobus tera	38.8	46.5	3.6	35.2	42.9	51	1.30	66.39
Lideta to Autobus tera	42.2	43.2	4.5	37.7	38.7	51	1.27	64.94
Pastor square to Autobus tera	21.6	23.1	1.95	19.65	21.15	51	0.68	34.68
Keranio square to Autobus tera	72.4	72.7	8.4	64	64.3	51	2.14	109.06

The economic impact of long travel time, specifically due to the existence of time loss, is a significant factor that affects productivity, efficiency, and overall economic performance. According to economic theories, such as the Time-Value of Money and Opportunity Cost, the concept of time loss suggests that the time spent on travel could have been utilized for more productive activities. This lost time translates into tangible costs, including reduced working hours, decreased output, and missed business opportunities. Additionally, transportation costs, such as fuel expenses and maintenance, further contribute to the economic burden. Mitigating the negative economic impact of long travel time requires investments in transportation infrastructure, innovative transportation solutions, and flexible work arrangements that minimize time loss and enhance productivity.

The table 4.10. Provides information on four routes, including the average travel time (ATT) from home to work and work to home, as well as the Free Flow Travel Time (FFTT) for each route. It also presents the time loss due to congestion for each direction, calculated by subtracting the FFTT from the actual travel time. Additionally, it includes the total time loss due to congestion for each route and the corresponding monetary value in Ethiopian Birr (ETB) lost per hour.

Analyzing the data, we can observe that the route from Abune Petros to Autobus Tera has an average travel time of 38.8 minutes from home to work and 46.5 minutes from work to home. The Free Flow Travel Time for this route is 3.6 minutes. Consequently, there is a significant time loss of 35.2 minutes from home to work and 42.9 minutes from work to home due to congestion. This results in a total time loss of 1.30 hours per day and a corresponding loss of 66.39 ETB. Considering the employed works for 22 days per month excluding the weekends each individual is losing time that has a value of **1,460.58** birr per month due to the congestion of traffic through on-street parking as a major cause.

Similarly, the Lideta to Autobus Tera route has an average travel time of 42.2 minutes from home to work and 43.2 minutes from work to home. The Free Flow Travel Time for this route is 4.5 minutes. Hence, the time loss due to congestion is 37.7 minutes from home to work and 38.7 minutes from work to home. The total time loss per day is 1.27 hours, resulting in a loss of 64.94 ETB. Considering the employed works for 22 days per month excluding the weekends each individual is losing time that has a value of **1,428.68** birr per month due to the congestion of traffic through on-street parking as a major cause.

Furthermore, the Pastor Square to Autobus Tera route has an average travel time of 21.6 minutes from home to work and 23.1 minutes from work to home. The Free Flow Travel Time for this route is 1.95 minutes. Consequently, there is a time loss of 19.65 minutes from home to work and 21.15 minutes from work to home due to congestion. This leads to a total time loss of 0.68 hours per day and a corresponding loss of 34.68 ETB. Considering the employed works for 22 days per month excluding the weekends each individual is losing time that has a value of **762.96** birr per month due to the congestion of traffic through on-street parking as a major cause.

Lastly, the Keranio Square to Autobus Tera route has an average travel time of 72.4 minutes from home to work and 72.7 minutes from work to home. The Free Flow Travel Time for this route is 8.4 minutes. Thus, there is a substantial time loss of 64 minutes from home to work and 64.3 minutes from work to home due to congestion. The total time loss per day is 2.14 hours, resulting in a loss of 109.06 ETB. Considering the employed works for 22 days per month excluding the weekends each individual is losing time that has a value of **2,399.32** birr per month due to the congestion of traffic through on-street parking as a major cause.

Environmental Impact

Respondents strongly support the notion that on-street parking around Autobis Tera is a major cause of traffic congestion, leading to heightened fuel consumption and subsequent greenhouse gas emissions by the moving cars. As a direct consequence of these emissions, air quality in the area has a chance to deteriorate. The respondents' collective perspective provides significant evidence for the environmental impact of on-street parking on traffic congestion, fuel consumption, greenhouse gas emissions, and overall air quality decline.

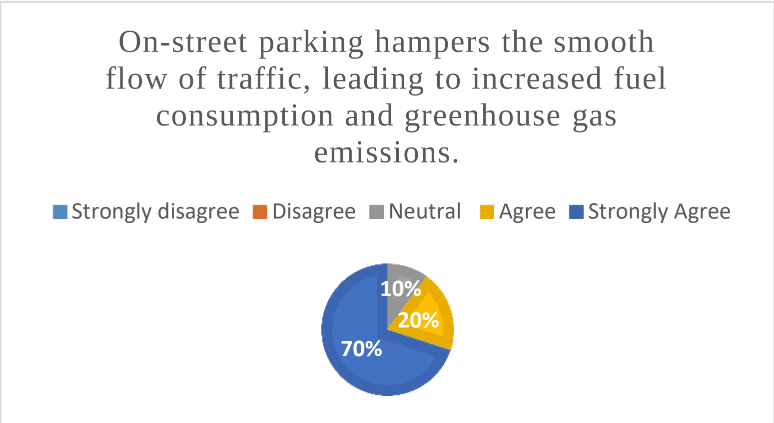

Figure 4.17: greenhouse gas emission and high fuel consumption due to the existence of unorganized on street parking

Based on the data provided, it is evident that a significant majority of respondents strongly agree, and agree (Specifically, 70% strongly agreed, 20% agreed, and 10% strongly disagreed) that on-street parking hampers the smooth flow of traffic, leading to increased fuel consumption and greenhouse gas emissions. This consensus emphasizes the need for effective parking management strategies to address the issue and mitigate its negative impacts. By implementing measures to alleviate congestion caused by on-street parking, cities can promote more efficient transportation systems, reduce traffic congestion, and contribute to environmental sustainability.

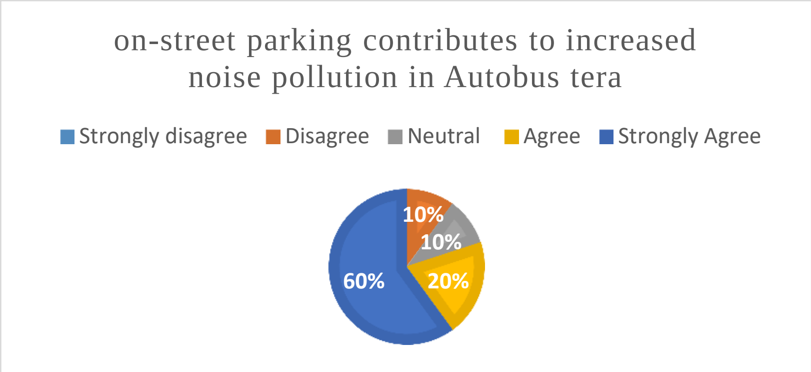

Figure 4.18: noise pollution due to the existence of unorganized on street parking

The data in Fig 4.16 reveals that a majority of respondents, consisting of 60% strongly agreeing and 20% agreeing, believe that on-street parking contributes to increased noise pollution in Autobus tera. The absence of any strong disagreement further strengthens this viewpoint. The implications are clear: there is a pressing need to address the issue of noise pollution caused by on-street parking in Autobus Tera. Implementing measures such as improved parking management, and alternative transportation options enhances the quality of life for users and creates a more peaceful environment in Autobus tera.

Table 4.11: impact of on street parking on environmental issues

Challenges	Strongly disagree(%)	Disagree(%)	Neutral(%)	Agree(%)	Strongly Agree(%)
The availability of on-street parking affects the overall air quality in Autobus Tera.	10	10	10	40	30
The lack of well-designed on-street parking spaces contributes to increased traffic congestion and vehicle emissions in Autobus tera.				20	80

The availability of on-street parking influences the use of alternative modes of transportation, such as walking, driving, or cycling, leading to reduced environmental impact.	10			20	70
The availability of on-street parking affects the overall aesthetics and green spaces in Autobus Tera.		10	10	20	60
on-street parking influences the use of public transportation, leading to reduced traffic congestion and environmental pollution				30	70
The lack of on-street parking spaces contributes to increased stress and frustration among drivers.				30	70
On-street parking hampers the smooth flow of traffic, leading to increased fuel consumption and greenhouse gas emissions.			10	20	70
on-street parking contributes to increased noise pollution in Autobus tera		10	10	20	60
on-street parking affects the overall traffic flow and road safety, leading to potential accidents and hazards in Autobus tera			10	40	50

4.5. On street parking Occupancy

Around Autobus Tera, it operates without a deliberately planned or well-designed on-street parking system, leading to the issue of private cars being parked on the road instead. This practice is illegal and has detrimental consequences. It diminishes the available width of the road, but it also amplifies congestion levels and increases travel time. Generally, the presence of unlawfully parked vehicles creates bottlenecks for urban motilities. Consequently, the flow of vehicles is impeded, causing delays and inconvenience for both the autobus service and other commuters.

Table 4.12: Average on street parking occupancy of Day 1 to Day 5

Averrage onstreet parking occupancy of five days(Day 1 – Day 5)							
segment(m)	location from	road width(m)	net road area, median excluding (m2)	occupied space by on street parked vehicles(m2)	% tage occupaied	middian(m)	remark
0 to 200	Autobus tera to Fit H/ Georgis street(west)	20	3400	642.40	19.00	3	two way road
200 -400	Autobus tera to Fit H/ Georgis street(west)	20	3400	467.60	13.76	3	two way road
400-800	Autobus tera to Fit H/ Georgis street(west)	20	6800	628.80	9.24	3	two way road
0 to 200	Autobus tera to Somali street	15	3000	807.20	26.90	-	One way road
200 -400	Autobus tera to somali street	15	3000	312.00	10.40	-	One way road
400-800	Autobus tera to Somali street	15	6000	483.60	8.06	-	One way road
0 to 200	Autobus tera to central africa street	30	4000	1024.4	25.62	10	two way road
200 -400	Autobus tera to central africa street	30	4000	774.80	19.38	10	two way road
400-800	Autobus tera to central africa street	30	8000	863.20	10.80	10	two way road
0 to 200	Autobus tera to fit H/ Georgis street(east)	30	4000	795.60	19.90	10	two way road
200 -400	Autobus tera to fit H/ Georgis street(east)	30	4000	624.00	15.60	10	two way road
400-800	Autobus tera to fit H/ Georgis street(east)	30	8000	702.00	8.78	10	two way road

In Table 4.12 the average on-street parking occupancy along the four different routes of 800 m (each side) is analyzed. The routes are Autobus Tera to Fit H/Georgis Street (east), Autobus Tera to Fit H/Georgis Street (west), Autobus Tera to somalii street, and Autobus Tera to central Africa Street. The corridors are experiencing congestion due to street parking.

In the segment ranging from 0 to 200, 200 to 400, and 400 to 800 meters from autobus tera as a landmark, the average road area that is occupied through the study was 22.75 %, 14.79

%, and 9.22 % respectively. The traffic flow at the center (autobus tera) is very high as we go from it to the other routes. That is why the researcher found such values above.

Traffic Congestion

On the study area the roads are busy and congested through different causes. The main cause for the congestion is illegal on street parking. Different are parked on the main road so that the capacity of the road to be served is very low. The following are some of the images that were captured by the researcher during the study.

As figure 4.19 illustrated all types of mode of transportation system parked on the main road illegally and it becomes the major cause to minimize the road capacity to pass as it designed before.

Figure 4.19: illegal on street parking

As figure 4.20 illustrated there is no well-designed taxi/city bus terminals. The cars are parked by overlapping each other. This has a capacity to close and minimize the road efficiency of the city.

Figure 4.20: improper taxi/bus terminal space design

Figure 4.21: poor road signage

Poor road signage:- around the study area there is a poor road signage to guide drivers like not stop here, and other regulatory signage’s.

Figure 4.22: shop owners vehicles that ore parked on the main road

Congestion parameters include average travel speed, delay, volume or demand, density, saturation flow rate, and capacity. In this study for urban streets, average traffic speed was considered for congestion evaluation for selected street networks.

Congestion: Limited on-street parking availability can contribute to increased congestion on roads. When drivers cannot find parking spaces, they may circle the area or double-park, causing traffic disruptions and slower travel times for other vehicles.

Congestion Analysis

The collected data was subjected to rigorous analysis using various mathematical computations and simple descriptive statistics. Percentages were calculated to determine the proportion of respondents falling into different categories. Mean values were calculated to determine the average response or outcome of interest. The researcher analyzed the delays for each route to help calculate the congestion index for the respective routes. The Freeflow travel time (FFTT) is calculated with a basic equation of physics by using the parameters of length and design speed (provided by Addis Ababa City Structure Plan, 2017).

The congestion index is calculated using the following simple equation.

$$CI = \frac{Delay}{FFTT} - - - - - - - - (13)$$

$$Delay = ATT - FFTT - - - -(14)$$

The study involved a sample of 384 respondents who were surveyed during the data collection process, with each of the 4 selected routes containing 96 respondents. This ensured a representative sample size for each route, allowing for valid analysis and meaningful comparisons.

To tackle the problem of traffic congestion, various measures have been developed for the identification and quantification of traffic congestion by various researchers. These measures can help find the degree of traffic congestion and the performance of the roadway. We are categorizing these measures into three parts: Travel time-based, speed-based, and level of service based (Table 4.11).

Table 4.13: illustration of traffic congestion using travel time based

	Travel time based: Travel time, which refers to the duration it takes for a vehicle to traverse a specific road segment, serves as a crucial factor in analyzing traffic congestion. The assessment of Urban Link's effectiveness was carried out by considering travel time as a key metric. Below are several indicators associated with the measurement of travel time.
Delay	Delay is a metric utilized to measure the extent of traffic congestion. It refers to the additional time required to travel a certain distance compared to the expected travel duration. In the study conducted by Lomax et al. (1997), delay was defined as the discrepancy between the free-flow travel time (FFTT) and the average travel time (ATT). Delay = ATT - FFTT
Congestion index (CI)	The CI measure refers to the ratio between the delay and the free-flow travel time (FFTT). In this context, delay is defined as the disparity between the average travel time (ATT) and the free-flow travel time (FFTT). To promote improved traffic management, it is desirable to minimize the average travel time (ATT) for commuters, as suggested by Karuppanagounder and Muneera (2017). The congestion index for a road link can be determined by utilizing travel time as : $\text{CI}=\frac{Delay}{FFTT}$
Travel time index	The TTI (Travel Time Index) is an index that represents the ratio between peak period travel time (PPTT) and free-flow travel time (FFTT), as described by Lomax and Schrank (2005). This measure is applicable in situations of both recurring and incident-related traffic

(TTI)	congestion, as highlighted by Rao and Rao (2012). $$\text{TTI}=\frac{PPTT}{FFTT}$$
Travel time index (TTI)	The TTI (Travel Time Index) is a ratio that compares the average travel time (ATT) to the free-flow travel time (FFTT), as explained by Karuppanagounder and Muneera (2017). To achieve improved traffic performance, the TTI should be as low as possible. $$\text{TTI}=\frac{ATT}{FFTT}$$

According to the standards of the congestion index, the following statements describe more.

Low Congestion (CI < 1): A congestion index below 1 indicates that the average travel time is lower than the free-flow travel time, suggesting minimal or no congestion. This means that the traffic flow is generally smooth, and drivers experience little delay.

Moderate Congestion (1 < CI < 1.5): A congestion index between 1 and 1.5 suggests moderate congestion. It indicates that the average travel time is slightly higher than the free-flow travel time, resulting in some delay. Traffic conditions may be moderately congested, but the flow remains relatively stable.

High Congestion (CI > 1.5): A congestion index above 1.5 indicates significant congestion. This means that the average travel time is considerably higher than the free-flow travel time, resulting in substantial delays. Traffic conditions may be congested, and drivers can expect significant travel time increases.

Table 4.14: from home to work delay and traffic time index of the selected routes

From Home to work					
Route	ATT	FFTT	Delay= ATT- FFTT	CI = Delay/ FFTT	TTI= ATT/FFTT
From Abune petros to autobus tera	38.80	3.60	35.20	9.78	10.78
Lideta to Autobus tera	42.20	4.50	37.70	8.38	9.38
Pastor square to Autobus tera	21.60	1.95	19.65	10.08	11.08
kolfe keranyo to Autobus tera	72.40	8.40	64.00	7.62	8.62

Since all routes in Table 4.14 have a congestion index of more than 1.5, they experience high congestion from home to work. This means that the average travel time is considerably higher than the free-flow travel time, resulting in substantial delays. Traffic conditions are congested, and drivers expect significant travel time increases.

Table 4.14 provides data representing different measurements related to travel time from home to work, including Actual Travel Time (ATT), Free Flow Travel Time (FFTT), Delay (the difference between ATT and FFTT), Congestion Index (CI), and Travel Time Index (TTI). Analyzing the values of TTI and CI, it is evident that there is a variation in the level of congestion experienced during the commute. The TTI values, which indicate the ratio of actual travel time to free flow travel time, range from 8.62 to 11.08, suggesting differing levels of congestion. A higher TTI value signifies more congestion and slower travel times. Similarly, the CI values, representing the delay as a percentage of FFTT, range from 7.62 to 10.08, further indicating variations in congestion levels. These values suggest that the commute experiences different levels of congestion, with some instances exhibiting higher congestion and longer travel times compared to others. Addressing the factors contributing to congestion, such as traffic management, infrastructure improvements, and alternative transportation solutions, can help alleviate congestion, reduce travel times, and improve the overall efficiency of commuting from home to work.

Table 4.15: from work to home delay and traffic time index of the selected routes

From work to Home					
Route	ATT	FFTT	Delay= ATT-FFTT	CI = Delay/ FFTT	TTI= ATT/FFTT
From Abune petros to autobus tera	46.50	3.60	42.90	11.92	12.92
Lideta to Autobus tera	43.20	4.50	38.70	8.60	9.60
Pastor square to Autobus tera	23.10	1.95	21.15	10.85	11.85
kolfe keranyo to Autobus tera	72.70	8.40	64.30	7.65	8.65

All routes in Table 4.15 have a congestion index of more than 1.5. Therefore, they experience high congestion from work to home. This means that the average travel time is considerably higher than the free-flow travel time, resulting in substantial delays. Traffic conditions are congested, and drivers expect significant travel time increases.

The given data pertains to travel time measurements from work to home, including Actual Travel Time (ATT), Free Flow Travel Time (FFTT), Delay (the difference between ATT and FFTT), Congestion Index (CI), and Travel Time Index (TTI). Analyzing the values of TTI and CI, it is evident that there are variations in congestion levels and travel times across different routes. The TTI values, which represent the ratio of actual travel time to free flow travel time, range from 8.65 to 12.92, indicating differing levels of congestion and travel efficiency. Higher TTI values indicate more congestion and slower travel times. Similarly, the CI values, which represent the delay as a percentage of FFTT, range from 7.65 to 11.92, further highlighting variations in congestion levels. These values suggest that the routes experience different levels of congestion and travel delays when commuting from work to home. Addressing the factors contributing to congestion, such as traffic management, infrastructure improvements, and alternative transportation options, can help reduce congestion, improve travel times, and enhance the overall efficiency of the commute from work to home.

4.6. Implication of the study

Impact of On-Street Parking Availability: The lack of pre-planned on-street parking options in the study area has created challenges in terms of traffic flow. This discovery underscores the necessity for effective parking management strategies to alleviate congestion and enhance the movement of vehicles.

Participant Profile Analysis: The majority of respondents in the study area had extensive experience and exposure to the effects of on-street parking. This indicates that the data collected from them is likely to be more accurate and reliable. Furthermore, efforts were made to include participants from diverse demographic groups, encompassing both males and females across various age ranges.

Modes of Transportation: The study findings revealed that a significant number of respondents relied on their personal vehicles as their primary mode of transportation. This highlights a high demand for parking spaces and emphasizes the importance of providing sufficient off-street or well-designed on-street parking facilities.

Selected Routes and Travel Time: The study examined four different routes with different lengths and traffic characteristics. It discovered that the availability of on-street parking significantly influenced travel time along these routes. These findings underscore the negative impact of on-street parking congestion on travel time and emphasize the need for effective traffic management measures.

Time Loss: The study quantified the average time lost by commuters during their journeys to and from work. It demonstrated that the absence of on-street parking availability contributed to increased travel time and overall time loss for commuters. This highlights the importance of addressing parking-related issues to improve commuting efficiency.

4.7. Design Proposal

Proper allocation and design of parking spaces are crucial for reducing on-street parking and enhancing the overall efficiency of a city's transportation system. A well-planned layout facilitates smooth vehicle movement by decreasing congestion and travel time. This includes providing adequate space for bus and taxi terminals, passenger waiting areas, on-street parking, adding lanes to existing roads, and sufficient parking lots behind some buildings.

On-street parking may be designated for short-term use, typically less than half an hour, allowing vehicle owners to complete quick tasks in high-traffic and commercial areas. In contrast, backyard parking can accommodate longer durations, ranging from one hour to a full day.

Figure 4.23: proposed design site plan around autobus tera

It is important to consider parking availability and management strategies as an integral part of urban development planning. In fig 4.20, incorporating parking requirements and provisions into the early stages of urban design and development projects is crucial. The design proposes the parking lot should not be very far from the main road and be sustainable. There is a basement parking and outdoor parking system. Both parking is recommended.

Figure 4.24: proposed road layout and parking lot

The study findings indicate a high reliance on private vehicles as the primary mode of transportation. To address parking-related challenges and reduce congestion, it is essential to promote sustainable transportation options. This can involve expanding public transportation networks, improving infrastructure for walking and cycling, providing a light railway system, and encouraging the use of electric vehicles. By fostering sustainable transport modes, the demand for parking spaces can be lowered.

Additionally, creating green corridors and adopting electric vehicles (which reduce fuel consumption) is vital. Both initiatives play a significant role in environmental protection and reducing fuel costs.

Figure 4.25: sustainable design and green corridor

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

In conclusion, this study focused on assessing the impact of on-street parking on urban mobility in Autobus Tera, Addis Ababa. The findings of the study provide valuable insights into the relationship between on-street parking availability, travel time, and traffic congestion.

The study revealed that illegal on-street parking has a significant negative impact on travel time. The high occupancy of on-street parking spaces leads to congestion and delays in traffic flow, resulting in increased travel times for commuters. This finding highlights the importance of well-organized and regulated parking systems to ensure efficient urban mobility and reduce travel-related delays.

The study demonstrated a clear correlation between on-street parking occupancy and traffic congestion. As on-street parking spaces become increasingly occupied, the flow of traffic is impeded, leading to congestion on the roads. This congestion not only affects commuters but also has broader implications for the overall livability and sustainability of the city. It emphasizes the need for effective parking management strategies and policies to optimize the utilization of parking spaces and mitigate traffic congestion.

The study shed light on the environmental impact of unregulated on-street parking. The presence of illegal and unorganized on-street parking contributes to increased greenhouse gas emissions and noise pollution. This finding underscores the importance of adopting sustainable and environmentally friendly approaches to parking management. Implementing measures such as promoting alternative modes of transportation and encouraging off-street parking facilities can help alleviate the negative environmental consequences associated with on-street parking.

Generally, this study highlights the detrimental effects of on-street parking on urban mobility in Autobus Tera, Addis Ababa. It emphasizes the need for well-planned and regulated parking systems to ensure efficient traffic flow, reduce travel time, and mitigate congestion. Additionally, sustainable parking management strategies are crucial to minimize the environmental impact of on-street parking. The findings of this study provide valuable insights for urban planners, policymakers, and stakeholders involved in improving urban mobility and enhancing the quality of life in cities.

5.2. Recommendation

Implement Effective Parking Management Strategies

The study emphasizes the need for effective parking management strategies to alleviate congestion and enhance the movement of vehicles. This recommendation suggests that pre-planned on-street parking options should be considered to address the challenges in traffic flow.

Provide Sufficient Parking Facilities

The study highlights the high demand for parking spaces, especially for personal vehicles. It underscores the importance of providing sufficient off-street or well-designed on-street parking facilities to meet the needs of commuters and alleviate parking-related issues.

Implement Traffic Management Measures

The study reveals that the availability of on-street parking significantly influences travel time along different routes. This finding suggests the need for effective traffic management measures to mitigate the negative impact of on-street parking congestion on travel time.

Improve Commuting Efficiency

The study quantifies the average time lost by commuters due to the absence of on-street parking availability. It emphasizes the importance of addressing parking-related issues to improve commuting efficiency, reduce travel time, and minimize overall time loss for commuters.

Encourage Alternative Modes of Transportation

Given that a significant number of respondents relied on personal vehicles as their primary mode of transportation, there is a need to promote and incentivize the use of alternative modes of transportation. This could include improving public transportation options, implementing bike lanes, and encouraging carpooling or ridesharing programs. By reducing the reliance on personal vehicles, the demand for parking spaces can be mitigated.

Consider Smart and Innovative Parking Solutions

The study's findings highlight the need for innovative parking solutions. Introducing smart parking technologies, such as sensors that provide real-time information on parking availability and dynamic pricing systems, can help optimize the utilization of parking spaces. By implementing smart parking solutions, it becomes easier for drivers to locate available parking spots, reducing the time spent searching for parking and minimizing congestion.

Exploring innovative parking solutions can help address the challenges of limited on-street parking. This could include implementing shared parking initiatives, developing automated parking systems, or exploring partnerships with private parking providers to optimize parking space utilization. Embracing new technologies and creative approaches can help maximize the efficiency and effectiveness of parking infrastructure.

Integrate Parking Planning into Urban Development

The study underscores the importance of considering parking availability and management strategies as an integral part of urban development planning. By incorporating parking requirements and provisions into the early stages of urban design and development projects, cities can ensure that adequate parking infrastructure is built and integrated seamlessly into the transportation network.

Conduct Periodic Parking Assessments

Given the dynamic nature of urban areas and evolving transportation patterns, it is crucial to conduct periodic assessments of parking demand and availability. Regular monitoring and evaluation of parking utilization rates, occupancy levels, and changing transportation trends can inform decision-making processes and allow for timely adjustments to parking management strategies.

Promote Sustainable Transportation Options

The study findings indicate a high reliance on personal vehicles as the primary mode of transportation. To mitigate parking-related challenges and reduce congestion, it is crucial to promote sustainable transportation options. This can include expanding public transportation networks, improving infrastructure for walking and cycling, and incentivizing the use of electric vehicles. By encouraging sustainable modes of transport, the demand for parking spaces can be reduced.

Engage Stakeholders in Parking Planning

Effective parking management requires collaboration and engagement with various stakeholders, including residents, businesses, and transportation authorities. Involving these stakeholders in the parking planning process helps ensure that their perspectives and needs are considered. It can lead to better decision-making, increased support for parking initiatives, and the development of solutions that address the concerns of different user groups.

Monitor and Evaluate Parking Policies

Regular monitoring and evaluation of parking policies and their impact are essential. This involves assessing the effectiveness of implemented strategies, monitoring changes in parking demand, and soliciting feedback from users. By continuously monitoring and evaluating parking policies, adjustments can be made to optimize their outcomes, address emerging challenges, and ensure that they align with the evolving needs of the community.

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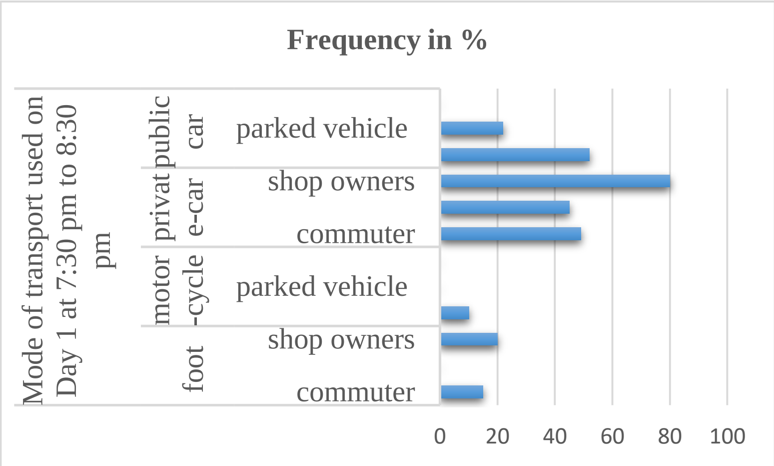
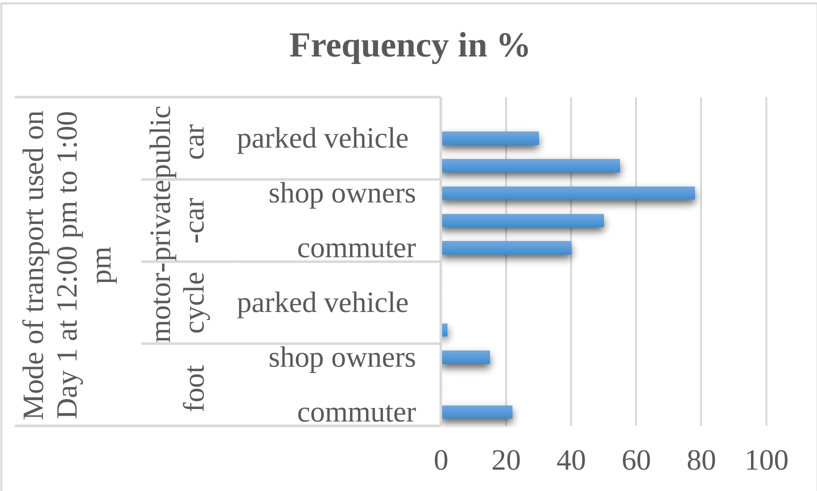
APPENDIX

Appendix A: Mode of transportation on Monday peak period travel time

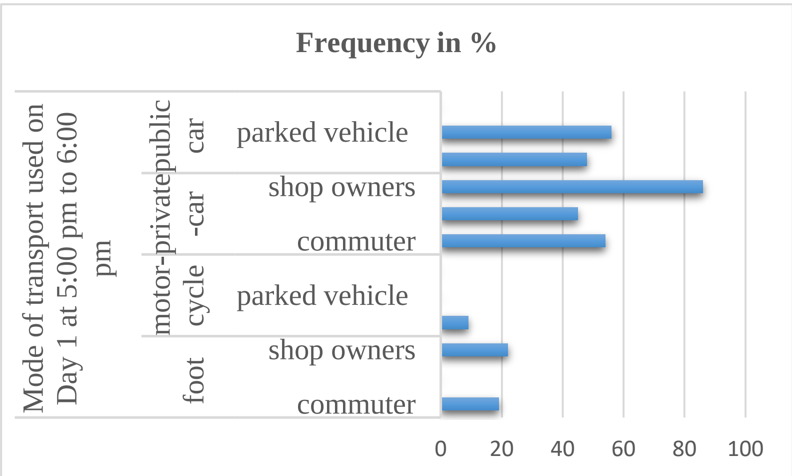
Mode of transportation on Day 1 at 7:30 pm to 8:30 pm



Mode of transportation on Day 1 at 12:00 pm to 1:00 pm

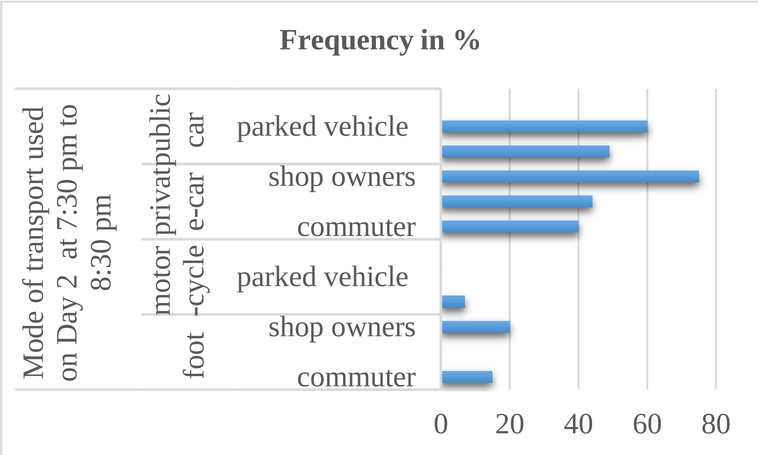


Mode of transportation on Day 1 at 5:00 pm to 6:00 pm

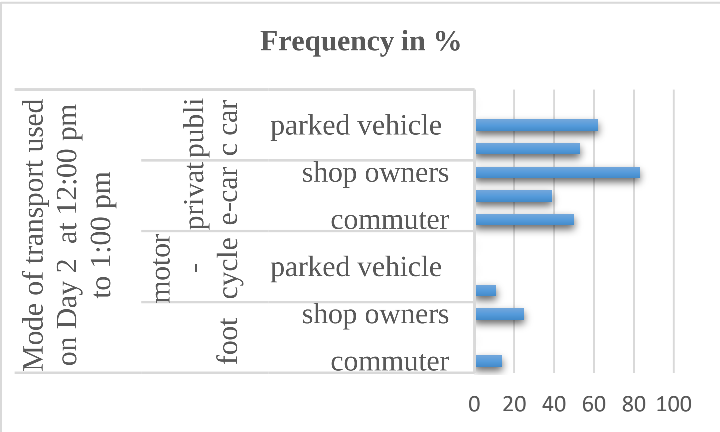


Appendix B: Mode of transportation on Wednesday peak period travel time

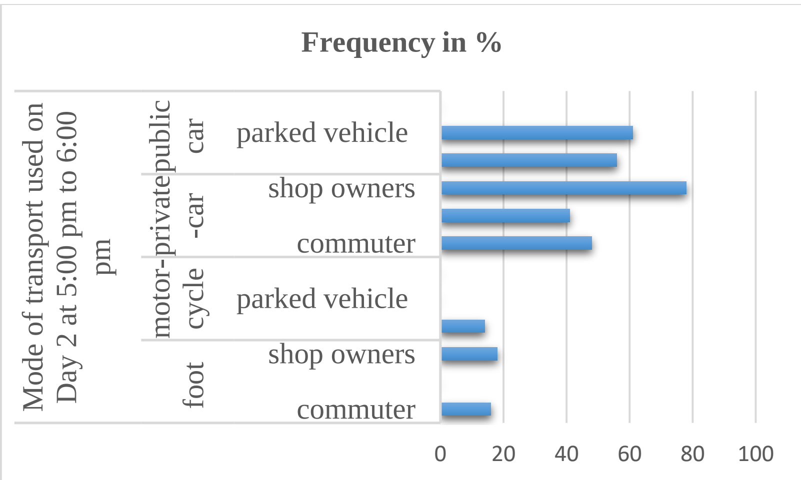
Mode of transportation on Day 2 at 7:30 pm to 8:30 pm



Mode of transportation on Day 2 at 12:00 pm to 1:00 pm

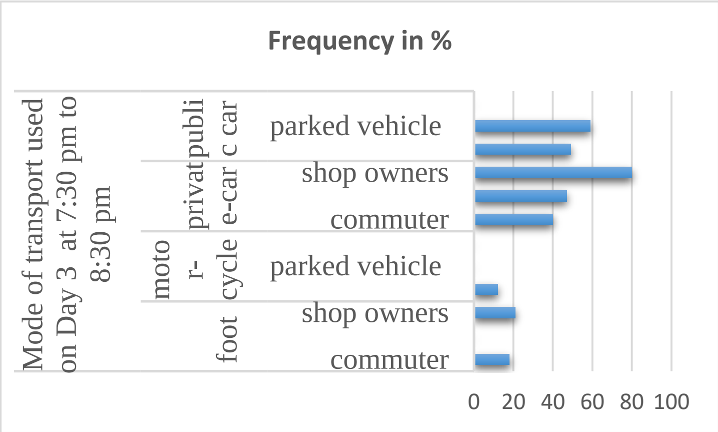


Mode of transportation on Day 2 at 5:00 pm to 6:00 pm

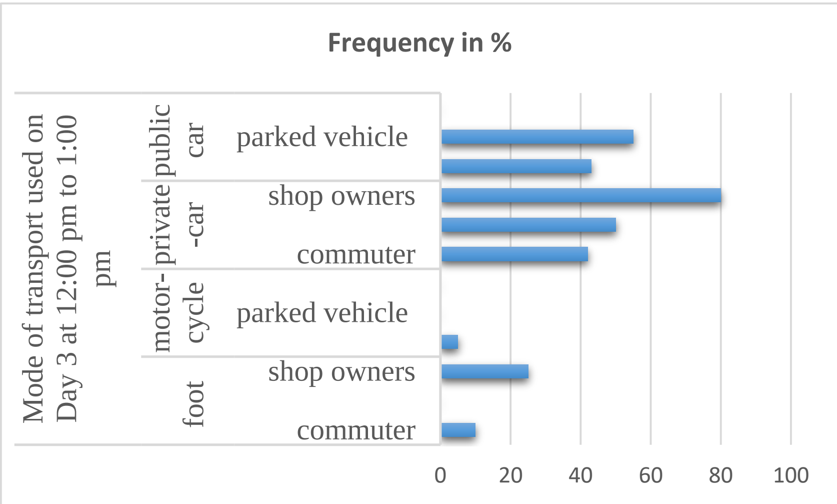


Appendix C: Mode of transportation on Friday peak period travel time

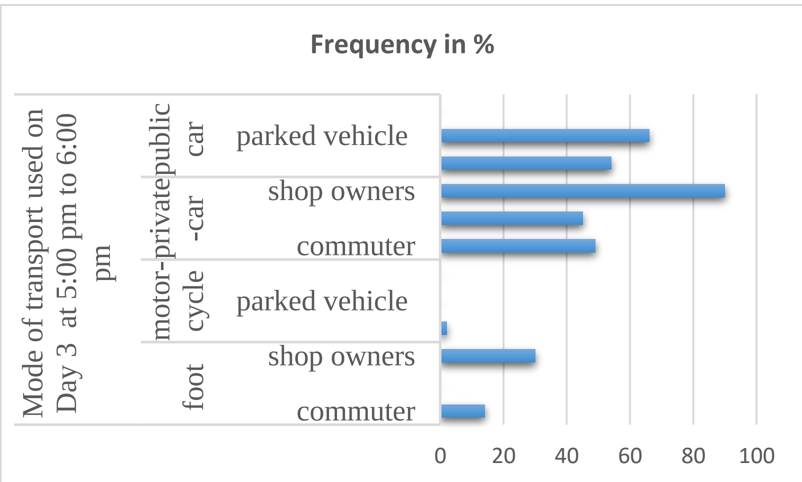
Mode of transportation on Day 3 at 7:30 pm to 8:30 pm



Mode of transportation on Day 3 at 12:00 pm to 1:00 pm

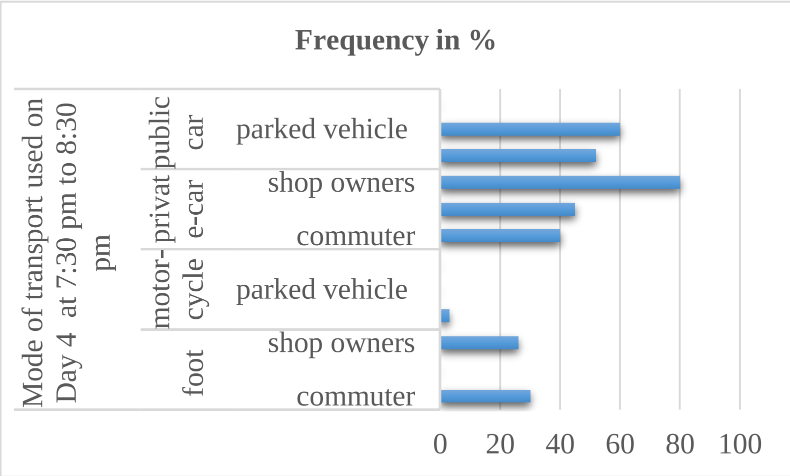


Mode of transportation on Day 3 at 5:00 pm to 6:00 pm

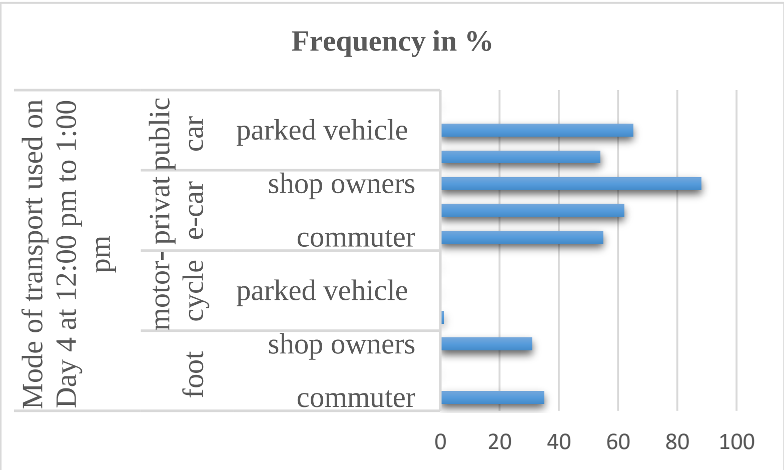


Appendix D: Mode of transportation on Saturday peak period travel time

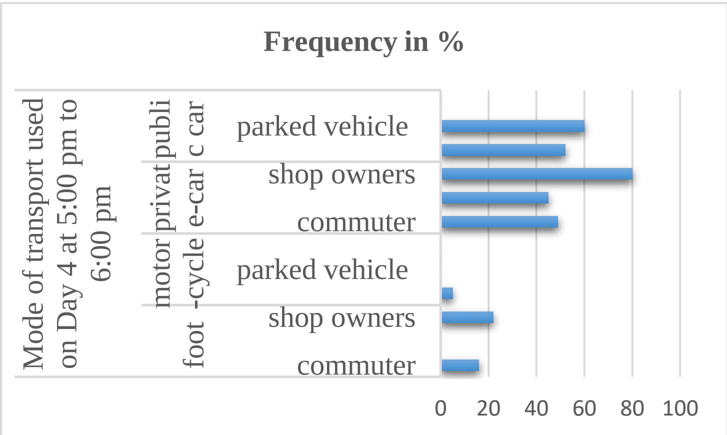
Mode of transportation on Day 4 at 7:30 pm to 8:30 pm



Mode of transportation on Day 4 at 12:00 pm to 1:00 pm

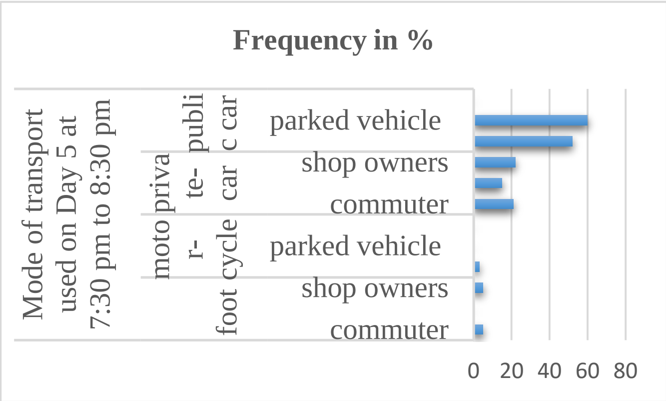


Mode of transportation on Day 4 at 5:00 pm to 6:00 pm

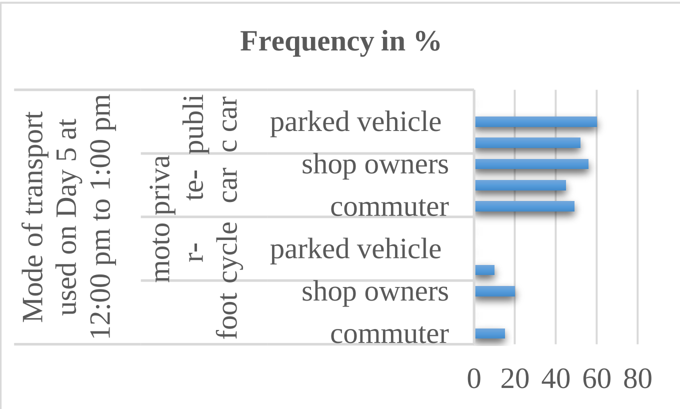


Appendix E: Mode of transportation on Sunday peak period travel time

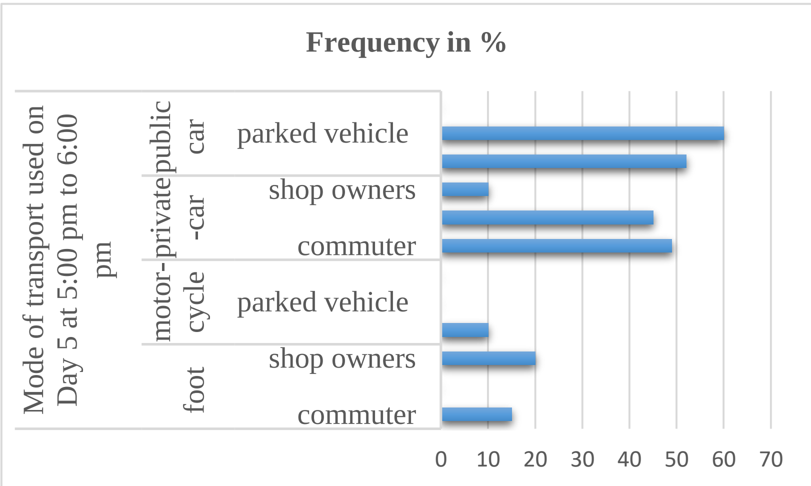
Mode of transportation on Day 5 at 7:30 pm to 8:30 pm



Mode of transportation on Day 5 at 12:00 pm to 1:00 pm



Mode of transportation on Day 5 at 5:00 pm to 6:00 pm



Appendix F: Respondents thought on the environmental impact of on-street parking/congestion.

Challenges	Strongly disagree(%)	Disagree(%)	Neutral(%)	Agree(%)	Strongly Agree(%)
The availability of on-street parking affects the overall air quality in Autobus tera.	10	10	10	40	30
The lack of well-designed on-street parking spaces contributes to increased traffic congestion and vehicle emissions in Autobus tera.				20	80
The availability of on-street parking influences the use of alternative modes of transportation, such as walking, driving or cycling, leading to reduced environmental impact.	10			20	70
The availability of on-street parking affects the overall aesthetics and green spaces in Autobus tera.		10	10	20	60
on-street parking influences the use of public transportation, leading to reduced traffic congestion and environmental pollution				30	70
The lack of on-street parking spaces contributes to increased stress and frustration among drivers.				30	70
On-street parking hampers the smooth flow of traffic, leading to increased fuel consumption and greenhouse gas emissions.			10	20	70
on-street parking contributes to increased noise pollution in Autobus tera		10	10	20	60
on-street parking affects the overall traffic flow and road safety, leading to potential accidents and hazards in Autobus tera			10	40	50

Appendix G: Average on street parking occupancy

Average on street parking occupancy on day1

segment(m)	location from	road width(m)	net road area, median excluding (m2)	occupied space by on street parked vehicles(m2)	% tage occupaied	middian(m)	remark
0 to 200	Autobus tera to Fit H/ Georgis street(west)	20	3400	800	23.52	3	two way road
200 -400	Autobus tera to Fit H/ Georgis street(west)	20	3400	500	14.70	3	two way road
400-800	Autobus tera to Fit H/ Georgis street(west)	20	6800	724	10.70	3	two way road
0 to 200	Autobus tera to somalia street	15	3000	1040	34.66	no	One way road
200 -400	Autobus tera to somalia street	15	3000	260	8.66	no	One way road
400-800	Autobus tera to somalia street	15	6000	494	8.24	no	One way road
0 to 200	Autobus tera to central africa street	30	4000	1196	29.90	10	two way road
200 -400	Autobus tera to central africa street	30	4000	884	22.10	10	two way road
400-800	Autobus tera to central africa street	30	8000	520	6.50	10	two way road
0 to 200	Autobus tera to H/ Georgis street(east)	30	4000	494	12.35	10	two way road
200 -400	Autobus tera to H/ Georgis street(east)	30	4000	377	9.43	10	two way road
400-800	Autobus tera to H/ Georgis street(east)	30	8000	936	11.7	10	two way road

Average on street parking occupancy on day 2

segment(m)	location from	road width(m)	median excluding (m2)	occupied space by on street parked vehicles(m2)	% tage occupaied	middian(m)	remark
0 to 200	Autobus tera to Fit H/ Georgis	20	3400	520	15.30	3	two way road

	street(west)						
200 -400	Autobus tera to Fit H/ Georgis street(west)	20	3400	338	9.94	3	two way road
400-800	Autobus tera to Fit H/ Georgis street(west)	20	6800	728	10.7	3	two way road
0 to 200	Autobus tera to somalia street	15	3000	650	21.66	no	One way road
200 -400	Autobus tera to somalia street	15	3000	260	8.66	no	One way road
400-800	Autobus tera to somalia street	15	6000	416	6.94	no	One way road
0 to 200	Autobus tera to central africa street	30	4000	780	19.5	10	two way road
200 -400	Autobus tera to central africa street	30	4000	754	18.86	10	two way road
400-800	Autobus tera to central africa street	30	8000	1040	13.00	10	two way road
0 to 200	Autobus tera to H/ Georgis street(east)	30	4000	988	24.70	10	two way road
200 -400	Autobus tera to H/ Georgis street(east)	30	4000	950	16.26	10	two way road
400-800	Autobus tera to H/ Georgis street(east)	30	8000	754	9.42	10	two way road

Average on street parking occupancy on day 3							
segment(m)	location from	road width(m)	net road area, median excluding (m2)	occupied space by on street parked vehicles(m2)	% tage occupaied	middian(m)	remark
0 to 200	Autobus tera to Fit H/ Georgis street(west)	20	3400	592	17.42	3	two way road
200 -400	Autobus tera to Fit H/ Georgis street(west)	20	3400	500	14.70	3	two way road
400-800	Autobus tera to Fit H/ Georgis street(west)	20	6800	480	7.06	3	two way road
0 to 200	Autobus tera to somalia street	15	3000	786	26.20	no	One way road
200 -400	Autobus tera to somalia street	15	3000	312	10.40	no	One way road
400-800	Autobus tera to	15	6000	494	8.24	no	One way

	somalia street						road
0 to 200	Autobus tera to central africa street	30	4000	728	18.20	10	two way road
200 -400	Autobus tera to central africa street	30	4000	468	11.70	10	two way road
400-800	Autobus tera to central africa street	30	8000	754	9.14	10	two way road
0 to 200	Autobus tera to H/ Georgis street(east)	30	4000	546	13.66	10	two way road
200 -400	Autobus tera to H/ Georgis street(east)	30	4000	520	13.00	10	two way road
400-800	Autobus tera to H/ Georgis street(east)	30	8000	260	3.25	10	two way road

Average on street parking occupancy on day 4

segment(m)	location from	road width(m)	net road area, median excluding (m2)	occupied space by on street parked vehicles(m2)	% tage occupaied	middian(m)	remark
0 to 200	Autobus tera to Fit H/ Georgis street(west)	20	3400	910	26.76	3	two way road
200 -400	Autobus tera to Fit H/ Georgis street(west)	20	3400	500	14.70	3	two way road
400-800	Autobus tera to Fit H/ Georgis street(west)	20	6800	728	10.70	3	two way road
0 to 200	Autobus tera to somalii street	15	3000	1140	34.66	no	one way road
200 -400	Autobus tera to somalii street	15	3000	520	17.34	no	one way road
400-800	Autobus tera to somalii street	15	6000	520	8.66	no	one way road
0 to 200	Autobus tera to central africa street	30	4000	1222	30.56	10	two way road
200 -400	Autobus tera to central africa street	30	4000	884	22.10	10	two way road
400-800	Autobus tera to central africa street	30	8000	1066	13.31	10	two way road
0 to 200	Autobus tera to H/ Georgis street(east)	30	4000	1014	25.36	10	two way road
200 -400	Autobus tera to H/ Georgis street(east)	30	4000	832	20.80	10	two way road
400-800	Autobus tera to H/ Georgis street(east)	30	8000	1040	13.00	10	two way road

Average on street parking occupancy on day 5

segment(m)	location from	road width(m)	net road area, median excluding (m2)	occupied space by on street parked vehicles(m2)	% ge occupied	median(m)	remark
0 to 200	Autobus tera to Fit H/ Georgis street(west)	20	3400	390	11.48	3	two way road
200 -400	Autobus tera to Fit H/ Georgis street(west)	20	3400	500	14.70	3	two way road
400-800	Autobus tera to Fit H/ Georgis street(west)	20	6800	480	7.06	3	two way road
0 to 200	Autobus tera to somalia street	15	3000	520	17.34	no	One way road
200 -400	Autobus tera to somalii street	15	3000	208	6.94	no	One way road
400-800	Autobus tera to somalii street	15	6000	494	8.24	no	One way road
0 to 200	Autobus tera to central africa street	30	4000	1196	29.90	10	two way road
200 -400	Autobus tera to central africa street	30	4000	884	22.10	10	two way road
400-800	Autobus tera to central africa street	30	8000	416	5.20	10	two way road
0 to 200	Autobus tera to H/ Georgis street(east)	30	4000	442	11.05	10	two way road
200 -400	Autobus tera to H/ Georgis street(east)	30	4000	364	9.10	10	two way road
400-800	Autobus tera to H/ Georgis street(east)	30	8000	520	6.50	10	two way road

Appendix H: Interview and Questioner

Department of Architecture and urban planning and design

School of Civil Engineering and Architecture

The purpose of this research is to gather important information on traffic congestion, specifically focusing on the "Impact of on-street parking on urban mobility in Autobus Tera, Addis Ababa." The researcher aims to collect data that will shed light on overall traffic congestion and assess the various effects of on-street parking, such as time lost due to congestion, potential solutions, and their impacts on the city. The information you provide will be used solely for academic purposes, contributing to an M.Sc. thesis in urban planning and design. Your detailed responses and data are greatly valued and will be kept confidential.

Instructions: Please respond to all questions by marking any marking style next to your choice and provide your opinions where requested. You do not need to include your name.

Part I: General Information about the respondents

1. Sex, Male -----------Female ---------

2. Age, 22- 30 ---------- 31– 40 ------- 41 – 50 ---------51 – 60 -------- Above 60 --------

Part II: Interview Question

1. What is the mode of travel you most often use in your day to day activity?

Mode of transport used on Monday											
foot			motor-cycle			private-car			public car		
commuter	parked vehicle	shop owners	commuter	parked vehicle	shop owners	commuter	parked vehicle	shop owners	commuter	parked vehicle	shop owners

2. your work place location ------------------------------
3. your home place location ---------------------------------
4. Time taken from your work to your home --

5. Time taken from your home to your work ---

6. How long you travel average distance from home to work?

1 – 3 km ---------- 3 - 7 km -----------7 - 8 km ------------ or specify if greater than 8 km ---

7. Is there vehicle congestion along the street due to on street parking?

----

8. How the on street parking affects the traffic congestion?

Affects highly	
Affects moderately	
Affects slightly	
Never affects	

9. What do you suggest to minimize congestion along the street?

Improve the road capacity ----------------------------------

Implement Traffic Management Measures-----------------

Provide Sufficient Parking Facilities-----------------

Improve City bus/taxi terminals ----------------------

Monitor and Evaluate Parking Policies-----------------

Engage Stakeholders in Parking Planning-----------------

Improve parking management --------------------------

Promote Sustainable Transportation Options-----------------

Use mass transport --------------------------------

Improve Commuting Efficiency-----------------

Consider Smart Parking Solutions-----------------

Improve traffic management strategy ----------------------------------

Conduct Periodic Parking Assessments-----------------

Explore Innovative Parking Solutions-----------------

Integrate Parking Planning into Urban Development

Improve light rail way transportation -------------------------------------

Implement Effective Parking Management Strategies-----------------

Encourage Alternative Modes of Transportation-----------------

List Any other measure ---------------------------------

Part III: questioner

1. How often you experiencing autobus tera.

   I use autbus tera frequently---------------

   I use autobus tera occasionally-----------

2. How are you experiencing autobus tera?

   I am working in shops around/ any work around--------------

   I just use only the corridor to pass over--------------------------

3. What type of mode of transportation you use?

   I just walk through it with my foot-----------------

   I use my car to move there---------------------------

   I use public car to move through it mostly---------

4. Fill the following table as per the the questions correspondingly with the level of your agreement.

Challenges	Strongly disagree(%)	Disagree(%	Neutral(%)	Agree(%)	Strongly Agree(%)
The availability of on-street parking affects the overall air quality in Autobus tera.					
The lack of well-designed on-street parking spaces contributes to increased traffic congestion and vehicle emissions in Autobus tera.					
The availability of on-street parking influences the use of alternative modes of transportation, such as walking, driving or cycling, leading to reduced environmental impact.					

The availability of on-street parking affects the overall aesthetics and green spaces in Autobus tera.	
on-street parking influences the use of public transportation, leading to reduced traffic congestion and environmental pollution	
The lack of on-street parking spaces contributes to increased stress and frustration among drivers.	
On-street parking hampers the smooth flow of traffic, leading to increased fuel consumption and greenhouse gas emissions.	
on-street parking contributes to increased noise pollution in Autobus tera	
on-street parking affects the overall traffic flow and road safety, leading to potential accidents and hazards in Autobus tera	