GIS Based Spatial Optimization of Sheger Bus Stops Accessibility in Addis Ababa: the Case of Piassa – Yeka Abado and Piassa – Jemo Bus Routes

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This is to certify that the Thesis prepared by Yibeltal Dubale, entitled; ***"GIS Based Spatial Optimization of Sheger Bus Stops Accessibility in Addis Ababa: the Case of Piassa – Yeka Abado and Piassa – Jemo Bus Routes"*** and submitted in partial fulfillment the requirement for the award of Masters of Art Degree in Geography and Environmental Studies (Specialization in GIS, Remote Sensing and Digital Cartography) complies with the regulation of the University and meets the accepted standards concerning originality and quality.

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Declaration

I, Yibeltal Dubale, with Registration Number GSR/3384/12, certify that this Thesis is my original work that has not been submitted partially; or in full for an award of a degree in any Universities or Institutions and all the reference materials used for this research have been properly acknowledged.

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Abstract

Bus stops play a significant role for efficient and effective public transport service as it serves as a point of contact between passengers and buses in the transit service. This study is aimed at evaluating the accessibility of existing bus stops and determining optimal location for bus stops. For this study seventy-seven (77) Sheger bus stops along two study bus routes (Piassa- Yeka Abado and Piassa – Jemo) were considered. The study employed a mixed research approach with a cross-sectional survey design. The data were drawn from both primary and secondary sources. The primary data related to the perceptions of bus users on the existing bus stops physical condition were collected through questionnaires from 163 sample Sheger bus users using convenient sampling along the study bus routes. Further, key informant interviews with professionals at Sheger Mass Transit Enterprise and field observation were also used. Secondary data related to the road network, bus route, the bus stops coordinate point, bus stops spacing, the number of bus and bus trips, population and parcel data were gathered from statistical records, shapefile or AutoCAD data from relevant institutions. The analysis was done using descriptive statistics such as percentage, mean and standard deviation, and inferential statistics such as T-test with the help of Statistical Package for Social Science Version 26 and spatial analysis such as service area network analysis with the help of ArcGIS 10.8. The result showed that most of the existing bus stops physical conditions are poor where 71.8% of the sample respondents agreed or strongly agreed on the overall quality of the bus stops as poor condition. Many of the bus stops are inconvenient to persons with disability and the elders due to the potholes and obstructions, lack adequate shades, seating chairs, and boarding and alighting space with safety and security concerns. The result also revealed that the majority of inbound (51.4%) and outbound (50.0%) bus stops were beyond the bus stops spacing standard of 800 meter indicating large service area gaps. Regarding bus stop accessibility evaluated based on three parameters: road density, trip generation, and population served, 36.0% of the inbound stops and 44.7% of the outbound bus stops had poor accessibility indexes, respectively. Optimal locations for bus stops were thus proposed based on the combined accessibility index of the three parameters and the bus stop spacing standard of 600-800 meters considering a 30–50-meter junction constraint. Accordingly, the optimization of bus stops involving retaining, relocating, dissolving and creating new bus stops has improved the good and moderate stop accessibility by 58.1% and decreased the poor stop accessibility by 68.3% for both the inbound and outbound bus stops. Finally, it is suggested that Addis Ababa City Transport Bureau in general and Sheger Mass Transit Enterprise in particular should give due consideration to the improvement of bus stops facilities with continuous follow up and the optimization of bus stops accessibility through appropriate planning, design and placement of bus stops.

Keywords: Accessibility, Buffer, Bus Stop, GIS, Spatial Optimization, Service Area

Table of Contents

List of Tables

List of Figures

Acronyms

AACPC	Addis Ababa City Plan Commission
AACRA	Addis Ababa City Road Authority
AACTB	Addis Ababa City Transport Bureau
AASHTO	American Association of State Highway Transportation Officials
ABTSE	Alliance Bus Transport Service Enterprise
ACBSE	Anbessa City Bus Service Enterprise
ADA	American Disability Act
AI	Accessibility Index
ASAI	Actual Stop Accessibility Indices
AU	African Union
CBD	Central Business District
CSA	Central Statistical Agency
DVRPC	Delaware Valley Regional Planning Commission
EGSI	Ethiopian Geospatial Institute
FITP	Foursquare Integrated Transport Planning
FTA	Federal Transport Authority
GIS	Geographic Information System
ITDP	Institute for Transportation and Development Policy
ISAI	Ideal Stop Accessibility Indices
LRT	Light Rail Transit
PPIAF	Public Private Infrastructure Advisory Facility
PSETSE	Public Service Employee Transport Service Enterprise
PT	Public Transport
SEPTA	South Eastern Pennsylvania Transport Authority
SMTSE	Sheger Mass Transit Service Enterprise
TCRP	Transit Cooperative Research Program
UNECA	United Nations Economic Commission for Africa
WB	World Bank
WMATA	Washington Metropolitan Area Transit Authority

CHAPTER ONE: INTRODUCTION

1.1. Background of the Study

Bus transport is an essential component of the public transport system, which provides access to various services and facilities (Yaakub & Napiah, 2011). It is one of the oldest and most common means of transport facilitating the movement of people within a city or remote locations (Rodrigue, 2020). Many people in cities worldwide depend on bus transport as the primary means of passenger transport. It accounts for the lion's share of passenger transport in most cities worldwide (George, 1999). In this regard, while some cities have achieved international recognition for their excellent public transport infrastructure and operation, others have poor public transport service quality and performance, pushing potential users to automobiles use (ITDP, 2020).

A conventional bus is the primary form of public transport in the majority of developing country cities because of its inexpensive beginning and operating costs, adaptable route system and accessibility to town and city centers (Iles, 2005; Verma & Ramanaya, 2014). Buses also provide mobility to those who do not have their own private car (those whose mobility is impaired) and for those who are not interested in driving a car. Moreover, bus transport encourages walking opportunity, which is critical in decreasing an individual's health risk for such as obesity, stroke, diabetes and heart disease (Yaakub & Napiah, 2011).

Bus transport is also the most important means of transport in Ethiopia, particularly in Addis Ababa with the high population (Melsmo & Hilemichael, 2022). The history of public transport service in Ethiopia, particularly in the city of Addis Ababa dated back to the end of the Italian invasion which was started in 1943 when Anbessa City Bus Service Enterprise (ACBSE) was established (Avis, Weldetinsae, Getaneh & Singh, 2018). There are now many public transport service providers such as Sheger Mass Transit Service Enterprise (SMTSE), Alliance Bus Transport Service Enterprise (ABTSE), Public Service Employees Transport Service Enterprise (PSETSE), Mini bus taxi associations, Higers and Kitkit midi bus owner associations and Addis Ababa Light Rail Transit (AALRT).

This study is focused on SMTSE, which was established on May 27, 2016 with a view to address the acute shortage of transport service in Addis Ababa. In 2021, the Enterprise managed to give service on 79 routes with 324 buses and 343 supportive cross-country buses, as well as 76 routes with 93 school buses. In the same year, the Enterprise transported an average of 159, 000 people/ day with around 50 million people/year (SMTSE, 2022).

In Addis Ababa city, there is imbalance between the demand and supply of the public transport with poor public transport service (Gebeyehu & Takano, 2007). In this regard, the design and location of the public transport infrastructures, such as the public transport routes, terminals and stations have a significant impact on the efficiency of the public transport service (Aklilu, 2018). As bus stops accessibility to the residents is one of the most important factors in offering an efficient and effective public transport service, it needs an intervention measures regarding to the location and spacing of bus stops. Therefore, it is essential to investigate the bus stops accessibility to optimize the bus stops location that can address the challenges regarding the bus stops accessibility to the residents.

1.2. Statement of the Problem

Although bus transport is one of the dominant means of passenger transport in the city, particularly for low-income people, the bus mode of travel performs poorly with poor accessibility of the service to the public owing to weak infrastructure, inefficient transport operations, and poor performance (Kenea, Kinnear & Akbar, 2017). The poor access to the bus service in general and the bus stops, in particular, steered the bus users to switch their means of transport to other modes, including the private car, resulting in increased traffic congestion in the city.

The bus stops in Addis Ababa city are not well planned where many of the bus stops placed randomly without detail study of the actual traffic situation, the road network condition, and land use characteristics (Dawd, 2020). The lack of proper planning of bus stop's location coupled with the inadequate and poor bus stop facilities leads for congestion and accidents at bus stops in the city (Aychew, 2020). Further, various evidences indicated that the accessibility of the public transport stops to the users in Addis Ababa city are poor with large bus stops service area gaps and some service area overlaps (Aklilu & Necha, 2017; Dawd, 2020; Melsmo & Hilemichael, 2022).

Despite the aforementioned bus stops accessibility challenges to the residents, there is lack of comprehensive researches conducted to ascertain the optimal bus stop locations in the city of Addis Ababa. Only few researches were conducted related to the bus stop accessibility with the focus on Anbesa bus stops. For instance, Melsmo & Hilemichael (2022) conducted a study on the accessibility of bus stops in the case of Anbesa City Bus Service Enterprise Route 101 and proposed bus stop locations for Anbesa city bus considering bus stop spacing as a parameter. Dawd (2020) also studied existing bus stop accessibility in the case of Anbesa City Bus Service Enterprise in Yeka Sub City, considering the road network density, trip generation, and population served, and proposed optimal locations for Anbesa city bus. However, both focused on the Anbesa city bus with bus stops closer to each other, with most bus stops lying between 300 – 500meter spacing intervals (Melsmo & Hilemichael, 2022) regardless of bus stops location standardization.

Although Sheger bus uses the stops of Anbesa buses, the Sheger bus bypasses some of the Anbesa bus stops and thus the Sheger bus stops are far apart with each other with a spacing interval of even up to 2000 meters in some areas (SMTSE, 2022). In this regard, lack of standardization of bus stops location confused the bus users. Therefore, this study is aimed to analyse the accessibility of existing Sheger bus stops on selected bus routes in the city to optimize the bus stops location that would provide maximum accessibility to the residents.

1.3. Research Objective

1.3.1. General Objective

The general objective of this research is to analyse the accessibility of Sheger bus stops and to optimize the bus stops location in Addis Ababa using GIS with the consideration of Piassa -Yeka Abado and Piassa - Jemo bus routes as a case study.

1.3.2. Specific Objectives

In line with the general objective, the following specific objectives are formulated:

1) To examine the physical conditions of existing bus stops in the study area;
2) To evaluate the accessibility of existing bus stops in the study bus routes;
3) To propose optimal locations for bus stops in the study bus routes.

1.4. Research Questions

1) How is the physical condition of the bus stops in the study bus routes?
2) How is the accessibility of the existing bus stops in the study bus routes?
3) Where to locate the bus stops to optimize the bus stop locations?

1.5. Significance of the Study

This research may be useful to transport planners and policy makers, particularly to Addis Ababa City Transport Bureau (AACTB), Addis Ababa City Road Authority (AACRA), and Addis Ababa City Administration. The bus stops accessibility analysis as a critical factor for affecting the efficiency and effectiveness of bus service will also benefit public transport service providers, such as SMTSE. The research output of the current study may provide important information regarding to the bus stops' accessibility to the residents to satisfy customers' demands and improve the economic return to the service providers. It may also be used as a benchmark for other researchers to conduct further study related to bus stops.

1.6. Scope of the Study

This study is focused on evaluating the existing bus stops' accessibility on the selected bus routes and attempts to find an ideal locations of bus stops to ensure optimum accessibility to its users. Thus, the study is geographically delimited to Piassa – Yeka Abbado and Piassa – Jomo bus routes in Addis Ababa as it is difficult to conduct detail investigation city wide with the time and financial constraint as well as lack of secondary data. The study will be thus conducted on selected two Sheger bus routes that serve the largest portion of commuters. As it originates from one of the major city hub (Piassa), and moving towards the largest residential condominiums housings in the city (Yeka Abado and Jemo), these selected study bus routes are good indicator of the overall bus routes. Furthermore, the daily bus dispatch along these two routes from the 54 Sheger bus routes is 92 (24.7%) from the total 370 daily bus dispatches, which is 10% higher than the average daily bus dispatch (14.6%) per route that makes the study routes appropriate.

Thematically, this study is focused on the analysis of the physical condition of the selected Sheger bus stops, including the quality of the bus stops and their facilities as well as the accessibility of the existing bus stops along the study bus routes.

1.7. Limitations of the Study

One of the major limitations of the study is lack of well-organized data related to trip generation capacity of the bus stops and thus the study is conducted using estimated trip generation instead of the actual trip generation capacity that would affect the result of the study. Furthermore, the study considers three parameters (road density, trip generation, and population served) to evaluate the bus stop accessibility.

1.8. Operational Definition of Key Terms

Accessibility–the ease with which a facility or location can be reached.

Buffer–a zone has drawn around any point, line, or polygon that encompasses all areas within a specified distance of the feature.

Buffer analysis– is the process that involves generating a buffer around existing geographic features and then identifying features based on whether they fall inside or outside the boundary of the buffer.

Bus– is a commercial, public transport vehicle designed to carry persons that could afford the fare and made to accommodate a large number of passengers, usually having an average carrying capacity of between 30-100 passengers.

Bus route – is the scheduled route that buses regularly follow on their trip.

Bus stop –a designated station on bus routes for passengers boarding and alighting. It includes street and curb space, sidewalks, shelter, and associated amenities for passengers.

Inbound – refers to travelling towards a particular place, especially when returning to the original point of departure.

Outbound refers to travelling away from a particular place, especially on the first leg of a return journey.

Euclidian Distance is a straight-line distance between two points on a plane.

Public transport also known as **public transportation** or **public transit** is a kind of passenger transport that includes minibuses, buses, trains, and ferries that are accessible to the general public and run according to a regular schedule (Vuchic, 2002).

1.9. Organization of the Thesis

This research is organized into five chapters. The first **Chapter** is an introductory chapter that covers the background of the study, problem statement, objectives of the study and research questions, scope of the study, significance, and operational definition of key terms.

Chapter 2 is a literature review to understand the study clearly. The chapter summarizes the conceptual, theoretical, and empirical literature reviewed to develop the concepts and presents the theoretical and practical framework.

Chapter 3 presents the study's methodology, which denotes the step-by-step procedure for conducting the study. This section elaborate the research approach and method, the data source, data collection instruments, sampling technique and sample size, and method of data analysis techniques as well as data validity and reliability were briefly discussed.

Chapter 4 presents the data analysis and discussion organized based on the study's objective. In this section, all the data analysed along with the necessary maps and findings were elaborated.

Chapter 5 is conclusion and recommendation that cover the main ideas drawn through the research and the recommendations based on the findings.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1. Introduction

This chapter addresses the conceptual, theoretical, and empirical literature related to the study. The conceptual and theoretical literature explains the subject under study that covers the definition of public transport and bus stops, the placement of bus stops, essential components of bus stops, and accessibility of bus stops and bus stop location optimization. On the other hand, the empirical literature provides a comprehensive understanding of bus stop accessibility related issues based on previous studies. In this regard, the empirical literature reviewed includes, the studies on bus stops accessibility in cities of some developing countries including Addis Ababa as well as the application of GIS in bus stops accessibility analysis.

2.2. Conceptual and Theoretical Literature

2.2.1. Overview of Public Transport

Public transport or public transportation, often known as public transit, is a kind of passenger transport that is accessible to the general public and run according to a regular schedule (Vuchic, 2002). Those who cannot drive, such as those who do not have access to a car or low-income people, children, persons with disabilities, and the elderly, depend mainly on public transport (Jansuwan, Christensen & Chen, 2013). In this regard, transit agencies are responsible for providing efficient, comfortable and reliable service, which is necessary to maintain an efficient and attractive public transport that can increase users' satisfaction (Vuchic, 2002). Developing countries are characterized by high population growth, low income and lack of resources forcing them to depend on public transport, which can transport large number of people at low cost (Ranawana & Hewage, 2015). However, existing public transportation supply in developing countries does not satisfy the demand for a number of reasons such as the quality of travel on public transport is poor; roads are not properly maintained and managed; the safety and comfort of people using public transportation is low.

The public transport system delivers enormous economic, social, and environmental benefits, as well as improvements to the quality of life for its citizens (Jiang, Liu & Lv, 2017). Increasing vehicle ownership has led to more and longer car trips, while public transport use has decreased. This decline in public transport, coupled with a rise in the number of automobiles on the road, resulted in a variety of severe adverse effects, including traffic congestion, higher energy consumption, air pollution, and increased accident risk. Thus, increasing public transport use would help ensure safety, ease traffic congestion, improve air quality, and reduce energy consumption and emission (Jaiswal & Sharma, 2012).

2.2.2. Public Transport Modes

Transport modes are the means supporting the mobility of passengers and freight. They are transport assets and fall into three basic types; **land** (road, rail, pipelines), **water** (shipping), and **air**. The modes of passenger transport could be categorized as motorized and non-motorized. The motorized modes of transport include rail, road and aerial cable cars etc; while non-motorized transport services include walking, cycling and animal carts. The most common means of public transport includes **buses** (minibuses, midi-buses, maxi-buses that include single decker, double decker, and articulated buses as well as trolleybuses, trains (conventional train, trams (light rail), rapid transit or metro and **ferries** (Rodrigue, 2020):

- ☑ **Buses:** is one of the oldest and most widely used types of passenger transport designed to transfer passengers inside a city or outlying areas. Buses can be classified as single- decker bus, double-decker bus and articulated buses; and smaller capacity buses are midi buses, and mini buses. Various sizes of buses carry from 12 to 120 people, but in heavy demand, situations, up to 150 passengers may be carried in a standard bus and up to 200 in an articulated bus.
  - ✓ **Minibus:** Minibuses have a seating capacity of between 9-17 passengers and are the most common means of urban transport. They are not only the most accessible but also cost-effective means of transportation.
  - ✓ **Midi-bus:** are often larger than conventional minibuses but smaller than standard single-decker buses. They have a seating capacity of between 17 - 40 passengers.
  - ✓ **Large bus:** Buses are public transport vehicles designed to carry large number of passengers, usually having an average carrying capacity between 60-120 passengers including those standing.
- ☑ **Train:** most governments are accelerating this form of transport by expanding the number of trains and modernizing those on the most congested routes. It consists of a conventional rail, streetcar or tram, light rail and metro.
  - ✓ **Conventional rail transit**: the conventional (low-speed) rail system is a system designed for the speed of up to 200km/h.
  - ✓ **Streetcar/ Tram** operate on a track constructed on city streets or a separate right-of-way and is ideally suited for major cities due to its capacity.

- ✓ **Light Rail Transit (LRT**) operates at a greater capacity and goes further than a tram. However, it moves more slowly and stops more often than a tram.
- ✓ **Metro** is **underground rail** with maximum performance, speed, capacity, and dependability with large initial capital expenditure.

The conventional bus is the most common public transport mode in developing countries mainly due to its low running and initial cost, route flexibility and permeability into town and city centres. This research is thus on bus transport system in Addis Ababa and focused on bus stops accessibility considering Sheger Mass Transport as a case study.

2.2.3. Advantages of Public Transport

Public transportation delivers enormous economic, social, and environmental advantages to any country, as well as improvements to the level of life for its citizens (Jiang, Liu & Lv, 2017). Improved the community health to affordability, public transport creates the foundation on which cities become more liveable and prosperous in a variety of ways. Increasing vehicle ownership has led to more and longer car trips, while public transport use has decreased. This decline in public transportation, coupled with a rise in the number of automobiles on the road, resulted in a variety of severe adverse effects, including traffic congestion, higher energy consumption, air pollution, and increased accident risk. Thus, increased usage of public transportation would result in huge benefits. Jaiswal and Sharma (2012) concur that public transport in Bhopal offers several benefits over private vehicles. Among the benefits they mention is public transportation:

- **Ensure safety:** Transit bus travel is 91 times safer than automobile travel.
- **Saves money:** Public transportation may save twice as much as private automobiles.
- **Eases traffic congestion:** Public transport can help alleviate the city's crowded network of roads by providing transport choices.
- **Improves air quality:** Public transportation contributes to better air quality by lowering vehicle use. Transit vehicles generate less emission per kilometer traveled than single-occupant automobiles (i.e., buses emit 80% less CO_2 than cars).
- **Reduces energy consumption:** Public transport may dramatically decrease dependence on gasoline, resulting in a yearly reduction of 1.5 billion-fuel usage.
- Fosters more liveable communities.

Despite these benefits of the public transportation system, the users are dissatisfied with its performance. They prefer to utilize alternative forms of transportation, such as private automobiles. For individuals to use public transit, its qualities must be improved. For instance, Nurdden, Rahmat, and Ismail (2008) discovered that journey time and travel cost reduction are the elements that contribute to the model shift from automobile to public transportation in Malaysia.

2.2.4. Bus Transport

Buses are the principal means of public transport that accounts for the lion's share of passenger transit in most cities worldwide (George, 1999). A bus is one of the oldest and most common modes of transport aimed at facilitating the movement of people within a city or to remote locations (Rodrigue, 2020). It is affordable, convenient, and accessible to people with disabilities and the low-income group (Yaakub & Napiah, 2011). The typical buses currently operating worldwide are presented in Figure 2.1.

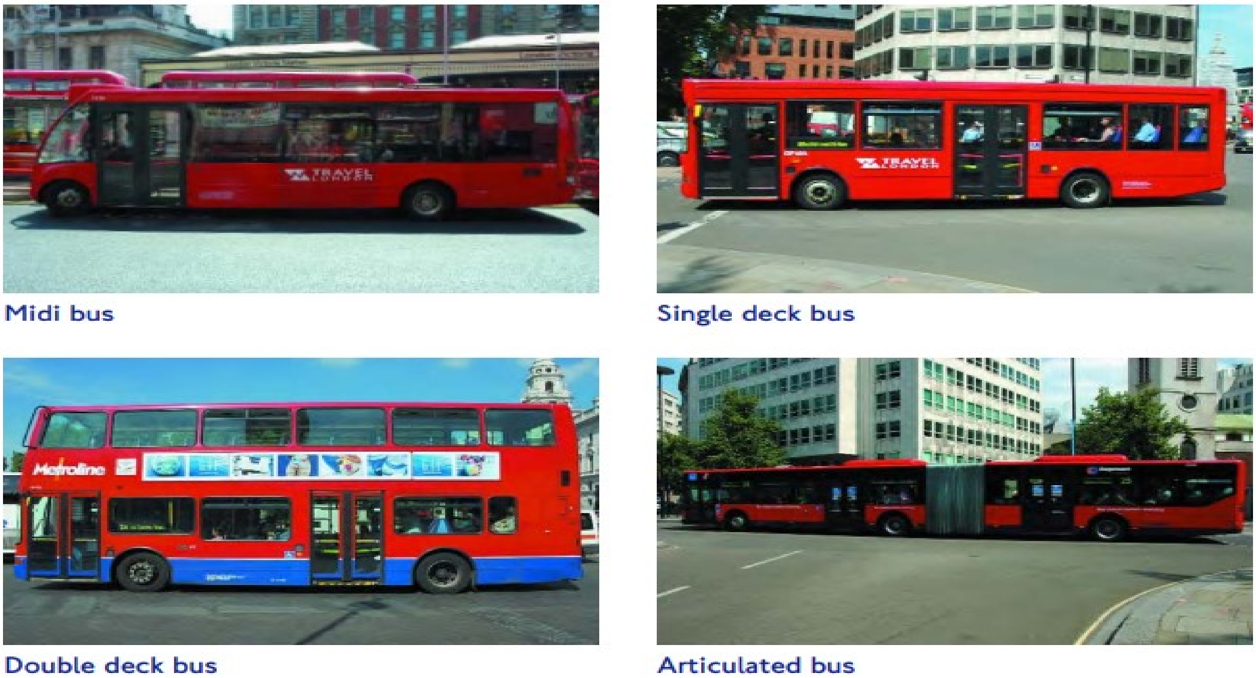

Figure 2.1: Types of Buses

Source: Transport for London (2006)

2.2.5. Bus Stops

Bus stop is an essential part of a bus passenger's trip. Bus stops play an important role for efficient and effective public transport service as it serves as a point of contact between passengers and buses in the transit service. According to the Washington Metropolitan Area Transit Authority (WMATA), bus stops often contain street and curb space, sidewalk, shelter, and other facilities for bus passengers. Bus stops, which are typically 25 to 50 meters long and provide room for buses to drive in and out to service bus stops, are included in the definition of a bus stop together with the bus stop itself. The bus stop area has to be big enough to accommodate the expected amount of people getting on and off (George, 1999).

Instead of being seen as only a place for a bus to halt, the bus stop is seen as a whole habitat. The environment of the bus stop consists of features for the comfort of passengers, such as seating and shelters; pedestrian access to and from stops, including connectivity with footways; suitability of waiting area; security and lighting; information - timetables, route maps, service numbers; bus stop pole and flag; approach and exit paths; drainage; and surface markings (Transport for London, 2017).

In high-traffic locations, bus stops may include shelters, chairs, and even electronic passenger information systems, while bus stops in less-trafficked areas may just use a pole and a flag to indicate their location. Bus stop architecture often reflects the level of use. Bus stops are sometimes gathered in one location to create transportation hubs that let users change routes and connect to other modes of public transportation. This makes it more convenient to use public transit (Ahsan, 2013).

According to the Delaware Valley Regional Planning Commission (DVRPC) (2019), "A high-quality bus stop is well linked to the neighbourhood or community it serves; fulfils the requirements of all transit passengers safely and pleasantly; and facilitates efficient and cost-effective transit operation." Inaccessible bus stops are often a weak point in the system for individuals with disabilities and may effectively discourage them from utilizing fixed-route bus services. Bus stop obstacles that are physical, cognitive, and psychological may drastically restrict how often persons with disabilities use buses, restricting their mobility and perhaps increasing the cost of transit services (Easter Seals Project ACTION, 2005).

Bus stops are often placed in pairs, with one stop on each side of the route. The bus will stop along the way in pairs that are extremely close to one another. The journey return will be simpler to organize as a result. Each location of bus stops should be evaluated independently to consider the fact that this is not always possible to achieve depending on the features of the road and the existing right-of-way (WMATA, 2009).

2.2.5.1. Types of Bus Stops

The bus stops should accommodate the most significant number of passengers without disrupting route delays or blocking the junction. The bus stops may be in the middle of the block, just in front of or right after a meeting place. The three types of bus stops based on the placement on the road network (DVRPC, 2012) are:

a) **Nearside** – the bus stop is located in advance of an intersection, before the crosswalk, in the direction of travel.
b) **Far side** – the bus stop is located immediately beyond an intersection, past the crosswalk, in the direction of travel.
c) **Midblock** – the bus stop is located between intersections.

Determining the proper location of bus stops involves choosing among these three typologies of bus stops: far-side, near-side, and midblock stops (see Figure 2.2 and Table 2.2). Table 2.2 presents a comparison of the advantages and disadvantages of each bus stop type. The following factors should be considered when selecting the type of bus stop:

- Adjacent land use and activities;
- Bus route (for example, is bus turning at the intersection);
- Bus signal priority (e.g., extended green suggests far side placement;
- Impact on intersection operations;
- Intersecting transit routes;
- Intersection geometry;
- Parking restrictions and requirements;
- Passenger origins and destinations;
- Pedestrian access, including accessibility for handicap/wheelchair patrons;
- Physical roadside constraints (trees, poles, driveways, etc.);
- Potential patronage;
- Presence of bus bypass lane;
- Traffic control devices

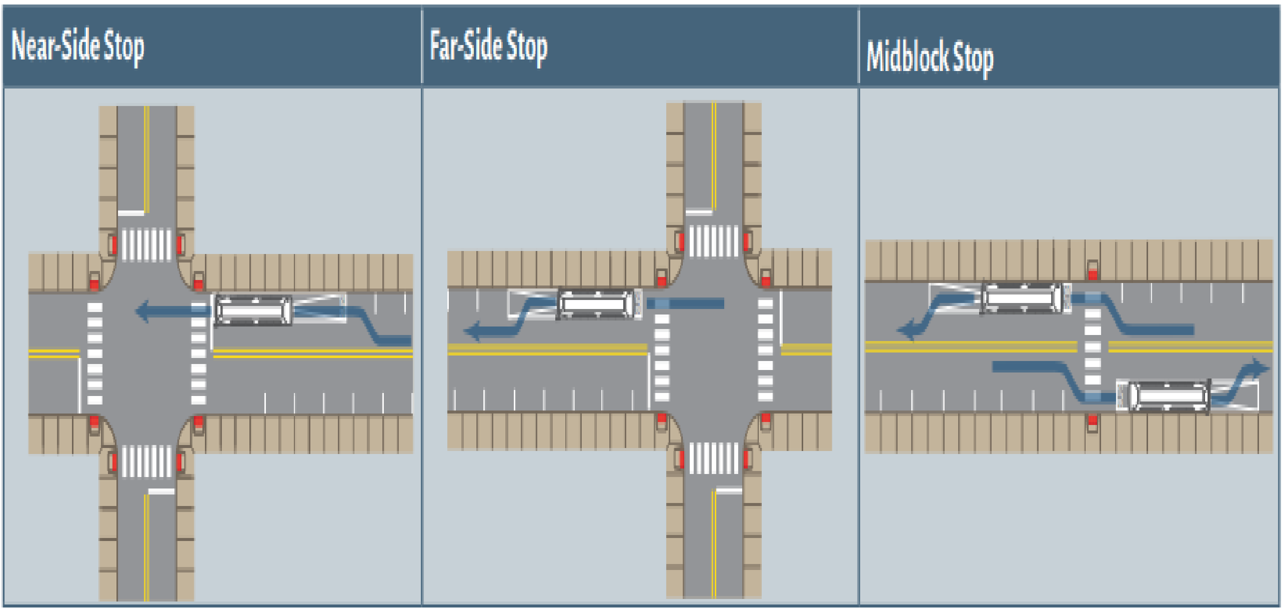

Figure 2.2: Types of Bus Stop Locations

Source: DVRPC (2012)

Table 2.2: Comparative Analysis of Bus Stop Locations

Stop Type	Advantages	Disadvantages
Near Side	• Minimizes interference when traffic is heavy on the far side of the intersection • Passengers access buses closest to crosswalks • The intersection is available to assist in pulling away from the curb • No double stopping • Buses can service passengers while stopped at a red light • Provides drivers with the opportunity to look for oncoming traffic, including other buses with potential passengers	• Conflicts with right-turning vehicles are increased • Stopped buses may obscure curbside traffic control devices and crossing pedestrians • Sight distance is covered for crossing vehicles stopped to the bus's right. • The through lane may be blocked during peak periods by queuing buses • Increases sight distance problems for crossing pedestrians
Far Side	• Minimizes conflicts between right-turning vehicles and buses • Provides additional right turn capacity by making curb lane available for traffic • Minimizes sight distance problems on approaches to the intersection • Encourages pedestrians to cross behind the bus • Requires shorter deceleration distances for buses • Gaps in traffic flow are created for buses re-entering the flow of traffic at signalized intersections	• Intersections may be blocked during peak periods by queuing buses • Sight distance may be obscured for crossing vehicles • Increases sight distance problems for crossing pedestrians • Stopping far side after stopping for a red light interferes with bus operations and all traffic in general • This may increase the number of rear-end accidents since drivers do not expect buses to stop again after stopping at a red light
Mid-block	• Minimizes sight distance problems for vehicles and pedestrians • Passenger waiting areas experience less pedestrian congestion	• Requires additional distance for no-parking restrictions • Encourages patrons to cross the street at mid-block (jaywalking) • Increases walking distance for patrons crossing at intersections

Source: TCRP (1996)

2.2.5.2. Bus Stop Elements

Bus stop elements are the way for communities to welcome visitors and for residents to take pride in their area. In certain instances, they could serve as a locality's visual identity and be seen as a resource for the neighbourhood. Bus stops should ideally include crosswalks, signalized crossings, and walkways connecting them to the surrounding community. People should be able to find their way to a stop when using a wheelchair, crutches, a stroller, or carrying heavy objects (DVRPC, 2019). Some of the common elements of bus stop (Fig 2.3).

a) **Public Art at Bus Stops:** Bus stops can be improved by including the local community to help design and create murals, street furniture, and overall place-making. Displaying creativity in these amenities can give people a sense of pride.

b) **Transit Shelters:** Shelters provide essential protection for passengers from all weather conditions. A quality shelter should have the following features:
   - The shelter should have a roof and be enclosed on at least two sides to provide a screen from prevailing winds.
   - Sun and rain or snow protections are essential. The shelter should be oriented and enclosed to protect against exposure.
   - The shelter opening should be oriented toward the path that leads to bus loading.

c) **Stop Area Seating:** If a bench is provided, it should be built of a sturdy material that won't rot from exposure to the elements and vandalism. The bench should have dimensions that are in compliance with the American Disability Act (ADA), with a suggested minimum length of 6.5 feet (2 meters) or the equivalent of 3 seats. Arms are a crucial component in helping the elderly and the disabled. A large-diameter tube approximately 2.5 feet (0.8 meters) above the stop position surface or slightly higher than seat height are options.

d) **Rubbish Receptacles:** Trash containers should be positioned at high-ridership stations, transfer points, and areas where it is evident that trash will accumulate over time. Including garbage cans necessitates more care. Consequently, a municipality or private body must have a maintenance plan and budget before installing them.

e) **Lighting at the bus stop increases safety by enhancing visibility for both drivers and passengers.** Additionally, it gives off a feeling of security and aids in defining the waiting area. Lighting may take a variety of shapes in any combination. Coordinating stop area illumination with a neighbouring street light may be more affordable.

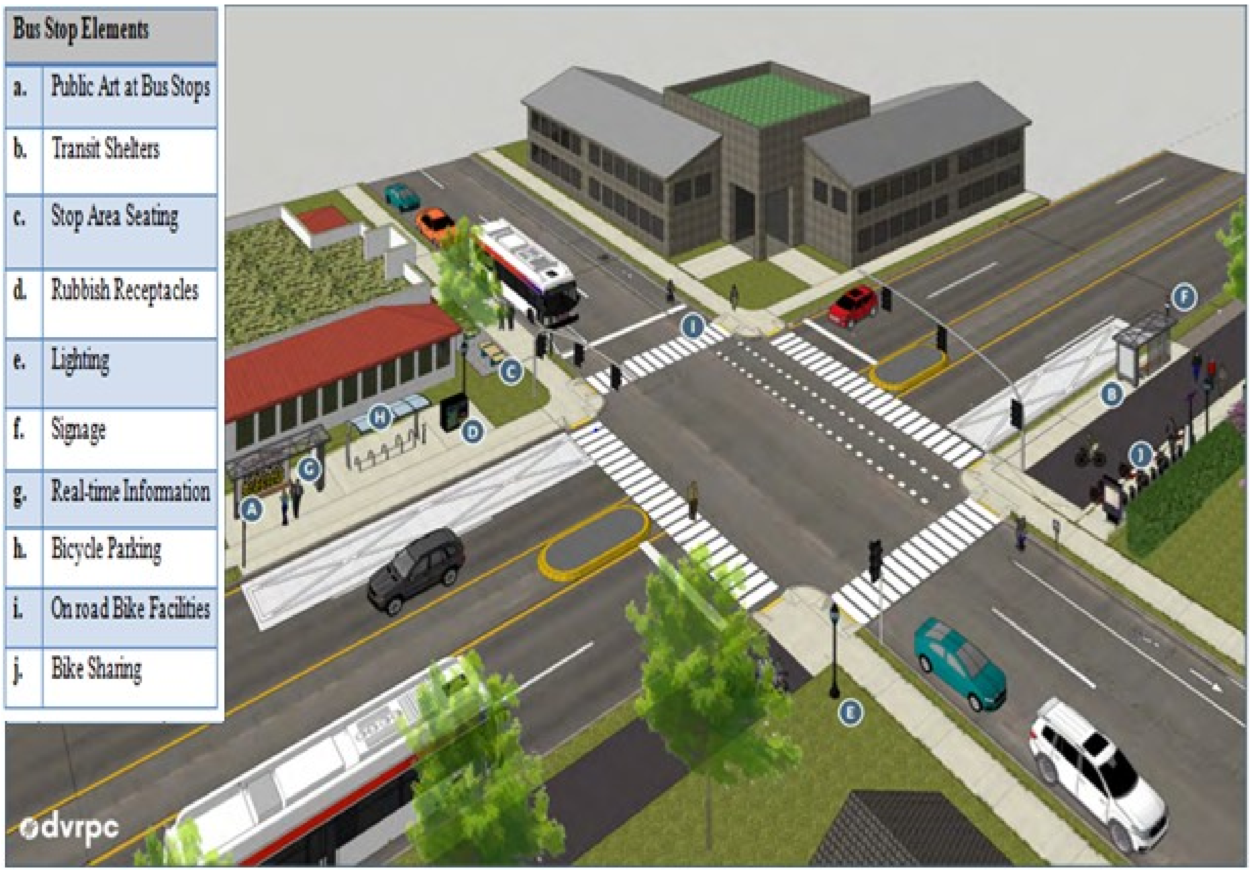

Figure 2.3: Bus Stop Elements Design Overview
Source: DVRPC (2019)

f) **Signage:** A double-sided sign attached to the bus stop's pole is the finest way to identify it. The sign's positioning makes it easier for passengers to see where the car will stop. The signpost may be a guide for those who use canes to identify the bus loading area if they have visual issues. Due to the signs' visibility, passengers can ensure they have arrived at the right location and are ready to board the right vehicle. The positioning of traffic signs and transit stop signs should not conflict with one another throughout the route. The notice should be placed two feet from the curb's edge and two feet from the bus loading zone. Additional static data, such as fare zones, fare pricing, wayfinding maps, signage to essential institutions and local retail hotspots, and transfer data to or between services and other modes, such as bike parking, bike share, parking for cars, or nearby trails, should be taken into consideration when appropriate.

g) **Real-time Information:** Sharing current bus position, operating, and schedule information with passengers for viewing at stations or on passengers' devices is referred to as "real-time passenger information." According to academic studies and customer satisfaction surveys, real-time data has a monetary value in the eyes of the general public, and this feature alone may boost ridership by 1-3%. (American Federal Transport Authority, 2002).

h) **Bicycle Parking:** To assist commuters who use bicycles for transportation but prefer not to utilize onboard bike racks, bicycle racks, and storage shelters are being employed more often. By providing safe bike storage at bus stops, bikers have an intermodal connection to the finish and additional flexibility.

i) **Safe Access for Bike Riders:** By constructing "protected" bike facilities on vital routes that link to bus stations, bikers and bus passengers may travel more quickly and safely. A barrier between bicycle and automobile traffic is necessary to protect bike infrastructure. On-street parking, sidewalks with planters, striped buffers with bollards, plain planters serving as medians, or any combination of these may serve as buffers.

j) **Bike Sharing:** Adding bike docks to bus stops close to bike share stations increases mode choice flexibility. By locating bike-sharing stations adjacent to bus stops, visitors can complete the "last mile," or the distance between their current location and the nearest stop.

2.2.5.3. Bus Stop Hierarchy

For many transit agencies and jurisdictions, resources for providing and improving passenger facilities are limited, requiring them to prioritize what and where improvements will be made. These improvements can be for safety, accessibility, comfort, and convenience. The hierarchy of bus stops that will guide the provision of bus elements and passenger amenities is classified into three: basic, enhanced bus service, and transit center.

Table 2.3: Bus Stop Hierarchy

Bus Stop Element	Basic Stop	Enhanced Service	Transit Centre
Bus Stop Sign	Yes	Yes	Yes
ADA 5'x8' Landing Pad	Yes	Yes	Yes
Sidewalk	Yes	Yes	Yes
Lighting	Evening Service	Yes	Yes
Seating	Trip Generator Based	Yes	Yes
Expand Boarding & Alighting Area (Rear-door access)	No	Site Specific	Yes
Bus Bay (Pull Off)	No	Site Specific	Yes
Shelter(s)	1 (50+ boarding/day)	1	2 +
Trash Receptacle	Site Specific	Yes	Yes
Information Case	Yes	Yes	Yes
System Map	Contingent on Shelter	Yes	Yes
Real-time Display (LED + Audio)	Optional	Yes	Yes
Interactive Phone System On-Site	No	No	Yes

Source: WMATA (2009)

2.2.6. Bus Stops Accessibility

In the literature, accessibility may be described in many different ways. Simmonds (1998) defines accessibility in terms of accessibility at both the origin and destination. According to Ross (2000), accessibility refers to how easily one may get to a place, which may include actual or perceived expenses in terms of time or money, travel distance, degree of comfort, accessibility to public transportation, dependability, or any combination of these factors. Physical access to a transit stop is measured in terms of how near the passenger's origin or destination is to the transit stop (TCRP, 1996). This is often done by small distances of walking, biking, or driving (Murray & Wu, 2003).

In this sense, a user's decision to utilize a transportation service is significantly influenced by the transit service's accessibility to their point of origin and destination (Jumsan et al., 2005). Al-Mamun & Lownes (2011) also evaluated three important accessibility factors. The first is trip coverage, which states that users will consider public transportation accessible if it is available to and from their trip origins/destinations. The second is spatial coverage, which states that users will consider public transportation accessible if it is reasonably close to their destination. The third is temporal coverage, which states that service is accessible if it is available during the desired travel times.

2.2.6.1. Bus Stop Access Coverage

Three methods for identifying bus stop catchment areas are suggested by researchers (Ahsan, 2013). The simplest method for creating transit catchment zones is to enclose a route in a buffer completely. The buffer, in this case, is determined by the greatest distance riders feel comfortable going to access the system, and it is focused on the route of interest. This method is predicated on the idea that the road can reach any place within the buffer zone. Building a walking-distance buffer zone surrounding each bus stop is the second empirical strategy. The limitation of this approach is that it does not consider the pedestrian network's connection, which might result in an overestimation of accessibility. The method finds all pedestrian network links near the bus stop that can be reached in the allotted amount of time by walking. In order to establish a reasonable service area surrounding each bus stop, this technique requires network analysis and a detailed understanding of network circumstances. The GIS may then use the proportion of each demographic zone to forecast the population and employment opportunities within walking distance of a bus stop.

Following that, bus stop access coverage would be determined using network analysis with a radius of the 400 meters access threshold, which is widely used among transit planners and researchers as the maximum distance that the majority of potential users are willing to travel to reach their nearest transit stop. It means a walking speed between 80 m/s and 95 m/s. The current network of pedestrian roads is taken into account while doing this. Bus stop access coverage would be calculated using network analysis with a radius of the 400m access criteria, and would be evaluated using network analysis with the 400m access threshold (Finnis & Walton, 2008). The coverage area derived from the current network of pedestrian routes gives a more accurate service area rather to building a circular buffer around a bus stop, which contains the error of overestimation (Foda & Ahmed, 2010). Such an overestimation is caused by the network of pedestrian routes' real topography being ignored, as well as the implicit assumption that passengers may reach the bus stop from anywhere within the circular buffer (the best case).

A technique to evaluate public transportation accessibility in metropolitan areas using a Geographic Information System (GIS) based on a pedestrian network with barriers was suggested by Salvo and Sabatini in 2005. In the framework of this research, consideration will be given to bus stop access coverage based on the current pedestrian road network around the bus stop. All pedestrian road network connections that are less than the 400-meter access threshold, which is the maximum walking distance, should be taken into consideration. Along the network of walkways connecting bus stops, the longest distance that can be walked would be measured. The endpoints of these linkages may be joined to provide a polygonal area for the bus stop. The region in concern is the "Actual Bus Stop Access Coverage." When comparing the access coverage of a bus stop, this polygonal region is seen to be more realistic than a circular buffer with a 400-meter diameter (Foda & Ahmed, 2010).

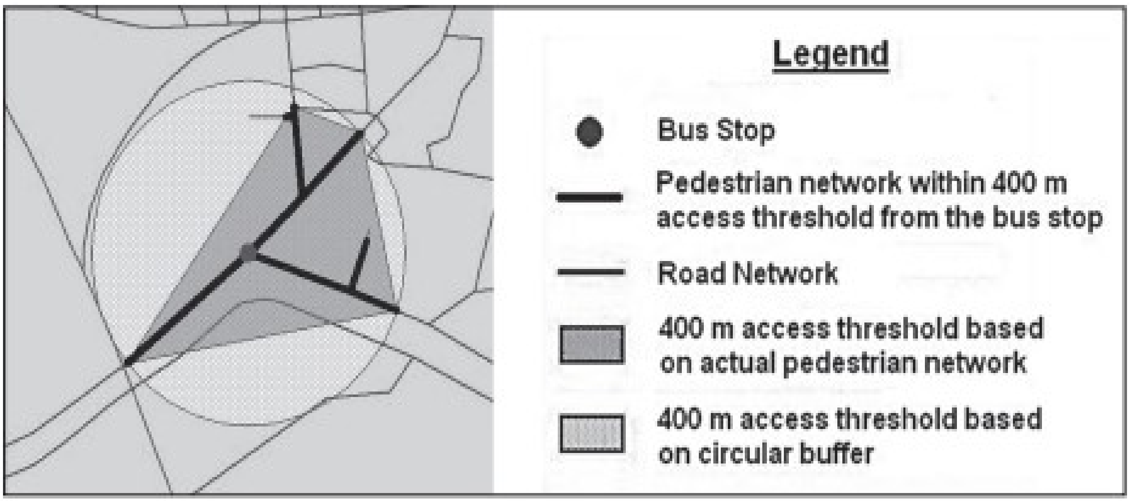

Figure 2.4: Ideal and Actual Bus Stop Access Coverage

Source: Foda & Ahmed (2010)

2.2.6.2. Actual Pedestrian Road Length and Pedestrian Road Network

The amount of pedestrian road's overall length that must be measured from the bus stop's commencement to determine the specific length of a pedestrian road is known as the actual length of a pedestrian road. The length of the parcel inside a road network may be less than the necessary length or equal to it (if the road ends before completing the particular length). The distance used in this investigation was a pedestrian lane's length, 400 meters from a bus stop. There are numerous pedestrian road lengths across the whole network, all of which start at the same bus stop (Ahsan, 2013).

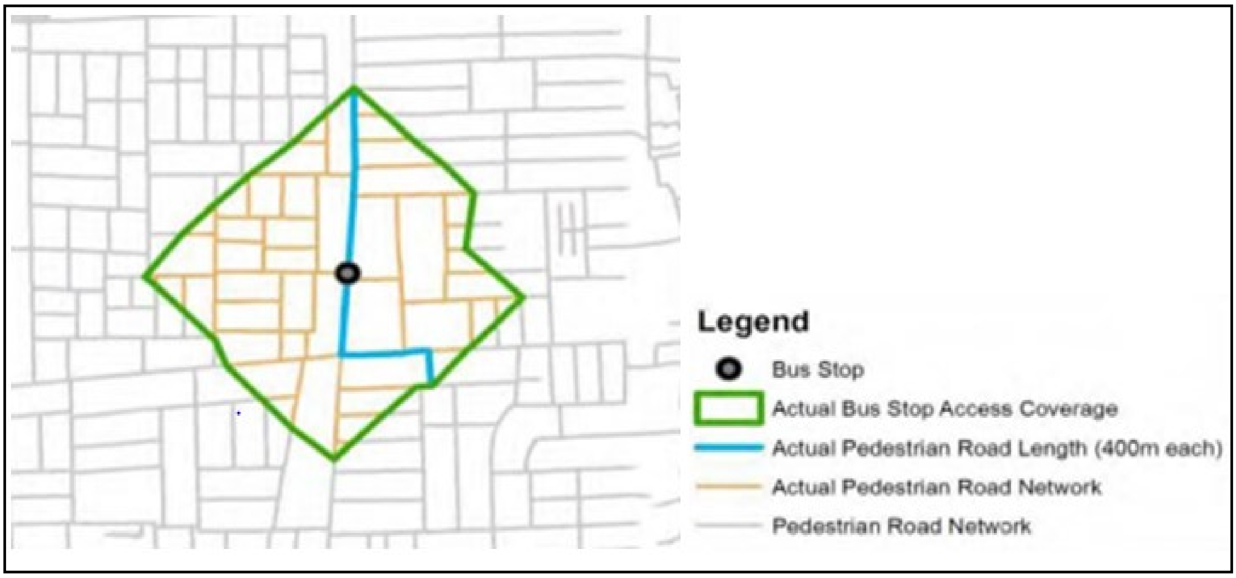

Figure 2.5: Actual Pedestrian Road Length and Actual Pedestrian Road Network

Source: Ahsan (2013)

2.2.7. Measuring Bus Stop Accessibility

According to Foda and Ahmed (2010), walking is the most common way to arrive at a bus stop when using a bus transportation service. Because every transit trip begins and ends with pedestrian travel, the accessibility of the bus stop site should consider how easily one can walk to the bus stop. Accessibility of bus stops is a term that may be used in this setting to evaluate how easily pedestrians can reach a bus stop using the local road network (Shatnawi, Al-Omari & Al-Qudah, 2020).

2.2.7.1. Ideal and Actual Stop Accessibility Index

The Ideal Stop-Accessibility Index (ISAI), which can be calculated by dividing the ideal access coverage area of the bus stop estimated as a circle by the total length of the pedestrian road network links lying within walking distance of 400m measured along the network paths (Km), can be used to assess the accessibility to a bus stop through the surrounding pedestrian road network. The area of a circle with a radius of 400 meters serves as the denominator, with the resultant value of this index representing the optimum pedestrian road network density within the access threshold from a bus stop (Km/Km2).

On the other hand, Actual Stop-Accessibility Index (ASAI) can be computed by dividing the total length of pedestrian road network within 400 meters of the bus stop that is estimated based on the pedestrian road network (measured in kilometers) by the actual access coverage area of the bus stop (measured in kilometers squared) (Foda & Ahmed, 2010).

Although only pedestrian road density can guarantee bus stop accessibility, trip generation and population service are other significant factors that influence this. Trip generation is one of the parameters since there are places, such as commercial zones, major retail malls, and marketing areas, where the road density may be relatively lower but may still generate many trips. Bus stops near retail establishments, educational institutions, medical facilities, and recreational locations may not have a lot of foot traffic. Nevertheless, they produce the most journeys in any place. Because they provide direct access to stops for many individuals, these stations often promote relatively better accessibility.

From this perspective, the bus stop in an area with a high population density will be easier to reach than the one with a lower population density. On the other hand, their coverage areas are identical. In addition, the accessibility of bus stops is impacted by various other factors, including gender, age, disability, and safety concerns. For example, women, elderly individuals, and persons with disabilities may find some bus stops more challenging to reach than others. The road density, trip generation, and population served are all considered.

1) **Road density**: The density of pedestrian roadways around bus stops is an essential criterion for evaluating accessibility. It indicates the number of pedestrian routes used to reach bus stops. The greater the number of pedestrian roads, the easier it will be for pedestrians to get to nearby bus stops. The road density may be computed by dividing the total length of pedestrian roads within the service area coverage by the bus stop's service area:

   $$\text{Road Density} = \frac{L\,(KM)}{A(\text{Km}^2)}$$

   Where: **'L'** is the sum of road length inside coverage of bus stops in km; **'A'** is the coverage area of the bus stop in Km^2

2) **Population Served:** Each bus stop's coverage area reveals which residents have direct access to that bus stop. However, mobile persons are not counted since it is

impossible to tally the varying quantities of people entering from all directions. The greater the bus stops coverage area, the higher the numbers of individuals who will have access to that bus stop, indicating the better the bus stops accessibility. Moreover, the accessibility of bus stops with the same coverage area might vary if they are situated in areas with varying population densities. For instance, the accessibility of the bus stop in a highly inhabited area will be greater than in a less densely populated one. The population served by a bus stops in the given service area can be calculated as follows:

$$\text{Population served} = \frac{\text{Total number of population}}{\text{total number of parcels}} * \text{No of parcels}$$

Therefore, the total number of households residing in the parcels within the 400-meter service area or polygon coverage area at each bus stop is the population served inside the bus stop service area at each bus stop.

3) **Trip Generation** is closely related to how an area uses its land. For instance, business and commercial areas will produce more travel than other areas. However, each bus stop estimates how many bus trips will be made to offer accessibility. As a result, journeys for public bus stops are generated using the coverage area of each bus stop. Therefore, trip generation is used to calculate accessibility with more accuracy. Trip generation is the overall number of people boarding each bus since several buses halt at a single bus stop. Therefore, the monthly bus travels for each bus route may be converted into daily travel by dividing the monthly trip by 30 days to assemble trip-generating data.

$$\text{Trips per day} = \frac{\text{Number of trip per month}}{\text{30 days}}$$

Then the trips for each bus stop were calculated by dividing the number of daily trips along the routes by the number of bus stops along the bus routes.

The accessibility of a bus stop is **ranked mainly** on a scale from excellent to bad, based on the aggregate accessibility index of the three factors presented in (Table 2.3). These categories are excellent, good, moderate, and poor (Muhammad et al., 2013). This suggests that the best bus stops have the highest potential accessibility indices (i.e., the stop, which ensures maximum road density, served population, and trip generation). As a result, stations that are rated as exceptional or good are those that offer users with comparatively the greatest accessibility, while stations that are rated as terrible provide them the least accessibility. With directions to bus stops, those ranked with highest accessibility (Ibid).

Table 2.4: Categorization of Accessibility Index

Bus Stop Category	Accessibility Index
Poor	<0.40
Moderate	0.40 – 0.59
Good	0.60 – 0.79
Excellent	>=0.80

Source: Ahsan (2013)

2.2.7.2. Bus Stops Spacing

Bus stop spacing is another important measure for bus stop accessibility. Stop spacing refers to the distance between stops along a route and reflects a trade-off between transit accessibility and operating efficiency (Foursquare Integrated Transportation Planning (FITP) & Jacobs Engineering, 2014).

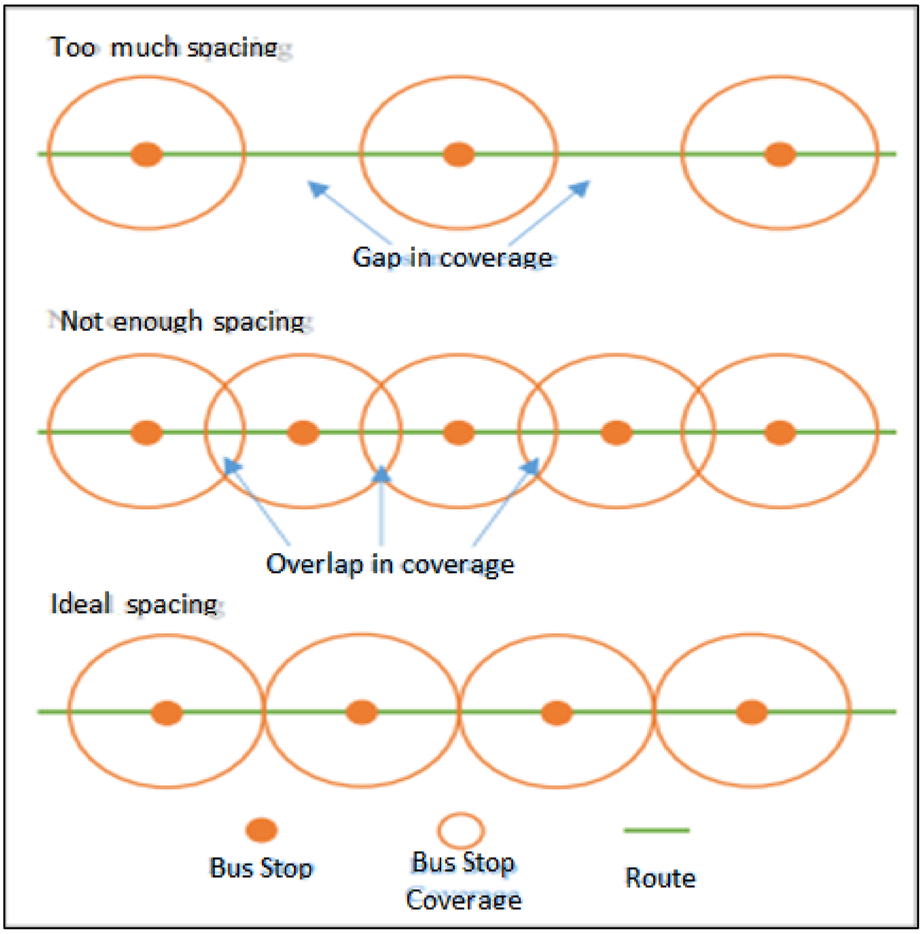

Figure 2.6: Spacing Impacts on Stop Coverage

Source: FITP & Jacobs Engineering (2014)

Closely spaced bus stops reduce passenger access distances but increase travel durations. Large bus stop spacing, on the other hand, decreases passenger in-vehicle time while decreasing system accessibility. Additionally, since buses must often stop to perform passenger services, closely spaced bus stops slow down traffic throughout the route, particularly during peak hours (Van-Nes & Bovy, 2000).

The distance between bus stops is somewhat governed by the geographical features of the region served by the route. Locks may be spaced farther apart in areas with a solid pedestrian infrastructure (excellent sidewalks, crosswalks, and traffic control devices) since there are fewer obstacles to pedestrian movement and access. There is neither a general agreement nor a universally accepted norm about the best stop spacing. Different countries have different minimum distances between bus stops that must be adhered to as a standard. The current stop spacing used by many public transportation services is not determined by official criteria but rather by historical practice, which may date as far back as the stop spacing used on defunct streetcar lines. Researchers determined the best stop spacing by simulating trip travel durations in numerous Dutch cities. It was found to vary from 600 meters in smaller towns to 800 meters in bigger ones (El-Geneidy et al., 2006).

2.2.8. Bus Stops Location Optimization

The optimal location for bus stops is those where passengers have the highest accessibility relative to other nearby destinations. The ideal placements of bus stops would be determined by two crucial considerations. The first one is using accessibility index, which combines three criteria: road density, population served, and trip generation (Ahsan, 2013). The second is bus stops spacing interval, with an average distance between 600 - 800 meters in major cities (El-Geneidy et al., 2006; Foda & Ahmed, 2010). Furthermore, the intersection or junction, topographic condition and policy factors determined the bus stops location. In this regard, it is indicated that bus stops should be positioned in no less than 30 meters from major intersections (Wang et al., 2016). Thus, to optimize the bus stop locations, four mitigation measures can be used:

a) **Kept Stops as it is**, if they are highly accessible and keep standard spacing;
b) **Creating new stops** where there is no existing bus stop along with a long distance between stops of more than 800m;
c) **Relocate** where the existing bus stops nearest to the optimal location; and
d) **Dissolving** bus stops that are situated in an uncomfortable area and very close to other bus stops.

2.3. Empirical Literature

2.3.1. Global Experience on Bus Stops

One of the crucial factors to consider when determining how good a transit system is its accessibility to public transport. Numerous studies have been conducted on the accessibility of bus stations. To establish each stop's effective service area, demand at each parcel, and undelayed running durations, historical stop analysis is used. Additionally, a GIS tool is used to assess the expected effects of stop delay on walking and cycling. Furth & Mekuria (2005) conducted a study in Boston, United States and discovered that eliminating the Mt. Hood Rd stop and moving the bulk of boarding and alighting to other stations would help to slightly lower the cost of satisfying the same demand. In Wuhan, China, Xuebin (2010) investigated stop location to optimize tradeoffs in eliminating stop duplication while maintaining accessibility and came to the conclusion that stops there are distributed haphazardly, which results in poor service quality. Consequently, using a geographic information system, the author created and categorized potential bus stops according to the walking distance between selected bus stops. A relocation and optimization model is then used to shorten the average stop distance.

Additionally, Shrestha and Zolnik (2013) looked at the benefits of pollution reduction through transportation equity by minimizing pauses in Virginia, United States. They eliminated bus stops that were more than 800 meters distant and set a walking threshold of 800 meters to the closest stop. Their study shows that doing away with bus stops will reduce operating costs, greenhouse gas (GHG) emissions, and travel time.

2.3.2. Public Transport in Addis Ababa

The modes of urban transport system in Addis Ababa are categorized into motorized and non-motorized transport. The motorized modes of transport include light rail transit, large city buses, midi-buses, and minibus taxis; while non-motorized transport services include walking, cycling and animal carts. The public transport system in the city of Addis Ababa is an important aspect of life for the residents that provide mobility to those who do not have access to private cars or to those who prefer public transport instead of private cars and it offers access to jobs, education, health and other social services.

The history of public transport service in the city of Addis Ababa dated back to the end of the Italian invasion, which was started in 1943 when Anbessa City Bus Service Enterprise (ACBSE) was, established (Avis, Weldetinsae, Getaneh & Singh, 2018). There are now many public transport service providers and among this Sheger Mass Transport, Alliance, Public

Transport Service Enterprise, Taxis, Higers, Kitkit and Light Rail Transit (LRT) are the major ones. City buses and minibus taxis are now the most frequent forms of public transportation in Addis Ababa. Despite having 30 seats for normal buses, each bus can accommodate between 70 and 100 people. Taxis can accommodate 4 (small taxis) to 12 people (large taxis). A light rail transport system on the other hand with a capacity of 261 people is also available in the city.

Since automobile ownership is uncommon, most citizens depend on buses, trains, and taxis for everyday transportation. In 2019, the public transport offered for mobility of more than 2.7 million people per day. From thus, the minibus taxis estimated to transported over 1.7 million people per day, followed by city buses (ACBSE, Sheger, PSTSE) (AACTB, 2021).

Table 2.1 revealed that minibuses (taxis) transported the largest portion of the passenger transport in the city with 1,728,272 passengers per day (63.7%) of the passengers transported. The city buses had also transported over 615,069 people daily (23.3%) from the city's total 2,729,175 daily passengers and the light rail transported 124,524 people daily (4.6%); while midibuses (Higer and Kitkit) transported 239,350 passengers per day (8.8%).

Table 2.1: Public Transport in Addis Ababa

Public Transport Type	**Number of vehicles**	**Passenger per day**	**Proportion (in %)**
Anbessa	761	217,000	8.0
Sheger	324	198,069	7.3
PSTSE	410	200,000	7.3
Alliance	125	21,960	0.8
LRT	41	124,524	4.6
Midi buses (Higer & Kitkit)	794	239,350	8.8
Minibus (Code1+Code3+Bajaji)	21029	1,728,272	63.3
Total	23484	2,729,175	100.0

Source: AACTB (2021)

This study is focused on Sheger Mass Transport Service Enterprise, which was established on May 27, 2016 with a view to address the acute shortage of transport service in Addis Ababa city. It began service with fifteen buses operating in two bus routes. In 2021, the Enterprise managed to give service on 79 routes with 324 buses of the Enterprise and 343 supportive cross-country buses, as well as 76 routes with 93 school buses. The Enterprise transported an average of 159,000 people per day and 50 million people in the year (SMTSE, 2021).

2.3.3. GIS Application for Bus Stops Accessibility Analysis

ArcGIS software is used in this work to analyze, process, and display all geographical data. It has numerous data capturing, analysis, processing, and display tools. For the current research, Geoprocessing and Network Analyst Extension tools were used.

Using buffer analysis with the Euclidean distance tool or service area analysis with network distance, the accessibility to the bus stop may be determined. The Euclidean distance establishes a circular buffer around the bus stop with a specified radius in a straight line, ignoring the network (Levinson, 2009). Numerous researchers have discovered that Euclidean analysis inflates the distance to the bus stop because the analyst creates buffers with a fixed radius around the transit station, regardless of the road network and the pedestrian prohibition of land use such as rivers, lakes, railroads, and highways, etc (Mavoa, 2012). On the other hand, the service areas analysis is a tool of the network dataset that specifies the access roads within a particular journey time or distance. The study relates to the network dataset and displays all streets involved at various break times approximately the facilities (O'Sullivan, 2000).

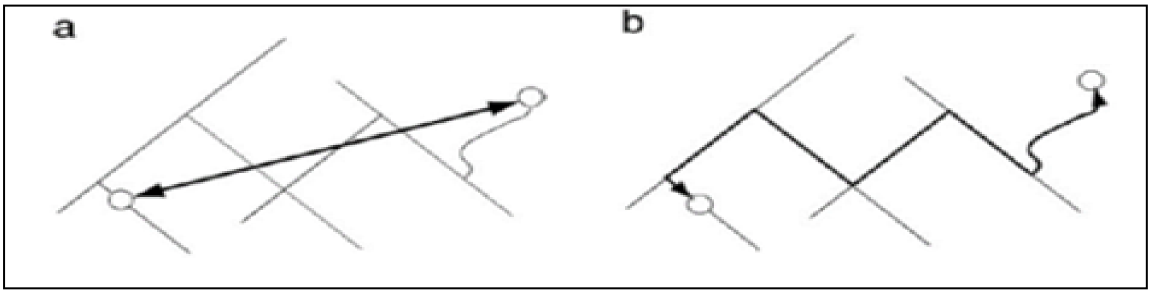

Figure 2.7: Difference between Euclidean (a) and Network Distance (b)

Source: Levinson (2009)

The service areas analysis is deemed more realistic than the buffer analysis (Langford, 2012). The buffer analysis for the bus stop seems to include greater territory and hence, a larger population. Since passengers cannot approach the bus stops directly from a birds-eye perspective, this study does not provide the most dependable findings. It, thus, assumed that passengers would utilize existing roads to reach the bus stops in the service area study.

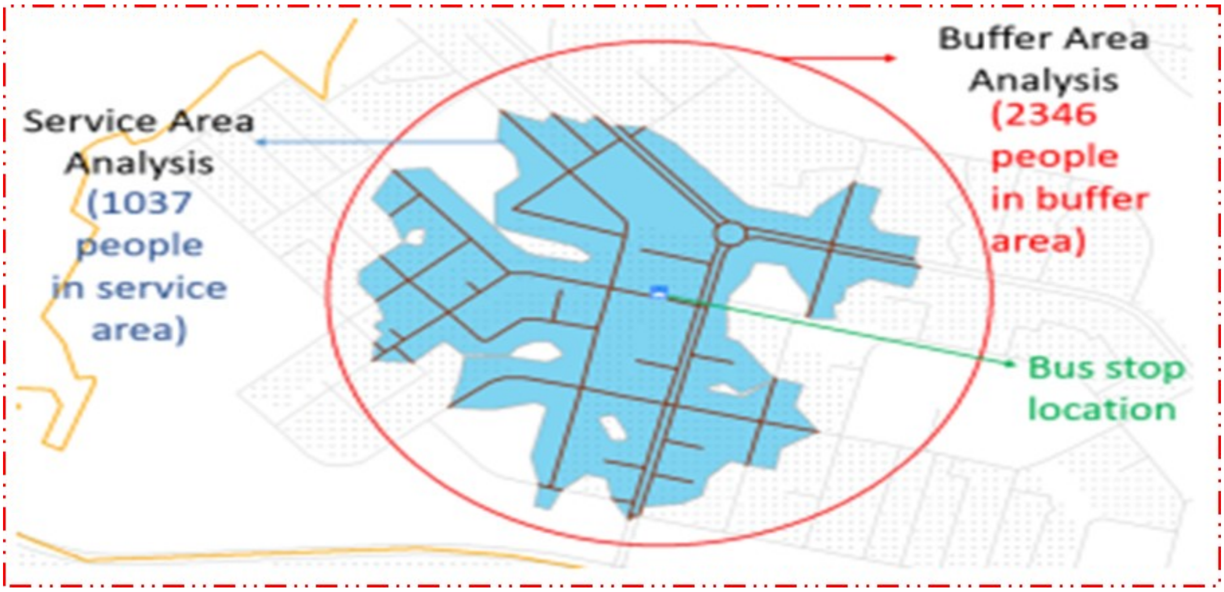

Figure 2.8: Comparison of Buffer and Service Area Analysis

Source: O'Sullivan (2000)

2.4. Research Gap

In Ethiopia, only few researches were conducted on bus stops. For instance, Melsmo & Hilemichael (2022) conducted a study on Anbesa bus stops accessibility considering Route 101. They concluded that a proposed change of 8% of the current bus stops could gain (2020) conducted a study on bus stop accessibility of Anbesa bus in Yeka Sub city. He found that more than 70% of Anbesa bus stops in Yeka Sub-city are categorized as poor accessibility and proposed optimal bus stops location for Anbesa bus in the study area. These studies were focused on the Anbesa bus stops that are placed somehow close to each other, with most of the bus stops lie in between 300 – 500-meter spacing intervals representing more service area overlap (Melsmo & Hilemichael, 2022). On the other hand, Sheger bus stops are far apart with a spacing interval up to 2000 meter (SMTSE, 2022) that needs to be standardized in the city considering all other types of buses including Sheger. The present analysis thus optimizes bus stops while taking trip production, population served, trip network density, and bus stop spacing into account. Large amounts of these various types of data are kept together inside a single database and are mapped, modelled, and displayed using GIS software as part of the study.

2.5. Conceptual Framework of the Study

The conceptual framework of the study shows the variables' interrelationships. To optimize bus stop accessibility, the existing conditions of the bus stops and its amenities were examined first. Second, the bus stop accessibility was evaluated using road density, trip generation, population served, and distance between stops. The best locations for bus stops were then chosen based on four alternative options. The first one is keeping the bus stop, as it is if it offers high accessibility with stop spacing complying with the standard. The second one is creating new stops, if the distance between stops is greater than 800 meter. The third one is relocating the bus stops, if the existing bus stop is closest to the best locations; and the fourth one is dissolving the bus stops that are uncomfortable or too close to other bus stops with poor accessibility (see Figure 2.9).

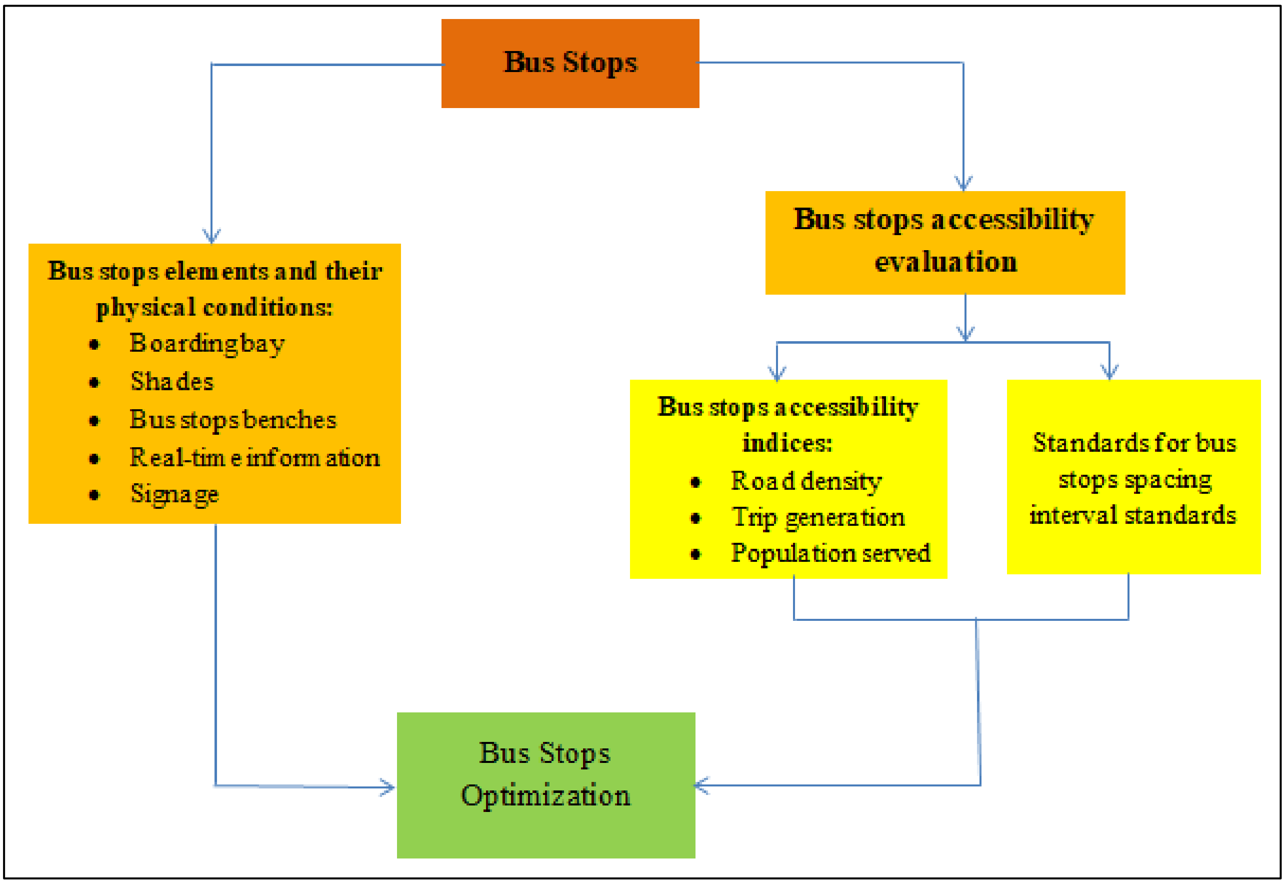

Figure 2.9: Conceptual Framework of the Study

Source: Researcher's Own Development Based on Literature Review (2022)

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

This chapter describes the methodology of the study. Kothari (2004) states that research methodology is the "science of carrying out research" and it describes the processes that researchers go through the research. To obtain accurate results from the research, the study has to be planned using an appropriate research design. Thus, this chapter covers description of the study area, the research approach and type of research, the study population, sampling technique and sample size, the data source and method of data collection, data reliability and validity issues, and the issue of ethical considerations.

3.2. Study Area

This study was carried out in Addis Ababa, the capital of Ethiopia and the political as well as the economic hub of the country. It is the headquarters of many international organizations and diplomats, including the African Union (AU), the United Nations Economic Commission for Africa (UNECA) and others.

Geographically, Addis Ababa city is located at 9° 2' N and 38° 45' E. The topography ranges from rolling to the hilly area with a relatively steep gradient and numerous stream valleys. It has an average elevation of 2500m above mean sea level with suitable and moderate weather and climatic conditions.

Addis Ababa occupies a total area of about 540 km^2 and is currently subdivided into 11 sub-cities. Addis Ababa is also a home to 25% of the urban population in Ethiopia and is one of the fastest-growing cities in Africa. The city's economy is growing annually by 14%, with a current contribution of approximately 50% towards the national GDP. The city projected population by 2021 is closer to 5 million (World Bank, 2021).

Public transport in the city consists of conventional bus services provided by Anbessa City Bus Service Enterprise (ACBSE), Sheger Mass Transit Service Enterprise (SMTSE), Alliance Bus Transport Service Enterprise (ABTSE), Public Service Employee Transport Service Enterprise (PSETSE), Addis Ababa Light Rail Transit (AALRT), midi-bus, and minibus. The city has 1,620 buses (Anbesa, Sheger, Public Service and Alliance), 794 midi buses, and 21,029 taxis operating in more than 260 routes (AACTB, 2021).

The city has a total of 2,561 km of asphalt road, 2,030 km of gravel road, 1,850 km of cobblestone road, and over 621 km of pedestrian ways. The road network coverage rose from 12.90% in 2010/11 to 18 % in 2014/15. However, the road network of Addis Ababa is limited in extent and right of way. Its capacity is low, with prevalent on-street parking and deteriorating pavement conditions.

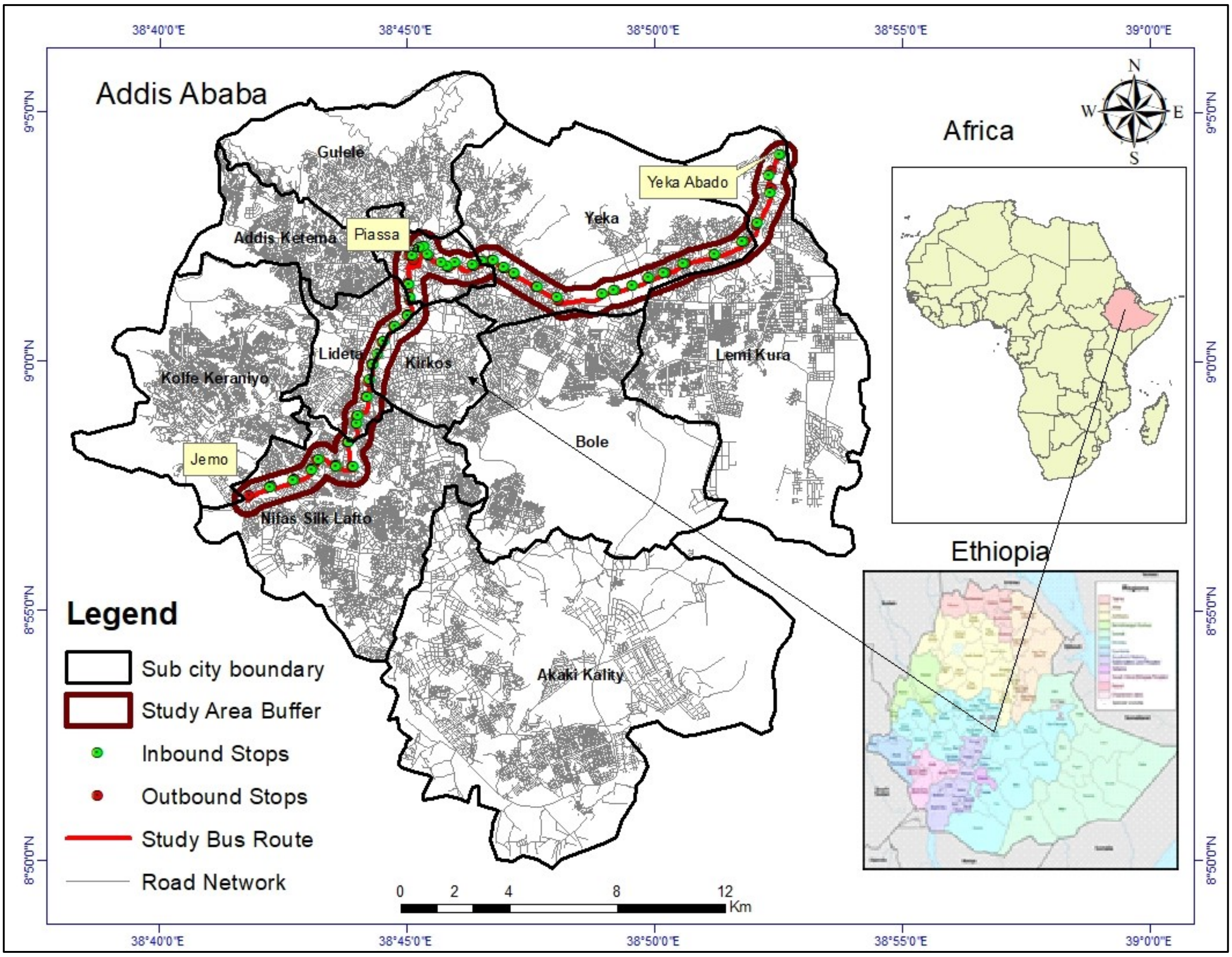

Figure 3.1: Location Map of the Study Area

Source: AACTB (2021)

For this study, two Sheger bus routes (i.e., Piassa – Yeka Abado and Piassa – Jemo) with large share of passengers and bus dispatch were selected. Along the study bus routes, all Sheger bus stops were considered in the study and the bus stops were categorized into two based on the traffic flow directions (Inbound and Outbound). Bus stops in the direction of traffic flowing inwards to the city center were considered inbound bus stop, and those in a reverse direction traveling outward from the city center towards the suburb area were considered outbound. Accordingly, 39 inbound and 38 outbound stop that make a total of 77 bus stops were considered for this study (see Figure 3.1 and Figure 3.2).

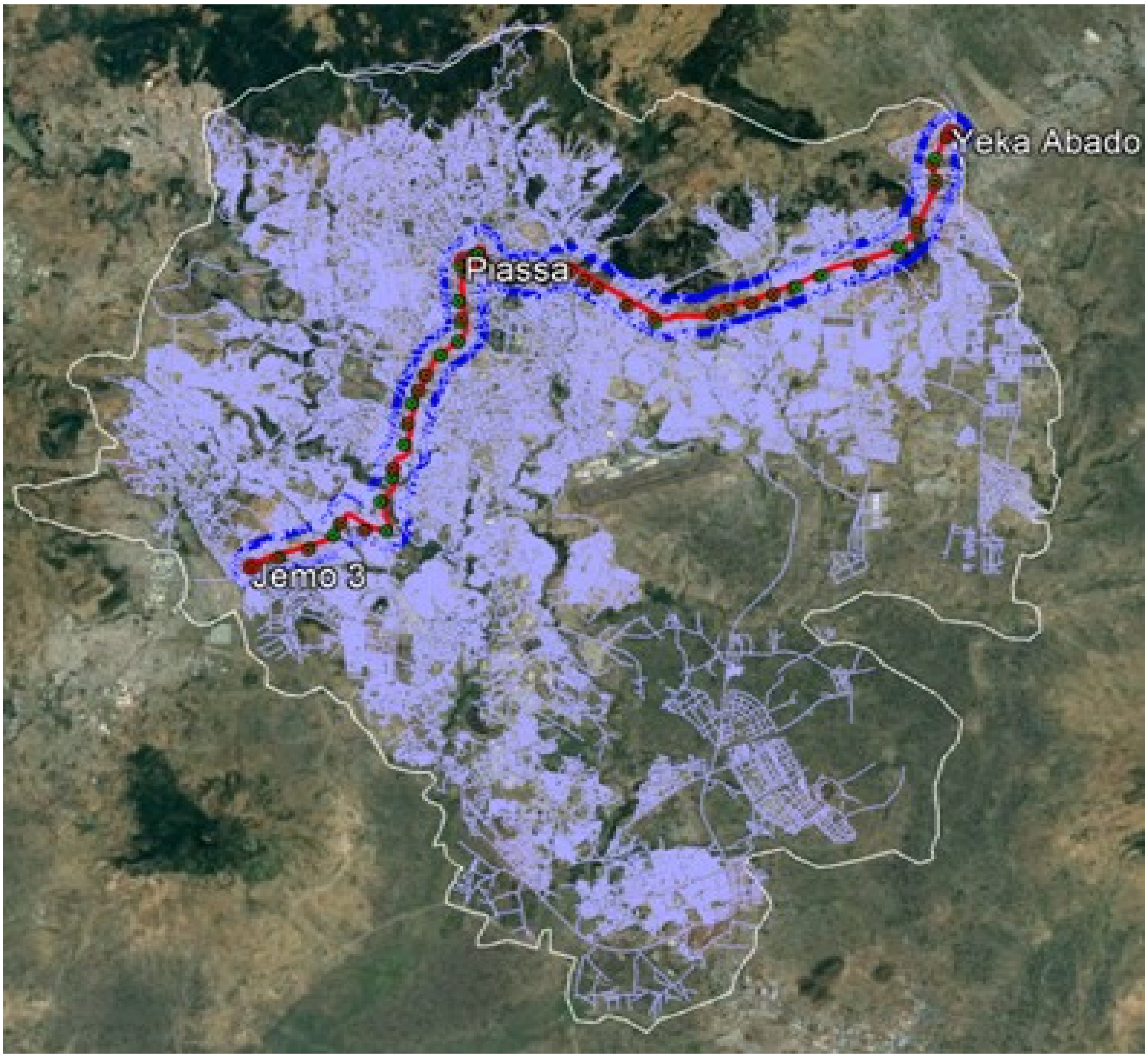

Figure 3.2: Image of the Study Bus routes

Source: Google Earth Pro (2022)

3.3. Research Design

For this research, a concurrent mixed research approach was used. The rationale for using mixed methods is due to its flexibility, which seems well suited to support rigorous examinations of promising ideas. Here the quantitative approach was used to analyze the existing condition of the bus stops and their accessibility to public transport users. While the qualitative approach was used to explore the opinion of transport professionals and officials on the accessibility of bus stops. Thus, by linking qualitative and quantitative research approaches, the advantages of both can be gained.

A descriptive research designs was employed for this research, as the aim of the research is to analyze the existing condition of the bus stops and its accessibility. The research strategy for the study employed was also a cross-sectional survey design as the focus of this research is to describe the existing scenario based on the data obtained from the sample population. The study also employed cross-sectional survey since the data were collected at a point in time.

3.4. Data Type and Sources of Data

To achieve the study's objective, both primary and secondary data sources were used in this research. The primary data were collected through questionnaires, interviews, and field observation. The questionnaires were distributed to Sheger bus users along the study bus routes, while the interviews were conducted with senior officers and officials from SMTSE and AACTB. Moreover, field observation was conducted to assess the exiting bus stops condition along the study bus routes. On the other hand, secondary data related to the number of bus stops, bus routes, bus trips, road networks, and parcel and population-related data were collected from relevant institutions, as presented in Table 3.1.

Table 3.1: Data and Data Source

Data	**Data type**	**Data Sources**
City and Sub city boundary	Shapefile	Addis Ababa City Plan Commission (AACPC)
Bus Stops and Bus routes	Shapefile/Excel	Addis Ababa City Transport Authority (AACTB) and Sheger Mass Transit Service Enterprise
Road network	Shape file/ AutoCAD	Addis Ababa City Road Authority (AACRA)
Land use and parcel data	Shape file/ AutoCAD	Addis Ababa City Plan Commission (AACPC)
Population data	Exel	Central Statistical Agency (CSA)
Bus number and bus trip	Exel	SMTSE
Image data	Image	Google Earth pro

3.5. Sampling Design

3.5.1. Target Population

The population is the study object and comprises groups, individuals, organizations, or conditions (Kothari, 2004). For this study, the study population includes the bus routes, bus stops, buses and bus users in Addis Ababa city, as well as professionals and officials from relevant institutions working on the public transport sector in the city. Accordingly, the study bus routes, bus stops, buses, bus users or bus passengers, and transport professionals were selected as discussed in the following sections.

3.5.2. Sample Size

After identifying the target population, the sample size for the study population should be determined. Accordingly, two bus routes (Piassa – Yeka Abado and Piassa – Jemo) were selected as they can represent the situation of the bus stops in the city with the origin at the main hub or center of the city (Piassa) towards the large residential condominium housings. These bus routes serve a large portion of passengers assigned many buses. About 77 (i.e., 39 inbound directions and 38 outbound) Sheger bus stops along the selected two bus routes were considered. Third, the sample size for passengers was determined using Kothari's (2004) formula at a 93% confidence level as passengers are more or less homogeneous being Sheger bus users.

$$\mathbf{n} = \frac{\mathbf{z2pq}}{\mathbf{e2}}$$

Where N = total number of bus users (unknown)

n = desired sample size,

Z = 1.81, at 93% confidence level, due to the homogeneity of the population

p = 0.5, estimated characteristics of the target population;

q = 1- p (maximum variation=0.5)

e = level of significance test (7%) margin of error

$$n = \frac{z^2pq}{e^2} = \frac{(1.81)^2*(0.5)*(0.5)}{(0.07)^2} = 167$$

3.5.3. Sampling Technique

To ensure that the findings represent the intended objective, it is essential to use an appropriate sampling strategy. For the current research, non-probability sampling was used. First, the researcher selected the study bus routes using purposive sampling. In this regard, two bus routes radiating from the hub or the center of the city (Piassa) with the concentration of traffic attracting administrative and commercial activities towards the two largest residential condominium housing areas generating a large number of passengers traffic were selected. Second, all Sheger bus stops along the study routes were chosen to be the focus of this research. Third, sample passengers were selected from those Sheger bus users along the study bus routes that were ultimately chosen for the study, both inbound and outbound direction. Quota sampling was used to distribute samples for the two bus routes in the inbound and outbound direction. Finally, passengers' (individual respondents) who participated in the study were chosen through convenience sampling. In addition, for the interview key informants were selected through purposive sampling technique.

3.6. Method of Data Collection

To address the research objective, the data for this research were collected through questionnaires, interviews, field observation, and document review. In this regard, as this research mainly depends on secondary data (GIS spatial data), extensive data preparation was made for the road network, bus stops, and parcel data to analyze bus stop accessibility.

3.6.1. Survey Questionnaire

A questionnaire elicits passengers' feelings, beliefs, experiences, perceptions, or attitudes. The questionnaire was prepared to collect data from Sheger bus users in the selected bus routes. In this regard, both close-ended and open-ended questions were prepared in English and translated into Amharic for the ease of collecting data from passengers of different categories. The first part of the questionnaire was on the socio-demographic characteristics of the respondents, such as age, sex, employment status, income level, and travel behavior. The second part of the questionnaire was on the existing bus stops physical condition and accessibility of the existing bus stops.

3.6.2. Key Informant Interview

Semi-structured interview questions were prepared for this research. The interviews were conducted face-to-face and by telephone to gather data from professionals in relevant transport institutions such as Addis Ababa City Transport Bureau and Sheger Mass Transit Service Enterprise. The face-to-face interview allows the researcher to obtain in-depth information and greater data clarity. A telephone interview was also employed to get clarification and consolidate the information.

3.6.3. Field Observation

Field observation was another method used in this study. The purpose of this observation was to record the physical condition of the bus stations located along the study bus routes. To document these events, photographs and videos were taken.

3.6.4. Document Review

Secondary data related to the bus routes, bus stops, the road network, the population, land parcels, and the number of trips generated by buses were gathered from relevant organizations. The city and sub-city boundary as well as the parcels shapefiles were obtained from AACPC. The bus route, bus stop, and road network data were obtained from AACRA and SMTSE, while population and household-related data were obtained from CSA. Moreover, the bus number, bus trip, and related data were obtained from SMTSE. Various documents such as relevant institutions' reports, statics, policies, magazines, brochures, online websites, journal articles, books, published conference papers, and previous researches were reviewed.

3.7. Method of Data Analysis

Data analysis methods used for this study include descriptive and inferential statistics with the help of SPSS version 26 and Microsoft Excel 2016 as well as thematic and spatial analysis with the help of ArcGIS version 10.8. The descriptive statistics involves the use of frequency distribution, percentage, mean, and standard deviation while the inferential statistics involves the use of t-test. Moreover, thematic analysis will be used to support the quantitative and spatial analysis. In this regard, the existing bus stops physical conditions were assessed using descriptive and inferential statistics while the accessibility of each bus stops were evaluated based on three parameters: population served, trip generation, and road density. From these parameters individual indexes for the parameters and combined accessibility index were developed using GIS. Further, the bus stops spatial optimization was done by considering bus stops accessibility index, stops spacing standard and junction constraints. To do so, first the network-distance-based service areas polygons for each bus stop were created using a service area solver, encompassing any edge that was 400 meters or less from the bus stop. Then, the three parameters: road density, trip generation and population served were prepared once the service area was established. These parameters were prepared in several shapefiles in order to evaluate the accessibility of the bus stops.

a). Road Density: The bus stop service area in square kilometer, the total length of the roads in kilometres, and the road density were calculated from the extracted road network data using the field calculator option in the feature attribute. The road density was calculated using ArcGIS's "field calculator" by dividing the total length of all the roads in the service area covered by the service area of the bus stop.

$\mathbf{RD} = \frac{\mathbf{L}}{\mathbf{A}}$, Where

RD= Road Density, "L" is the total road length within the bus stop's coverage area in kilometers and "A" is the coverage area in square kilometres.

The road density of 39 Inbound and 38 outbound bus stops has been calculated and is shown in Annex V and Annex VI, respectively.

b). Trip Generation: it refers to the total number of passengers per day served by a bus stop. Due to the absence of trip generation data for bus stops, the daily trip generation for each bus stop was estimated based on the average daily trip made by each of the bus passing the stop. In this regard, the total number of Sheger buses passing each bus stop throughout the study route and their trip data were collected, and the daily trip generation of each bus stop was estimated by dividing the total daily bus trip by the total number of bus stops along the route. Thus, the number of daily bus trips for each bus stop was calculated by dividing the number of passengers per day along the bus route by the number of bus stops along the bus route. The trip-generation data for both (inbound and outbound) bus stop were shown in Annex V and Annex VI, respectively.

c). Population Served: The population served by the bus stops was calculated by multiplying the number of parcels in the service area and the average household size (5) using the "field calculator". The number of clipped parcels within the bus stop service area was counted from the attribute table for each bus stop and then multiplied by the number of households per parcel. The population served for each of the inbound and outbound bus stops was presented in Annex V and Annex VI, respectively.

After preparation of the road density, trip generation, and population-served shapefile data, they were converted into raster data. Using the ArcGIS geoprocessing tool, "reclassify" each of the parameter were reclassified into four categories (>0.80 as ‘Excellent’, 0.60 - 0.79 as ‘Good’, 0.40 - 0.59 as ‘Moderate’ and <0.39 as ‘Poor’), to get the accessibility index for each parameter. Then, to prepared combined accessibility index weight was given to Road density (64%), trip generation (26%) and population served (10%), which was then added using a "Raster Calculator" (Muhammad et al., 2013). Each of the three parameters' accessibility indices for (Inbound) and (Outbound) bus stops are shown in Annex V and VI, respectively.

Next, to optimize the bus stops accessibility, three criteria were considered: the combined accessibility index (excellent, good and moderate) (Mohammed etal, 2013), the bus stops spacing standard (600-800 meters) (Foda & Ahmed, 2010; El-Geneidy et al., 2006), and junction constraint (30 - 50 meters) (Wang et al., 2016). Accordingly, first bus stops spacing of 800 meter was measured starting from the origin (Piassa) towards the two ends of the study bus routes and proposed stops were prepared considering the aforementioned criteria. Thus, the optimization of the bus stop location involves four alternatives: keeping the existing bus stop as far as it comply with the criteria, relocate (shift backward or forward) if the bus stop do not comply with the criteria, creating a new bus stop if the bus stops are very far apart with each other, or eliminating the existing stops if very close with each other.

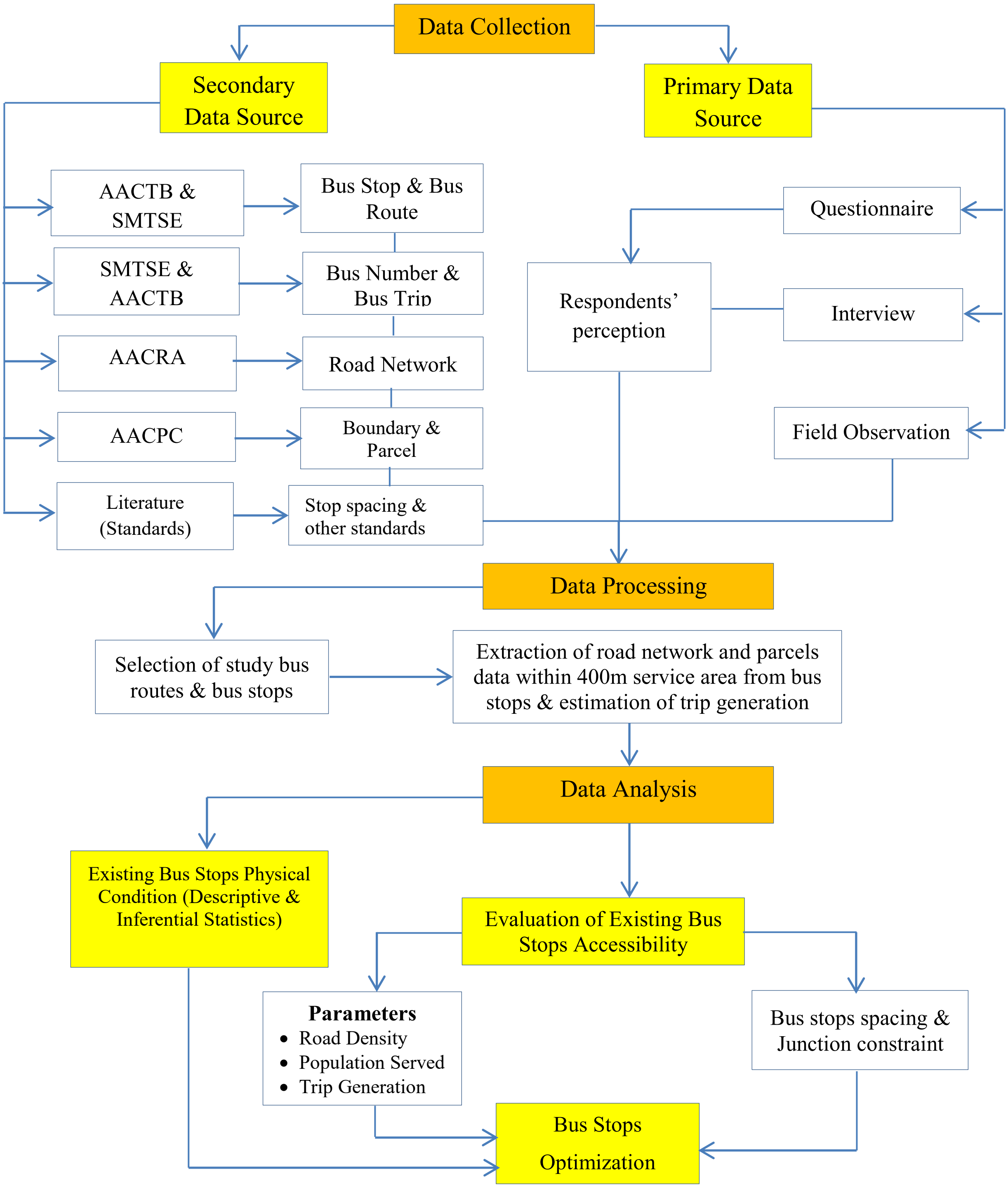

Figure 3.3: Flow Chart of Method of Data Analysis
Source: Researcher's Own Development (2022)

3.8. Data Reliability and Validity

Reliability is the degree of consistency that the instrument demonstrates. It implies that whatever the method of data collection to be used should be consistent with every subject studied. Thus, a reliability test was performed to check the internal consistency using Cronbach's Alpha. The reliability coefficients between 0.70 and 0.90 are generally internally consistent (Tavakol & Dennick, 2011). Accordingly, as the Cronbach Alpha coefficient was 0.828, the internal consistency is satisfactory, and the data was reliable.

Table 3.2: Cronbach's Alpha Reliability Test

Reliability Statistics		
Items	No. of Items	Cronbach's Alpha
Passengers' perception of bus stops the physical condition	13	0.828

Source: Field Survey (2022)

Validity shows how effective the research instrument is in measuring what they are supposed to measure. To ensure the validity of the tools, a pilot test was done. The pilot test gives guidance on aspects such as the adequacy of the sampling frame, the variability of parameters within the survey population, and the non-response. Pilot testing is thus used as a precaution taken before the main survey is conducted (Van-Thiel, 2014). The effectiveness of the questionnaire wording and design was established from the pilot survey. Thus, based on the pilot test, addition, omission, and modification of questions were undertaken.

3.9. Ethical Considerations

In research, ethical considerations are essential. This pertains to the moral norms that the researcher must examine at every step of the study. As a result, the researcher was able to get key informants for the interview, informed consent from respondents to complete the questionnaire, and a letter from the Department of Geography and Environmental Studies permitting the gathering of secondary data from pertinent organizations. The purpose and confidentiality of the study were explained to respondents and key informants in the introduction to the questionnaires and interview guide. Therefore, this study avoided respondents' data processing and presentation customization. In addition, all resources used for this study have been acknowledged.

CHAPTER FOUR: RESULT AND DISCUSSION

4.1. Introduction

This chapter covers the findings of the study based on surveys, interviews, field observations, and desk review. The study outcome was also validated by triangulating the data acquired via various methodologies. Accordingly, the existing condition of the bus stops and their accessibility to were evaluated using three bus stops accessibility parameters: the road density, trip generation and population served as well as the bus stops spacing interval. Finally, optimal locations for bus stops were proposed based on these specified accessibility parameters.

4.2. Response Rate

For this study, from the 167 questionnaires distributed, 163 were properly filled and returned. Hence, a 97.6% response rate was achieved (see Table 4.1). In addition to the questionnaire, four key informant interviews were conducted with managers and officers from Addis Ababa City Transport Bureau and Sheger Mass Transport Enterprise.

Table 4.1: Response Rate

Direction	O/D	Distributed	Returned	Response Rate
Outbound	Piassa- Yeka Abado	42	40	95.2%
	Piassa- Jemo	42	41	97.6%
Inbound	Yeka Abado - Piassa	42	41	97.6%
	Jemo – Piassa	41	41	100%
Total		167	163	97.6%

4.3. Demographic Profile of the Respondents

The respondents' demographic profile, including sex, age, level of education, occupation, and monthly income, were taken into account in the survey questionnaire, and the results are provided in Table 4.2. Accordingly, 105 (64.4%) of the 163 responders were male, while 58 (35.6%) were female. This indicates that male bus users comprised the majority of the respondents (passengers). On the other hand, the respondents' age group was classified into five groups and more than half of the respondents' (54.6%), were adults between the ages of 26 and 45, followed by those between the ages of 18 and 25 (19.6%).

Regarding the level of education, the majority of the respondents were degree holders, 52 (31.9%), followed by 37 (22.7%) and 34 (20.9%) secondary education and diploma holders, respectively. On the other hand, in terms of occupation, it was found that most of the respondents, 61 (37.4%), were government employed, followed by 32 (19.6%) privately employed and 29 (17.8%) students. Concerning the respondents' monthly income, 58

(35.6%) of the respondents have a monthly income of 2500-5000 ETB, and 33 (20.2%) of the respondents do not mention their monthly income, which could be a group of students or fresh graduates who are searching for a job.

Table 4.2: Demographic Characteristics of Respondents

No.	Item	Category	Frequency	Percentage
1.	**Sex**	Male	105	64.4
		Female	58	35.6
		Total	163	100
2.	**Age**	Below 18 Years	29	17.8
		18-25 Year	16	9.8
		26-35 Year	47	28.8
		36-45 Year	36	22.1
		46-55 Year	27	16.6
		Above 55 Year	8	4.9
		Total	163	100.0
3.	**Level of Education**	Illiterate	0	0
		Read and write	22	13.5
		Primary Education	18	11.0
		Secondary Education	37	22.7
		Diploma	34	20.9
		Degree and above	52	31.9
		Total	163	100.0
4.	**Occupation**	Government Employed	61	37.4
		Private Employed	32	19.6
		NGO Employed	7	4.3
		Self-Employed	13	8.0
		Unemployed	21	12.9
		Students	29	17.8
		Total	163	100.0
5.	**Monthly Income**	Less than 2500 ETB	30	18.4
		2500-5000 ETB	58	35.6
		5000-7500 ETB	21	12.9
		7500-10000 ETB	13	8.0
		Above 10000 ETB	8	4.9
		Others	33	20.2
		Total	163	100.0

Source: Field Survey (2022)

4.4. Respondents Travel Characteristics

4.4.1. Modes of Travel

The survey result on the frequency of travel by different modes of public transport is presented in Table 4.3. The result revealed that most of the respondents frequently use buses and minibuses; where the majority (41.1% and 26.4%) of sample passengers use buses 3-5 days a week and every day, respectively; and 38.0%, 23.3%, and 22.1% of sample passengers use minibus (Blue & White taxi) 3-5 days a week and every day, respectively. On the other hand, 29.4% and 34.4% of sample passengers use LRT once a week and twice a week, respectively; and while 26.4%, 23.3%, and 20.2% of them use minibus (Higer & Kitkit) once a week, twice a week and never use respectively. This implies that most of the respondents use minibus taxis and buses that demand the improvement of bus service to increase the number of passengers further to be travelled by bus.

Table 4.3: Frequently Used Mode of Travel

Frequency of Use		Never	Once a month	Once a week	Twice a week	3-5 days a week	Every day	Total
LRT	Freq.	14	21	48	56	18	6	163
	%	8.6	12.9	29.4	34.4	11	3.7	100
Bus (Anbesa, Sheger, Public Service & Alliance)	Freq.	0	6	19	28	67	43	163
	%	0	3.7	11.7	17.2	41.1	26.4	100
Midibus (Higer & Kitkit)	Freq.	33	27	43	38	20	2	163
	%	20.2	16.6	26.4	23	12.3	1.2	100
Minibus (Blue & White taxi)	Freq.	4	13	24	29	57	41	163
	%	2.5	8	14.7	17.8	35.0	25.2	100.0
Total	Freq.	51	67	134	151	162	92	
	%	31.3	41.1	82.2	92.6	99.4	56.4	

Source: Field Survey (2022)

4.4.2. Purpose of Travel

The result on passengers' trip purposes presented in Figure 4.1 revealed that 45.4% of the respondents travel to work; while 24.5% travel for education purposes; 14.7% commute for shopping, 5.5% for recreation purposes; and the remaining 9.8% of the sample respondents commute for other reasons. This implies that most of the trip's purpose is for working, followed by an education trip.

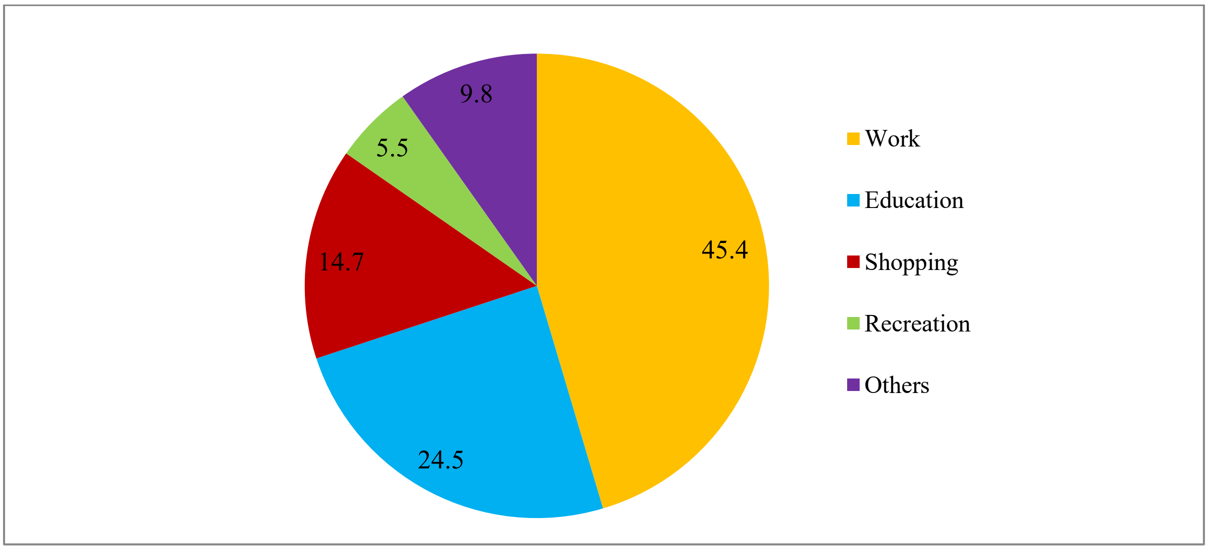

Figure 4.1: Passengers' Trip Purpose

Source: Field Survey (2022)

4.4.3. Distance from Home to the Nearest Stop

The walking distance to bus stop for a well-served urban area should be in the range of 300 to 500m from home to work place. Distance in excess of 500m may be acceptable in low-density area but the maximum should not exceed 1000 meter (Armstrong-Wright & Thiriez, 1987). The response on average distance travelled from home to the nearest bus stops is presented in Figure 4.2 revealed that 30.1% of sample passengers spent more than 1200 m and 34.4% of the passengers spent 800-1200m with only 13.5% of the passengers spent less than 400m that complies with the standard and thus needs for intervention.

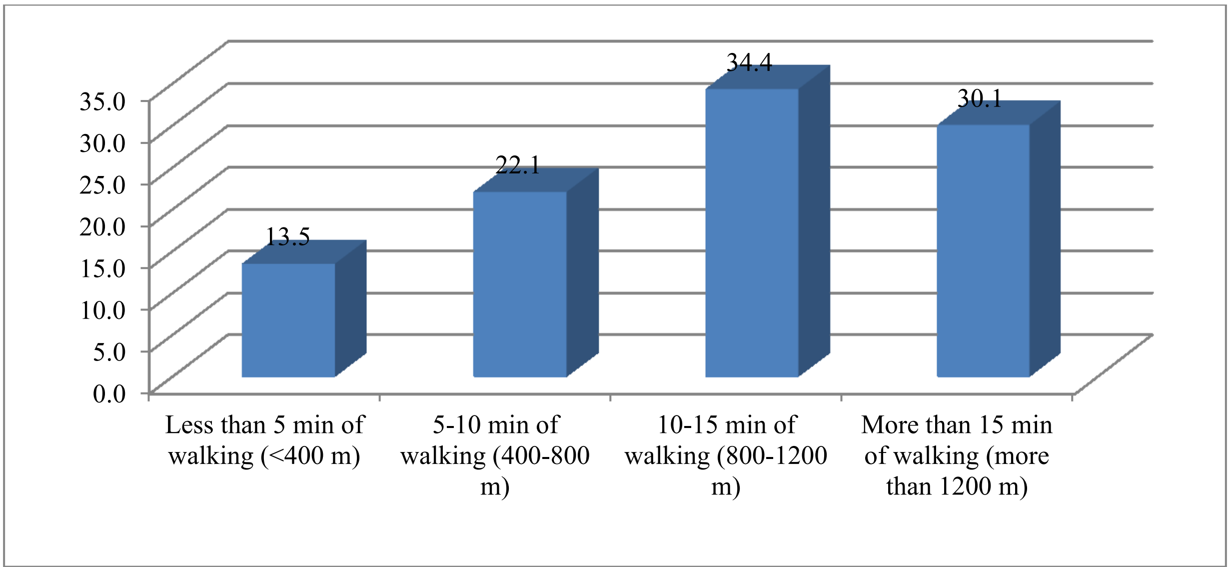

Figure 4.2: Passengers Walking Distance from Home to Nearest Bus Stop

Source: Field Survey (2022)

4.4.4. Waiting Time at Bus Stops

According to Armstrong-Wright & Thiriez (1987), in developing countries to achieve a reasonable level of service, the average waiting time should be in the average of 5 to 10 minutes, with a maximum waiting time of 10 to 20 minutes under the prevailing conditions. However, the response on average waiting time at bus stops presented in Table 4.4 revealed that the majority (41.7%) of the passengers spent 20- 40 minutes waiting at bus stops, and 17.2% of the respondents spent 40 minutes – an hour while 10.4% spent more than 1 hour. Only 4.9% of the passengers spent less than 10 minutes that complies the reasonable average waiting time at bus stops.

Table 4.4: Passengers' Waiting Time at Sheger Stops

Waiting Time	Frequency	Percentage (%)
Less than 10 minutes	8	4.9
10-20 minutes	42	25.8
20-40 minutes	68	41.7
40 minutes -1 hour	28	17.2
More than 1 hour	17	10.4
Total	163	100.0

Source: Field Survey (2022)

4.5. Findings of the Study

4.5.1. Bus Stops Physical Condition

The quality of bus stop is significantly important for the efficient and cost-effective transit operations. In this regard, passengers were asked about their agreement or disagreement on the quality of the existing bus stops using the parameters presented in Table 4.5. Accordingly, the result revealed that the majority (36.8% & 29.4%) of the sample passengers disagree and strongly disagree with the convenience of bus stops for people with disability, the elder, and women. In comparison, only 17.2% and 7.4% agree and strongly agree, respectively. Bus stop elements, such as bus shades, benches or chairs, lighting, safety barriers, trash bins, information signage and others can make the waiting time for passengers at bus stops comfortable and safe. However, majority (35.0% & 28.2%) of the passengers disagree and strongly disagree on the adequacy of bus shades or shelters to protect passengers from rain, sun and dust, respectively. The responses on the adequacy of seating arrangements also show that majority of the respondents (36.2% and 23.3%) disagree and strongly disagree on the adequacy of benches for passengers, respectively. While only 7.4% and 6.1% of the respondents agree and strongly agree, respectively. Since, the seating chairs for the passengers are insufficient; thus, many passengers wait standing for a long at bus stops. Moreover, majority of the respondents (39.3% and 25.8%), disagree and strongly disagree on the suitability of the boarding and alighting spaces respectively. The majorities of respondents (33.1% and 23.3%) disagree and strongly disagree on the safety of bus stops, respectively.

On the other hand, in terms of security, majority (32.5% & 22.7%) of the passengers agreed and strongly agreed that the stops have sufficient lighting and are relatively secure. However, some of the passengers still complain about the security of bus stops due to the presence of street children who robbed bags and mobiles at night time. Passengers also feel unsafe since some of the bus stops are used by homeless youths for sleeping at night who steal bags and mobile phones. Some of the lighting at the bus stops are dysfunctional, which led to an increased number of crimes committed at night.

Table 4.5: Level of Agreement on the Quality of the Study Bus Stops

No	Evaluation Parameters		SDA	DA	N	A	SA	Total
1)	Bus stops are **convenient** for people with a disability, elder, and women	Freq.	63	78	4	10	8	163
		%	38.7	47.9	2.5	6.1	4.9	100
2)	Bus stops have **adequate shelters** to protect passengers from the sun and rain	Freq.	66	75	7	9	6	163
		%	40.5	46.0	4.3	5.5	3.7	100
3)	Bus stops have adequate **seating arrangements/benches**	Freq.	59	70	11	14	9	163
		%	36.2	42.9	6.7	8.6	5.5	100
4)	Bus stop areas have **adequate boarding** and **alighting** passengers	Freq.	56	68	10	17	12	163
		%	34.4	41.7	6.1	10.4	7.4	100
5)	Bus stops area are **safe** with adequate lighting	Freq.	62	66	11	16	8	163
		%	38.0	40.5	6.7	9.8	4.9	100
6)	Bus stops are **secured** for passengers with adequate lightings	Freq.	58	63	13	19	10	163
		%	35.6	38.7	8.0	11.7	6.1	100
	Average		37.2	42.9	5.7	8.7	5.4	100

Source: Field Survey (2022)

NB: *SDA=Strongly Disagree, DA=Disagree, N=Neutral, A= Agree, and SA=Strongly Agree*

As indicated in Table 4.6, the p-value for all the parameters is less than 0.05, which implies they are statistically significant. These bus stops are less convenient, lack adequate boarding and alighting space, seating arrangement, and shelter, with safety and security problems, and thus needs an intervention measures.

Table 4.6: One-Sample T-Test

Evaluation Parameters	N	Mean	Std. Deviation	Std. Error Mean	T	Df	Sig. (2-tailed)	Mean Difference	95% Conf. Int.	
									Lower	Upper
Bus stops convenience	163	2.36	1.271	.100	-6.410	162	.000	-.638	-.83	-.44
Adequacy of boarding and alighting space	163	2.49	1.330	.104	-4.887	162	.000	-.509	-.71	-.30
Adequacy of Seating	163	2.56	1.277	.100	-4.356	162	.000	-.436	-.63	-.24
Adequacy of Shelters	163	2.56	1.383	.108	-4.020	162	.000	-.436	-.65	-.22
Safety of bus stops	163	3.34	1.376	.108	3.188	162	.002	.344	.13	.56
Security at bus stops	163	2.56	1.315	.103	-4.229	162	.000	-.436	-.64	-.23

Source: Field Survey (2022)

The researcher also observed that some of the bus stops have potholes and obstructions affecting those passengers using a wheelchair or pushchair, the elders, and people with sight difficulties (see Figure 4.3). Street vendors and beggars also occupy some of the bus stop shades and benches or chairs. This implies that the bus stops should be as convenient as possible for all groups of bus users considering the convenience and adequacy of the bus stop facilities.

Figure 4.3: Obstructions on Bus Stops (at 4Killo Tourist Hotel)

Source: Photograph taken by the Author (October, 2022)

Even though there are bus stop shades at many of the bus stops (see Annex III and IV for outbound and inbound bus stops respectively), the researcher observed that most of the bus stops do not have adequate shades particularly at busy bus stops, with large numbers of passengers waiting for a long time standing at bus stops. The area designated for buses to pick up and drop off passengers is crowded at many bus stops servicing all three types of buses (Sheger, Alliance, and Anbesa buses), which only have a small amount of space available for passenger pickup and drop-off (see Figure 4.4).

Figure 4.4: Congested Bus Stops (at Megenagna)
Source: Photograph taken by the Author (October, 2022)

The researcher also observed that lack of safety barriers at bus stops make passengers feel vulnerable for danger of being involved in a traffic collision and some of the bus stops were damaged due to traffic accident happened at bus stops (see Figure 4.5). Therefore, it is necessary to consider appropriate location for bus stops with safety barriers.

Figure 4.5: Damaged Bus Stops (at Mekanisa and Mexico Lideta)
Source: Photograph taken by the Author (October, 2022)

Aychew (2020) also discovered that minibuses use some bus stop and caused for bus drivers experienced blockage, which in turn led to traffic accidents whenever the buses stopped at bus stops. Additionally, people who rush to cross the bus routes cause accidents at bus stops. Thus, majority of the studies indicated that it would be preferable to put the bus stops no more than 30 meters away from the main road's intersection (Wang et al., 2016).

Figure 4.6 also revealed the sample respondents' evaluation of the overall quality of the existing bus stops. Accordingly, about 71.8% of the sample respondents agreed and strongly agreed that the overall quality of the bus stops was poor. As mentioned above, many of the bus stops are inconvenient for passengers particularly for persons with disability and the elders due to the potholes and obstructions at the bus stops. Moreover, lack of important bus stop elements such as the bus stop shades, benches or chairs as well as overcrowded stops to pick up and drop off passengers and lack of safety barriers at bus stops that makes passengers feel unsafe in inconvenient. This implies that the bus stops need improvement with appropriate stop facilities and standardization in spacing interval to make use of bus stops accessible to the users.

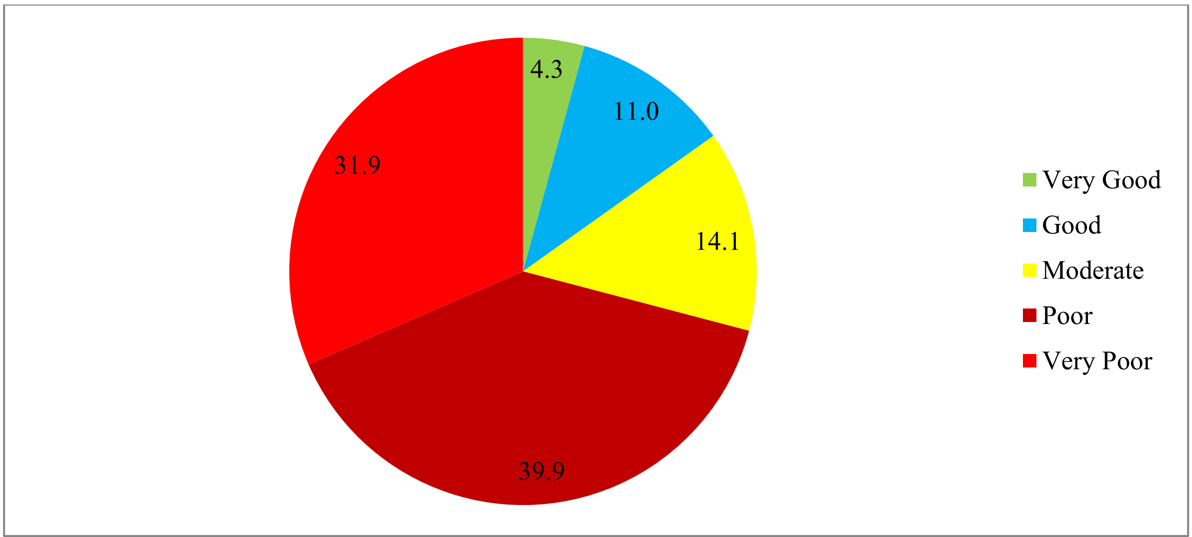

Figure 4.6: Response to Overall Quality of Bus Stops

Source: Field Survey (2022)

4.5.2. Bus Stops Compliance with Spacing Standards

The existing bus stops were evaluated in accordance with compliance to the bus stop spacing standards. Although the criteria for bus stop spacing vary from country to country, the most widely accepted spacing standard lies between 600 - 800 meters for large cities (Foda & Ahmed, 2010; El-Geneidy et al., 2006). Accordingly, the study bus stops spacing interval and its comparison with the standards are shown in Table 4.7 and Table 4.8.

Table 4.7: Existing Sheger Bus Stops Spacing in the Study Routes

Inbound Stops			Outbound Stops		
Stop ID	**Stop Name**	**Distance (m)**	**Stop ID**	**Stop Name**	**Distance (m)**
1	Jemo 3	0	1	Piassa (Jemo St.)	0
2	Jemo 2	800	2	Tewodros Sq.	800
3	Jemo 1	1050	3	Tikur Anbesa	600
4	Jemo Michael Square	1300	4	National Theater	500
5	Jemo Michael Bridge	800	5	Mexico Federal Police	1500
6	Germen Square	800	6	Africa Union	600
7	Mekanisa	1000	7	Sarbet Bridge	1000
8	Mekanisa Abo	1200	8	Vatican Embassy	750
9	Vatican Embassy	900	9	Mekanisa Abo	800
10	Sarbet Bridge	800	10	Mekanisa	650
11	African Union	1050	11	Germen Square	1500
12	Mexico Federal Police	500	12	Jemo Michael Bridge	1000
13	National Theater	1450	13	Jemo Michael Square	1200
14	Tikur Anbesa	700	14	Jemo 1	900
15	Tewodros Sq.	500	15	Jemo 2	800
16	Piassa (Jemo End)	700	16	Jemo 3	700
	Total	13,550		Total	13,300
1	Yeka Abado 13	0	1	Piassa (Abado St.)	0
2	Cross	700	2	Seba Dereja	1300
3	Gedera	1000	3	Ras Mekonen	400
4	Kara Michael	1200	4	4 Killo Silasie	900
5	Kara Square	1050	5	Aware	400
6	Abem	1200	6	Bylier	500
7	Wesen Grossery	1250	7	Kokebe Tsibha	800
8	St. Michael	1000	8	British Embassy	1100
9	Hillside School	800	9	Sholla	900
10	Ethio China	600	10	Megenagna	900
11	Lamberet	900	11	Abysinia	1000
12	Abysinia	1000	12	Lamberet	1200
13	Megenagna	950	13	Ethio China	900
14	Sholla	700	14	Hillside School	600
15	British Embassy	900	15	St. Michael	700
16	Kokebe Tsibha	1000	16	Wesen Grossery	800
17	Bylier	950	17	Abem	1100
18	Aware	700	18	Kara Square	1300
19	4 Killo Silasie	700	19	Kara Michael	1000
20	Tourist Hotel	400	20	Gedera	1300
21	St. Mariam Mezoria	300	21	Cross	800
22	Seba Dereja	400	22	Yeka Abado 13	600
23	Piassa (Abado End)	700		Total	31800
	Total	31950			

Source: GIS Output (2022)

The bus stops spacing interval were evaluated based on the most widely used international standards and the result indicated that only 5 (13.5%) inbound and 4 (11.1%) outbound stops were below the stop spacing interval of 600 meters. On the other hand, about 19 (51.4%) inbound and 18 (50.0%) outbound bus stops were beyond the spacing interval of 800 meters. It is only 13 (35.1%) inbound and 14 (38.9%) outbound bus stops comply with the stop spacing standards (600-800 meters). This implies that most of the bus stops did not comply with the widely used stop spacing standards and seem to be located haphazardly, thus requiring for bus stops location optimization. Accordingly, more than half of both the inbound and outbound bus stops were beyond 800 meter, which is different from the findings of Dawd (2020) and Melsmo & Hilemichael (2022) for Anbessa bus stops.

Table 4.8: Bus Stops Compliance with Standards

Inbound			Outbound		
Spacing (meter)	Number of bus stops	%	Spacing (meter)	No. of bus stops	%
<600	5	13.5	<600	4	11.1
600-800	13	35.1	600 – 800	14	38.9
>800	19	51.4	>800	18	50.0
Total	37	100.0	Total	36	100.0

Source: GIS Output (2022)

4.5.3. Existing Bus Stops Accessibility

4.5.3.1. Bus Stops Service Area Coverage

In order to evaluate the accessibility of existing bus stops, first bus stop service area coverage (polygon) with a threshold of 400 meters of walking distance was prepared as commonly used worldwide standard (Foda & Ahmed, 2010). As shown in Figures 4.7 and 4.8 Sheger bus stops service area was prepared for both inbound and outbound bus stops.

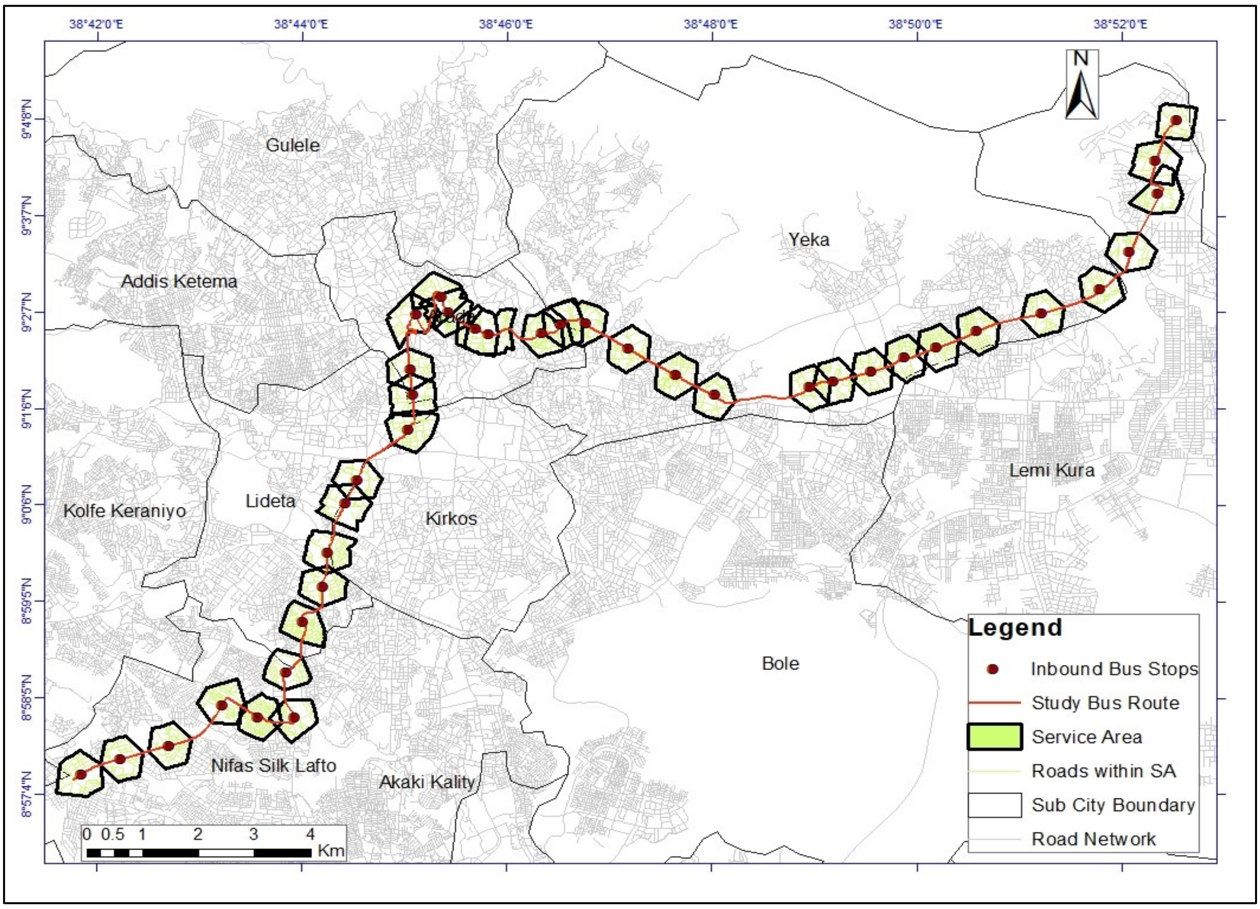

Figure 4.7: Existing Inbound Bus Stops Service Area Coverage

Source: GIS Output (2022)

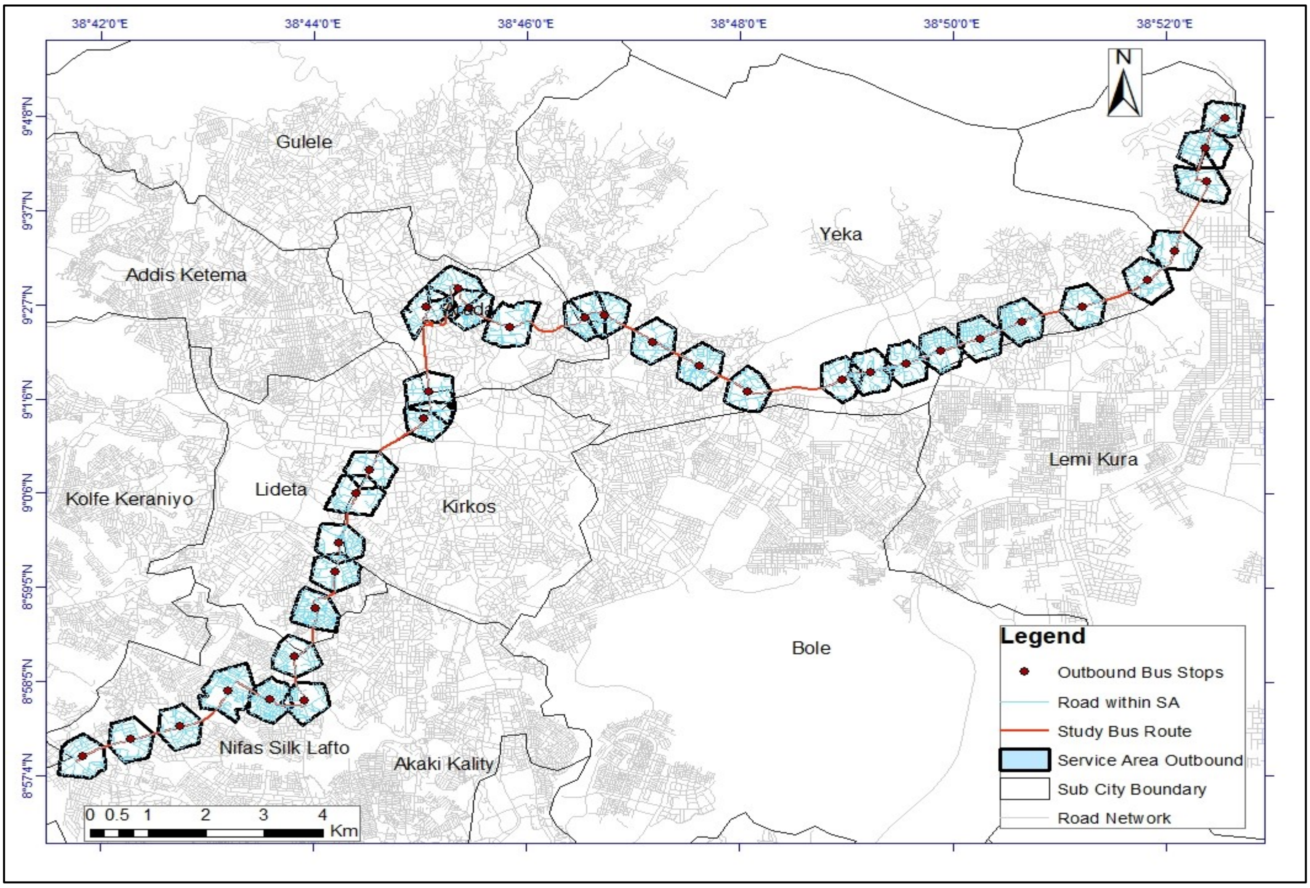

Figure 4.8: Existing Outbound Bus Stops Service Area Coverage

Source: GIS Output (2022)

As shown in Figure 4.7 and 4.8, the service area coverage for both the inbound and outbound Sheger bus stops had a large uncovered service area with few services area overlaps. This would make the bus stops inaccessible to the users, and the wastage in service area overlap would reduce the number of actual bus users.

Following the creation of the polygon representing the service area, three parameters were computed: population served, trip generation, and road density. To do this, the road density of each bus stop was determined by taking the total length of pedestrian roads included within the service area covered and dividing it by the total area served by that bus stop. The population that is served by the bus stop within the service area coverage was determined by multiplying the total number of parcels that are contained within the bus stop service area with the average number of people living in each household, which was found to be five (5) (CSA, 2022). In addition, the number of trips that were generated by bus was estimated based on the data collected from SMTSE. Accordingly, the accessibility index for each of the three parameters—road density, population served, and trip generation at each bus stop—was computed.

4.5.3.2. Inbound Bus Stops Accessibility

The accessibility index of the bus stops for each of the three parameters presented in Table 4.9 indicated that many of the bus stops had low accessibility indexes in either one of the parameters or in all of the parameters while some others had better accessibility.

Table 4.9: Accessibility Index for Each of the Three Parameters (Inbound Bus Stops)

Stop ID	Bus Stop Name	Service Area (Km^2)	Road Length (Km)	Road Density	Population Served	Daily Trip Generation	Road Density Index	Population Served Index	Trip Generation Index
1	Jemo 3	0.47	17.12	36.43	1155	641	0.62	0.79	0.19
2	Jemo 2	0.41	15.98	38.98	892	778	0.66	0.61	0.23
3	Jemo 1	0.48	22.34	46.54	1428	1922	0.79	0.97	0.57
4	Jemo Michael Square	0.53	16.88	31.85	972	1922	0.54	0.66	0.57
5	Jemo Michael Bridge	0.48	20.85	43.44	1228	2196	0.74	0.84	0.65
6	Germen Square	0.46	19.51	42.41	956	2379	0.72	0.65	0.70
7	Mekanisa	0.45	14.27	31.71	975	2379	0.54	0.67	0.70
8	Mekanisa Abo	0.41	16.03	39.10	1468	2379	0.66	1.00	0.70
9	Vatican Embassy	0.47	8.24	17.53	612	2379	0.30	0.42	0.70
10	Sarbet Bridge	0.54	19.00	35.19	1264	2379	0.60	0.86	0.70
11	African Union	0.54	6.11	11.31	476	2608	0.19	0.32	0.77
12	Mexico Federal Police	0.48	18.90	39.38	1184	2608	0.67	0.81	0.77
13	Natonal Theater	0.53	9.86	18.60	484	3020	0.32	0.33	0.89
14	Tikur Anbesa	0.47	7.12	15.15	945	1052	0.26	0.65	0.31
15	Tewodros Square	0.48	4.99	10.40	1352	1052	0.18	0.92	0.31
16	Piassa (Jemo End)	0.43	18.98	44.14	1455	3386	0.75	0.99	1.00
1	Yeka Abado 13	0.43	25.38	59.02	1465	1114	1.00	1.00	0.33
2	Cross	0.54	20.20	37.41	1152	1114	0.63	0.79	0.33
3	Gedera	0.52	10.81	20.79	480	1400	0.35	0.33	0.41
4	Kara Michael	0.48	11.44	23.83	412	1400	0.40	0.28	0.41
5	Kara Roundabout	0.47	18.24	38.81	1284	1400	0.66	0.88	0.41
6	Abem	0.48	15.84	33.00	1120	987	0.56	0.76	0.29
7	Wesen	0.5	21.66	43.32	1335	987	0.73	0.91	0.29
8	St. Michael	0.48	18.19	37.90	1144	987	0.64	0.78	0.29
9	Hillside School	0.48	12.00	25.00	1024	987	0.42	0.70	0.29
10	Ethio-china	0.48	11.24	23.42	416	987	0.40	0.28	0.29
11	Lamberet	0.53	8.21	15.49	1015	987	0.26	0.69	0.29
12	Abyssinya	0.47	8.17	17.38	875	1400	0.29	0.60	0.41
13	Megenagna	0.45	20.00	44.44	1460	1973	0.75	1.00	0.58
14	Sholla	0.48	18.33	38.19	870	1973	0.65	0.59	0.58
15	British Embassy	0.48	12.66	26.38	1120	1973	0.45	0.76	0.58
16	Kokebe Tsibha	0.55	9.98	18.15	1260	1973	0.31	0.86	0.58
17	Bieler	0.5	8.11	16.22	832	1241	0.27	0.57	0.37
18	Aware	0.46	10.77	23.41	1016	1241	0.40	0.69	0.37
19	4 Killo Silase	0.55	14.60	26.55	1276	1241	0.45	0.87	0.37
20	Tourist Hotel	0.49	9.02	18.41	745	891	0.31	0.51	0.26
21	St. Mariam Mezoria	0.48	14.31	29.81	656	891	0.51	0.45	0.26
22	Seba Dereja	0.53	5.62	10.60	1175	891	0.18	0.80	0.26
23	Piassa (Abado End)	0.43	18.98	44.14	1460	2037	0.75	1.00	0.60

Source: GIS Output (2022)

For example, bus stop with stop Id 4 (at 4 Killo Silasie) had high population served but lower trip generation and road density, while bus stop with stop Id 18 (at Kara Square) had high road density but low trip generation and population served. On the other hand, bus stop with stop Id 7 (at Kokebe Tsibha School) had high trip generation with low road density and population served. Therefore, the accessibility of each bus stops were combination of the three parameters indices (i.e. road density, trip generation and population served) which provided bus stops excellent, good, moderate and poor accessibility results. In this sense, the bus stops' location in an area with fewer roads and fewer connections, the fact that they serve fewer passengers, a combination of two or more parameters, or any of these parameters alone might account for the stops' low accessibility.

Table 4.10: Accessibility Index for Inbound Bus Stops

Stop ID	Bus Stop Name	Road Density Index	Population Served Index	Trip Generation Index	Combined Accessibility Index
1	Jemo 3	0.62	0.79	0.19	0.62
2	Jemo 2	0.66	0.61	0.23	0.60
3	Jemo 1	0.79	0.97	0.57	0.81
4	Jemo Michael Square	0.54	0.66	0.57	0.57
5	Jemo Michael Bridge	0.74	0.84	0.65	0.75
6	Germen Square	0.72	0.65	0.70	0.70
7	Mekanisa	0.54	0.67	0.70	0.59
8	Mekanisa Abo	0.66	1.00	0.70	0.75
9	Vatican Embassy	0.30	0.42	0.70	0.37
10	Sarbet Bridge	0.60	0.86	0.70	0.68
11	African Union	0.19	0.32	0.77	0.28
12	Mexico Federal Police	0.67	0.81	0.77	0.71
13	Natonal Theater	0.32	0.33	0.89	0.38
14	Tikur Anbesa	0.26	0.65	0.31	0.36
15	Tewodros Square	0.18	0.92	0.31	0.38
16	Piassa (Jemo End)	0.75	0.99	1.00	0.84
1	Yeka Abado 13	1.00	1.00	0.33	0.93
2	Cross	0.63	0.79	0.33	0.64
3	Gedera	0.35	0.33	0.41	0.35
4	Kara Michael	0.40	0.28	0.41	0.37
5	Kara Square	0.66	0.88	0.41	0.69
6	Abem	0.56	0.76	0.29	0.59
7	Wesen Grocery	0.73	0.91	0.29	0.74
8	St. Michael	0.64	0.78	0.29	0.64
9	Hillside School	0.42	0.70	0.29	0.48
10	Ethio-china	0.40	0.28	0.29	0.36
11	Lamberet	0.26	0.69	0.29	0.38
12	Abyssinya	0.29	0.60	0.41	0.39
13	Megenagna	0.75	1.00	0.58	0.80
14	Sholla	0.65	0.59	0.58	0.63
15	British Embassy	0.45	0.76	0.58	0.54
16	Kokebe Tsibha	0.31	0.86	0.58	0.48
17	Bylier	0.27	0.57	0.37	0.36
18	Aware	0.40	0.69	0.37	0.47
19	4 Killo Silase	0.45	0.87	0.37	0.55
20	Tourist Hotel	0.31	0.51	0.26	0.36
21	St. Mariam Mezoria	0.51	0.45	0.26	0.47
22	Seba Dereja	0.18	0.80	0.26	0.35
23	Piassa (Abado End)	0.75	1.00	0.60	0.80

Source: GIS Output (2022)

Table 4.10 shows that the combined accessibility index for inbound stops varies from 0.28 at African Union for Jemo - Piassa route to 0.93 at Yeka Abado for Yeka Abado - Piassa route.

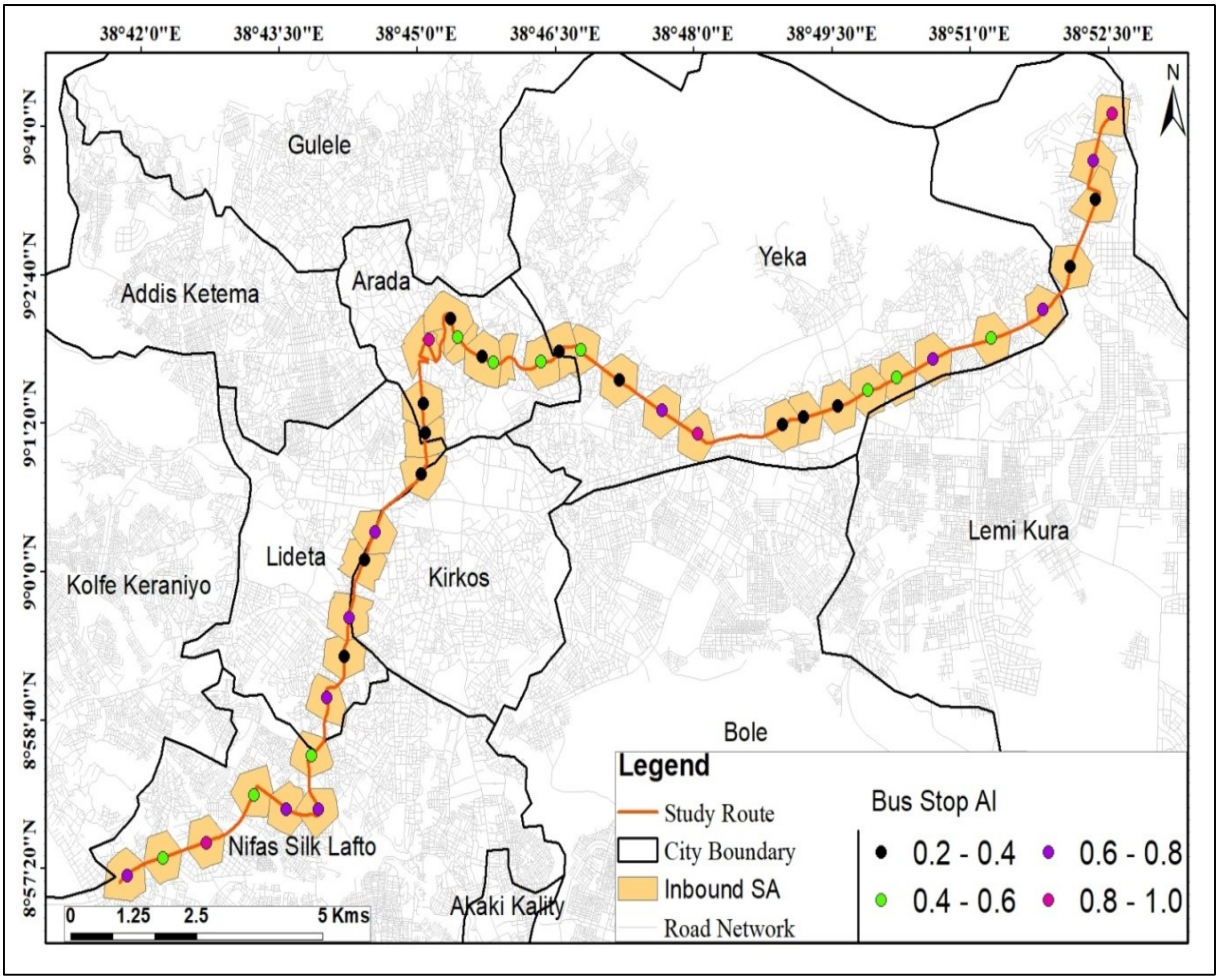

Figure 4.9: Combined Inbound Bus Stops Accessibility Index
Source: GIS Output (2022)

As revealed in Table 4.11, from the total of 39 inbound bus stops, the majority of the bus stops, 14 (36.0%), had poor accessibility index, and 10 (25.6%) had moderate accessibility index. Only 5 (12.8%) and 10 (25.6%) of stops had an excellent and good accessibility index with relatively better road density, population served, and trip generations.

Table 4.11: Proportion of Existing Inbound Bus Stops Accessibility

Category	Range of Accessibility Index	Number of Stops	%
Excellent	>=0.80	5	12.8
Good	0.60 – 0.79	10	25.6
Moderate	0.40 – 0.59	10	25.6
Poor	< 0.40	14	36.0
Total		39	100.0

Source: GIS Output (2022)

4.5.3.3. Outbound Bus Stops Accessibility

The accessibility index of the bus stops for each of the three parameters presented in Table 4.12 indicated that many bus stops had low accessibility indexes in either one of the parameters or in all of the parameters. This could be because of less connectivity, a smaller number of trips generated, or a smaller population that would be served by the bus stops or it could be due to a combination of two or more accessibility parameters.

Table 4.12: Accessibility Index for Each of the Three Parameters (Outbound Bus Stops)

Stop ID	Bus Stop Name	Service Area Km^2)	Road Length (Km)	Road Density	Population Served	Daily Trip Generation	Road Density Index	Population Served Index	Trip Generation Index
1	Piassa (Jemo St.)	0.37	15.55	42.03	1450	1098	0.82	0.99	0.53
2	Tikur Anbesa	0.52	8.23	15.83	755	1327	0.31	0.52	0.64
3	Tewodros Square	0.49	8.13	16.59	640	1327	0.32	0.44	0.64
4	National Theater	0.54	7.45	13.80	485	1922	0.27	0.33	0.93
5	Mexico Federal Police	0.50	15.41	30.82	890	1601	0.60	0.61	0.78
6	Africa Union	0.48	5.84	12.17	650	1601	0.24	0.44	0.78
7	Sarbet Bridge	0.48	13.87	28.90	680	1647	0.56	0.46	0.80
8	Vatican Embassy	0.47	6.26	13.32	755	1601	0.26	0.52	0.78
9	Mekanisa Abo	0.41	8.31	20.27	855	1601	0.39	0.58	0.78
10	Mekanisa	0.46	15.81	34.37	770	1601	0.67	0.53	0.78
11	Germen Square	0.49	12.37	25.24	896	1601	0.49	0.61	0.78
12	Jemo Michael Bridge	0.55	9.21	16.75	525	1876	0.33	0.36	0.91
13	Jemo Michael Square	0.53	22.31	42.09	965	1876	0.82	0.66	0.91
14	Jemo 1	0.54	11.37	21.06	1325	1876	0.41	0.90	0.91
15	Jemo 2	0.48	18.06	37.63	885	778	0.73	0.60	0.38
16	Jemo 3	0.53	13.89	26.21	1140	641	0.51	0.78	0.31
1	Piassa (Abado St.)	0.37	15.55	42.03	1450	1264	0.82	0.99	0.61
2	Seba Dereja	0.41	5.46	13.32	750	1397	0.26	0.51	0.68
3	Ras Mokenn	0.45	5.45	12.11	895	1397	0.24	0.61	0.68
4	4 Killo Silasie	0.57	12.84	22.53	1960	1630	0.44	1.34	0.79
5	Aware	0.49	7.16	14.61	706	1630	0.28	0.48	0.79
6	Bylier	0.52	6.22	11.96	852	1630	0.23	0.58	0.79
7	Kokebe Tsibha	0.54	6.41	11.87	675	2063	0.23	0.46	1.00
8	Abebie Suk	0.53	6.18	11.66	735	2063	0.23	0.50	1.00
9	Sholla	0.49	11.24	22.94	1090	2063	0.45	0.74	1.00
10	Megenagna	0.47	24.19	51.47	1105	2063	1.00	0.75	1.00
11	Abyssinia	0.52	5.06	9.73	1055	1464	0.19	0.72	0.71
12	Lamberet	0.43	4.57	10.63	845	1031	0.21	0.58	0.50
13	Ethio-china	0.54	8.12	15.04	850	1031	0.29	0.58	0.50
14	Hillside School	0.50	10.92	21.84	1445	1031	0.42	0.99	0.50
15	St. Michael	0.53	18.34	34.60	1350	1031	0.67	0.92	0.50
16	Wesen	0.50	16.62	33.24	1434	1031	0.65	0.98	0.50
17	Abem	0.53	13.20	24.91	1305	1031	0.48	0.89	0.50
18	Kara Square	0.48	20.99	43.73	280	1464	0.85	0.19	0.71
19	Kara Michael	0.51	9.14	17.92	545	1464	0.35	0.37	0.71
20	Gedera	0.47	7.24	15.40	270	1464	0.30	0.18	0.71
21	Cross	0.52	15.03	28.90	875	1165	0.56	0.60	0.56
22	Yeka Abado 13	0.48	12.24	25.50	1150	1165	0.50	0.78	0.56

Source: GIS Output (2022)

After computing the accessibility index for each of the three parameters, a combined accessibility index was prepared for both the inbound and outbound bus stops. The combined accessibility index was designed by multiplying each of the parameter accessibility indexes with the priority weights of road density (64%), trip generation (26%), and population served (10%) and then combining them together (Aslan., 2013). Accordingly, the combined accessibility index was calculated for the outbound bus stops by combining the accessibility index of the three parameters as already mentioned for the inbound bus stops. The result of the combined accessibility index of each bus stops for the outbound bus stop was presented in Table 4.13 and Figure 4.10.

Table 4.13: Accessibility Index for Outbound Bus Stops

Stop ID	Bus Stop Name	Road Density Index	Population Served Index	Trip Generation Index	Combined Accessibility Index
1	Piassa (Jemo St.)	0.82	0.99	0.53	0.83
2	Tikur Anbesa	0.31	0.52	0.64	0.39
3	Tewodros Square	0.32	0.44	0.64	0.38
4	National Theater	0.27	0.33	0.93	0.35
5	Mexico Federal Police	0.60	0.61	0.78	0.62
6	Africa Union	0.24	0.44	0.78	0.34
7	Sarbet Bridge	0.56	0.46	0.80	0.56
8	Vatican Embassy	0.26	0.52	0.78	0.38
9	Mekanisa Abo	0.39	0.58	0.78	0.48
10	Mekanisa	0.67	0.53	0.78	0.64
11	Germen Square	0.49	0.61	0.78	0.55
12	Jemo Michael Bridge	0.33	0.36	0.91	0.39
13	Jemo Michael Square	0.82	0.66	0.91	0.79
14	Jemo 1	0.41	0.90	0.91	0.59
15	Jemo 2	0.73	0.60	0.38	0.66
16	Jemo 3	0.51	0.78	0.31	0.56
1	Piassa (Abado St.)	0.82	0.99	0.61	0.84
2	Seba Dereja	0.26	0.51	0.68	0.37
3	Ras Mokenn	0.24	0.61	0.68	0.38
4	4 Killo Silasie	0.44	1.34	0.79	0.71
5	Aware	0.28	0.48	0.79	0.39
6	Bylier	0.23	0.58	0.79	0.38
7	Kokebe Tsibha	0.23	0.46	1.00	0.37
8	Abebie Suk	0.23	0.50	1.00	0.38
9	Sholla	0.45	0.74	1.00	0.58
10	Megenagna	1.00	0.75	1.00	0.94
11	Abyssinia	0.19	0.72	0.71	0.38
12	Lamberet	0.21	0.58	0.50	0.33
13	Ethio-china	0.29	0.58	0.50	0.39
14	Hillside School	0.42	0.99	0.50	0.58
15	St. Michael	0.67	0.92	0.50	0.72
16	Wesen	0.65	0.98	0.50	0.72
17	Abem	0.48	0.89	0.50	0.59
18	Kara Square	0.85	0.19	0.71	0.66
19	Kara Michael	0.35	0.37	0.71	0.39
20	Gedera	0.30	0.18	0.71	0.31
21	Cross	0.56	0.60	0.56	0.57
22	Yeka Abado 13	0.50	0.78	0.56	0.58

Source: GIS Output (2022)

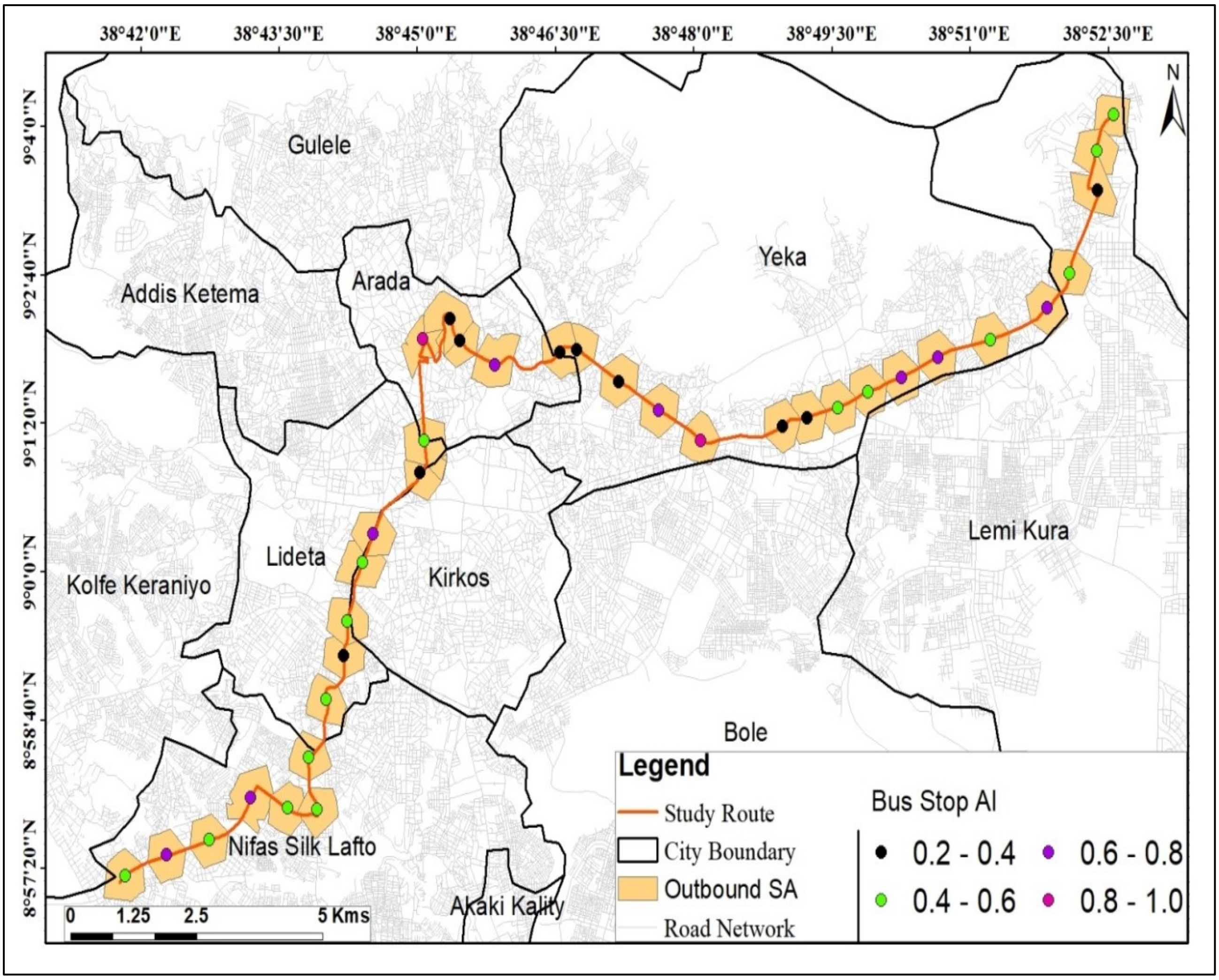

Figure 4.10: Combined Accessibility Index for Outbound Bus Stops

Source: GIS Output (2022)

The combined accessibility index of the outbound bus stops shown in (Table 4.14) indicated that from the total 38 bus stops, the majority, 17 (44.7%) and 10 (26.3%), are with poor and moderate accessibility indexes, respectively. Only 3 (7.9%) and 8 (21.1%) of these bus stops had excellent and good accessibility index categories, respectively. This implies that most outbound bus stops in the study area are under the moderate and poor accessibility category that needs to be optimized for better accessibility.

Table 4.14: Proportion of Outbound Bus Stops Accessibility

Category	Range of Accessibility Index	Number of Stops	%
Excellent	>=0.80	3	7.9
Good	0.60 – 0.79	8	21.1
Moderate	0.59 – 0.60	10	26.3
Poor	< 0.40	17	44.7
Total		38	100.0

Source: GIS Output (2022)

4.5.4. Bus Stops Optimization

The accessibility index, which was calculated in this study using three criteria (road density, population served, and trip generation), as well as a standard bus stop spacing of 600–800 meters (Ahsan., 2013) and junctions' constraints of 30–50 meters, was used to determine the best locations for bus stops (Wang et al., 2016). In order to maximize the bus stop placement, four possibilities were considered: keeping as it is, relocating (shift forward and backward), adding or creating new stops, and eliminating or removing the existing bus stops. On the large segment of the bus routes, new bus stations are suggested in places where there is no bus stops within 800 meters. Due to their inappropriate stopping spacing and proximity to other bus stops, the existing bus stops that offer poor accessibility were relocated. This is because bus-stop spacing has a significant effect on how well bus services operate (Li et al. 2011), where close-spaced bus stops provide quick access for passengers but lengthen trip times, whereas large bus stop spacing minimizes passengers' in-vehicle time but decrease the system's accessibility (Van Nes & Bovy, 2000).

The suggested ideal bus stop was determined using the same formula used to calculate the road density and people served at current bus stops. Two hypotheses were used to estimate trip generation. One is that the trip generation for that bus stop was believed to be a current bus stop value closest to the proposed stop if the proposed bus stop is located within the existing service area. On the other hand, since the service area for recently proposed bus stops was new, the average trip generating value of the bus stop trips was taken into account.

Thus, excellent and moderate bus stops accessibility for both inbound and outbound bus stops increased by 58.1% (from 49.3% to 77.9%) as a result of the bus stop location optimization. In comparison, poor accessibility of both inbound and outbound bus stops decreased by 68.3% (from 40.4% to 12.8%). The placement of the bus stop was thus improved, increasing accessibility to the excellent & moderate inbound bus stop by 23.2 (from 51.2% to 74.4%). As seen in Table 4.16, it reduced the accessibility of bus stops by 22% (from 36.0% to 14%).

4.5.4.1. Inbound Optimal Bus Stops

The optimal location for the inbound bus stops involves retaining 19 existing bus stops, relocating 19 stops, proposing 5 new bus stops, and removing 1 bus stop. Due to the optimization of the inbound bus stop locations, the numbers of inbound bus stops are thus increased from 39 to 43.

Table 4.15: Proposed Inbound Bus Stops

Stop Id	Stop Name	Service Area (Km^2)	Road Length (Km)	Road Density	Population Served	Daily Trip Generation	Road Density Index	Pop. Served Index	Trip Index	Combined Accessibility Index	Remark
1	Jemo 3	0.47	17.12	36.43	1155	641	0.62	0.79	0.19	0.62	Retained
2	Jemo 2	0.46	18.98	41.26	1047	778	0.70	0.71	0.23	0.66	Relocated
3	Jemo 1	0.48	22.34	46.54	1428	1922	0.79	0.97	0.57	0.81	Retained
4	Jemo Yetebaberut	0.48	21.76	45.33	625	1922	0.77	0.43	0.57	0.66	New
5	Jemo Michael Sq.	0.47	18.55	39.47	977	1922	0.67	0.67	0.57	0.66	Relocated
6	Jemo Michael Brdg	0.48	21.85	45.52	1228	2196	0.77	0.84	0.65	0.78	Relocated
7	Germen Square	0.46	20.51	44.59	956	2379	0.76	0.65	0.70	0.72	Relocated
8	Mekanisa	0.47	16.99	36.15	1208	2379	0.61	0.82	0.70	0.68	Relocated
9	National Alcohol	0.51	10.20	20.00	1401	2379	0.34	0.95	0.70	0.54	New
10	Mekanisa Abo	0.41	16.03	39.10	1468	2379	0.66	1.00	0.70	0.75	Retained
11	Vatican Embassy	0.46	9.98	21.70	805	2379	0.37	0.55	0.70	0.45	Relocated
12	Sarbet Bridge	0.54	19.00	35.19	1264	2379	0.60	0.86	0.70	0.68	Retained
13	Africa Union	0.47	8.11	17.26	555	2379	0.29	0.38	0.70	0.36	Relocated
14	Mexico Fed. Police	0.48	18.90	39.38	1184	2608	0.67	0.81	0.77	0.71	Retained
15	Mexico Shebele	0.50	21.21	42.42	719	3020	0.72	0.49	0.89	0.68	New
16	National Theater	0.53	9.86	18.60	484	1052	0.32	0.33	0.31	0.32	Retained
17	Tikur Anbesa	0.47	7.12	15.15	945	1052	0.26	0.64	0.31	0.36	Retained
18	Tewodros Square	0.47	8.74	18.60	652	1052	0.32	0.44	0.31	0.35	Relocated
19	Piassa (Jemo End)	0.43	18.98	44.14	1455	3386	0.75	0.99	1.00	0.84	Retained
1	Yeka Abado 13	0.43	25.38	59.02	1465	1114	1.00	1.00	0.33	0.93	Retained
2	Cross	0.54	20.20	37.41	1152	1114	0.63	0.78	0.33	0.64	Retained
3	Gedera	0.41	15.71	38.32	820	1400	0.65	0.56	0.41	0.60	Relocated
4	Kara 1	0.43	13.92	32.37	1286	1400	0.55	0.88	0.41	0.62	New
5	Kara Michael	0.41	13.35	32.56	1244	1400	0.55	0.85	0.41	0.61	Relocated
6	Kara Square	0.47	18.24	38.81	1284	1400	0.66	0.87	0.41	0.69	Retained
7	Kara 2	0.50	14.13	28.26	1455	1400	0.48	0.99	0.41	0.61	New
8	Abem	0.50	16.92	33.84	1398	987	0.57	0.95	0.29	0.64	Relocated
9	Wesen Grocery	0.50	21.66	43.32	1335	987	0.73	0.91	0.29	0.74	Retained
10	St. Michael	0.47	20.90	44.47	1209	987	0.75	0.82	0.29	0.73	Relocated
11	Hillside School	0.48	12.00	25.00	1024	987	0.42	0.70	0.29	0.48	Retained
12	Ethio-china	0.51	14.82	29.06	1443	987	0.49	0.98	0.29	0.60	Relocated
13	Lamberet	0.48	15.78	32.88	1252	987	0.56	0.85	0.29	0.61	Relocated
14	Abyssinia	0.52	9.14	17.58	852	1400	0.30	0.58	0.41	0.38	Relocated
15	Megenagna	0.45	20.00	44.44	1460	1973	0.75	0.99	0.58	0.80	Retained
16	Sholla	0.48	18.33	38.19	870	1973	0.65	0.59	0.58	0.63	Retained
17	British Embassy	0.47	13.88	29.53	1220	1973	0.50	0.83	0.58	0.59	Relocated
18	Kokebe Tsibha	0.55	9.98	18.15	1260	1973	0.31	0.86	0.58	0.48	Retained
19	Bylier	0.42	14.31	34.07	1097	1241	0.58	0.75	0.37	0.60	Relocated
20	Aware	0.44	11.83	26.89	1235	1241	0.46	0.84	0.37	0.55	Relocated
21	4 Killo Silase	0.55	14.60	26.55	1276	891	0.45	0.87	0.26	0.54	Retained
22	St. Mariam Mezoria	0.49	9.02	18.41	745	891	0.31	0.51	0.26	0.36	Retained
23	Seba Dereja	0.48	9.81	20.44	712	891	0.35	0.49	0.26	0.37	Relocated
24	Piassa (Abado End)	0.43	18.98	44.14	1460	2037	0.75	0.99	0.60	0.80	Retained

Source: GIS Output (2022)

The proposed five new bus stops are at Jemo Yetebaberut, Mekanisa National Alchol, Mexico Shebele, Kara 1 and Kara 2 that are created due to the service area gaps (uncovered service area), while one bus stop at 4 Killo Tourist Hotel was removed or dissolved due to service area overlap with the presence of closer bus stop at 4 Killo Silasie and St. Mariam Mazoria. Due to the bus stops optimization, the inbound bus stops spacing were also improved with spacing interval range of 600 – 850 meters considering the junction constraints at very few locations (See Annex XII).

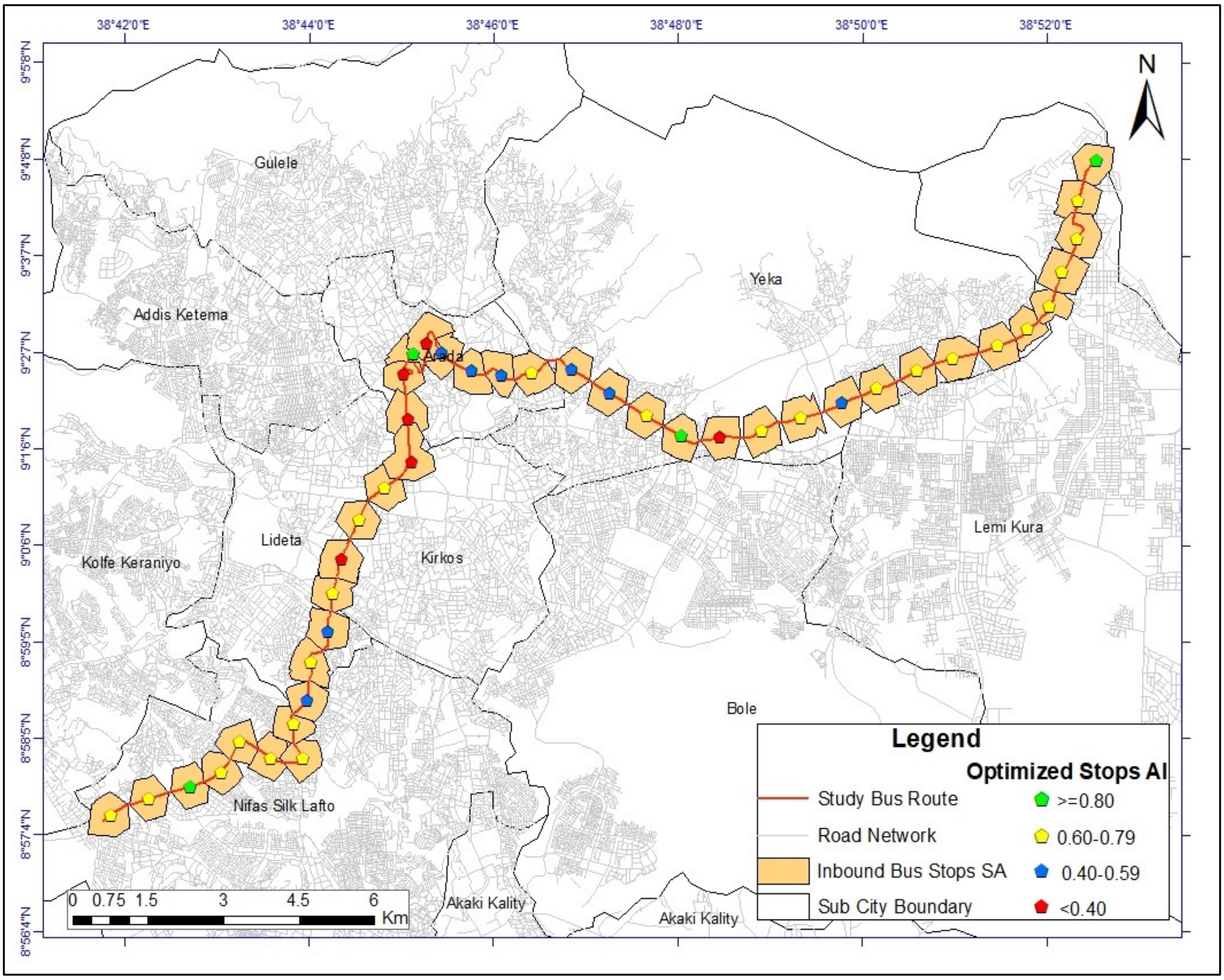

Figure 4.11: Proposed Inbound Bus Stops Accessibility Index

Source: GIS Output (2022)

The optimization of the bus stop location increased good & moderate inbound direction bus stop accessibility by 45.3% (from 51.2% to 74.4%). It decreased poor bus stop accessibility by 61.1% (from 36.0% to 14%), as presented in Table 4.16.

Table 4.16: Proportion of Proposed Inbound Bus Stops Accessibility

Category	Range of Accessibility Index	Existing Bus Stops		Proposed Bus Stops	
		Number of Stops	%	Number of Stops	%
Excellent	>=0.80	5	12.8	5	11.6
Good	0.60 – 0.79	10	25.6	24	55.8
Moderate	0.40 – 0.59	10	25.6	8	18.6
Poor	< 0.40	14	36.0	6	14.0
Total		39	100.0	43	100.0

Source: GIS Output (2022)

4.5.4.2. Outbound Optimal Bus Stops

Table 4.17: Proposed Outbound Bus Stops

Stop Id	Stop Name	Service Area (Km^2)	Road Length (Km)	Road Density	Pop. Served	Daily Trip Generation	Road Density Index	Pop. Served Index	Trip Index	Combined Accessibility Index	Remark
1	Piassa (Jemo St.)	0.37	15.55	42.03	1450	1098	0.82	0.99	0.53	0.83	Retained
2	Tewodros Square	0.48	9.33	19.44	352	1327	0.38	0.24	0.64	0.37	Relocated
3	Tikur Anibesa	0.54	8.23	15.24	755	1327	0.30	0.52	0.64	0.39	Retained
4	National Theater	0.53	13.12	24.75	1065	1922	0.48	0.73	0.93	0.59	Relocated
5	Mexico Fedederal Police	0.51	15.41	30.22	890	1601	0.59	0.61	0.78	0.61	Retained
6	Africa Union	0.38	7.84	20.63	1356	1601	0.40	0.93	0.78	0.57	Relocated
7	Sarbet Bridge	0.48	13.87	28.90	680	1601	0.56	0.46	0.78	0.56	Retained
8	Vatican Embassy	0.44	9.51	21.61	950	1601	0.42	0.65	0.78	0.51	Relocated
9	Mekanisa Abo	0.45	18.52	41.16	1005	1601	0.80	0.69	0.78	0.77	Relocated
10	National Alcohol	0.45	17.29	38.42	905	1601	0.75	0.62	0.78	0.72	New
11	Mekanisa	0.45	17.97	39.93	705	1601	0.78	0.48	0.78	0.70	Relocated
12	Germen Square	0.49	12.37	25.24	896	1876	0.49	0.61	0.91	0.56	Retained
13	Jemo Michael Brdg	0.55	9.21	16.75	525	1876	0.33	0.36	0.91	0.39	Retained
14	Jemo Michael Sq.	0.53	18.98	35.81	965	1876	0.70	0.66	0.91	0.71	Relocated
15	Jemo Yetebaberu	0.52	11.14	21.42	1223	1876	0.42	0.83	0.91	0.57	New
16	Jemo1	0.54	11.37	21.06	1325	1876	0.41	0.90	0.91	0.59	Retained
17	Jemo 2	0.48	18.06	37.63	885	778	0.73	0.60	0.38	0.66	Retained
18	Jemo 3	0.53	13.89	26.21	1140	641	0.51	0.78	0.31	0.56	Retained
1	Piassa (Abado St.)	0.37	15.55	42.03	1450	1264	0.82	0.99	0.61	0.84	Retained
2	ETHOF Store	0.38	13.55	35.66	1273	1397	0.69	0.87	0.68	0.74	New
3	Seba Dereja	0.51	9.6	18.82	1129	1397	0.37	0.77	0.68	0.50	Relocated
4	Ras Mekonn	0.47	18.93	40.28	975	1397	0.78	0.67	0.68	0.74	Relocated
5	4 Killo Silasie	0.57	12.84	22.53	1460	1630	0.44	1.00	0.79	0.62	Retained
6	Aware	0.58	13.91	23.98	1437	1630	0.47	0.98	0.79	0.63	New
7	Bylier	0.59	16.7	28.31	1442	1630	0.55	0.98	0.79	0.69	Relocated
8	Kokebe Tsibha	0.48	20.91	43.56	690	2063	0.85	0.47	1.00	0.76	Relocated
9	British Embassy	0.48	14.35	29.90	765	2063	0.58	0.52	1.00	0.61	Relocated
10	Sholla	0.53	18.76	35.40	1125	2063	0.69	0.77	1.00	0.74	Relocated
11	Megenagna	0.47	24.19	51.47	1105	2063	1.00	0.75	1.00	0.94	Retained
12	Abyssinia	0.52	8.18	15.73	670	1464	0.31	0.46	0.71	0.39	Relocated
13	Lamberet	0.51	20.4	40.00	875	1031	0.78	0.60	0.50	0.70	Relocated
14	Ethio-china	0.49	14.15	28.88	1050	1031	0.56	0.72	0.50	0.60	Relocated
15	Hillside School	0.53	18.46	34.83	1443	1031	0.68	0.98	0.50	0.74	Relocated
16	St. Michael	0.53	18.34	34.60	1350	1031	0.67	0.92	0.50	0.72	Retained
17	Wesen Grocery	0.51	16.62	32.59	1435	1031	0.63	0.98	0.50	0.71	Retained
18	Abem	0.53	19.92	37.58	1325	1031	0.73	0.90	0.50	0.75	Relocated
19	Kara 1	0.58	17.83	30.74	1300	1464	0.60	0.89	0.71	0.68	New
20	Kara Square	0.48	20.99	43.73	280	1464	0.85	0.19	0.71	0.66	Retained
21	Kara Michael	0.51	22.99	45.08	645	1464	0.88	0.44	0.71	0.75	Relocated
22	Kara 2	0.51	17.54	34.39	480	1464	0.67	0.33	0.71	0.58	New
23	Gedera	0.47	7.24	15.40	270	1464	0.30	0.18	0.71	0.31	Retained
24	Cross	0.52	11.35	21.83	1415	1165	0.42	0.97	0.56	0.58	Relocated
25	Yeka Abado 13	0.48	12.24	25.50	1150	1165	0.50	0.78	0.56	0.58	Retained

To optimize the outbound bus stops, 17 existing bus stops that comply with the spacing standard (600 - 800 m) were retained, 20 stops that are below and above the stop spacing standard were relocated and 6 new bus stops were also proposed. This resulted in the number of outbound bus stops to be increased from 38 to 43.

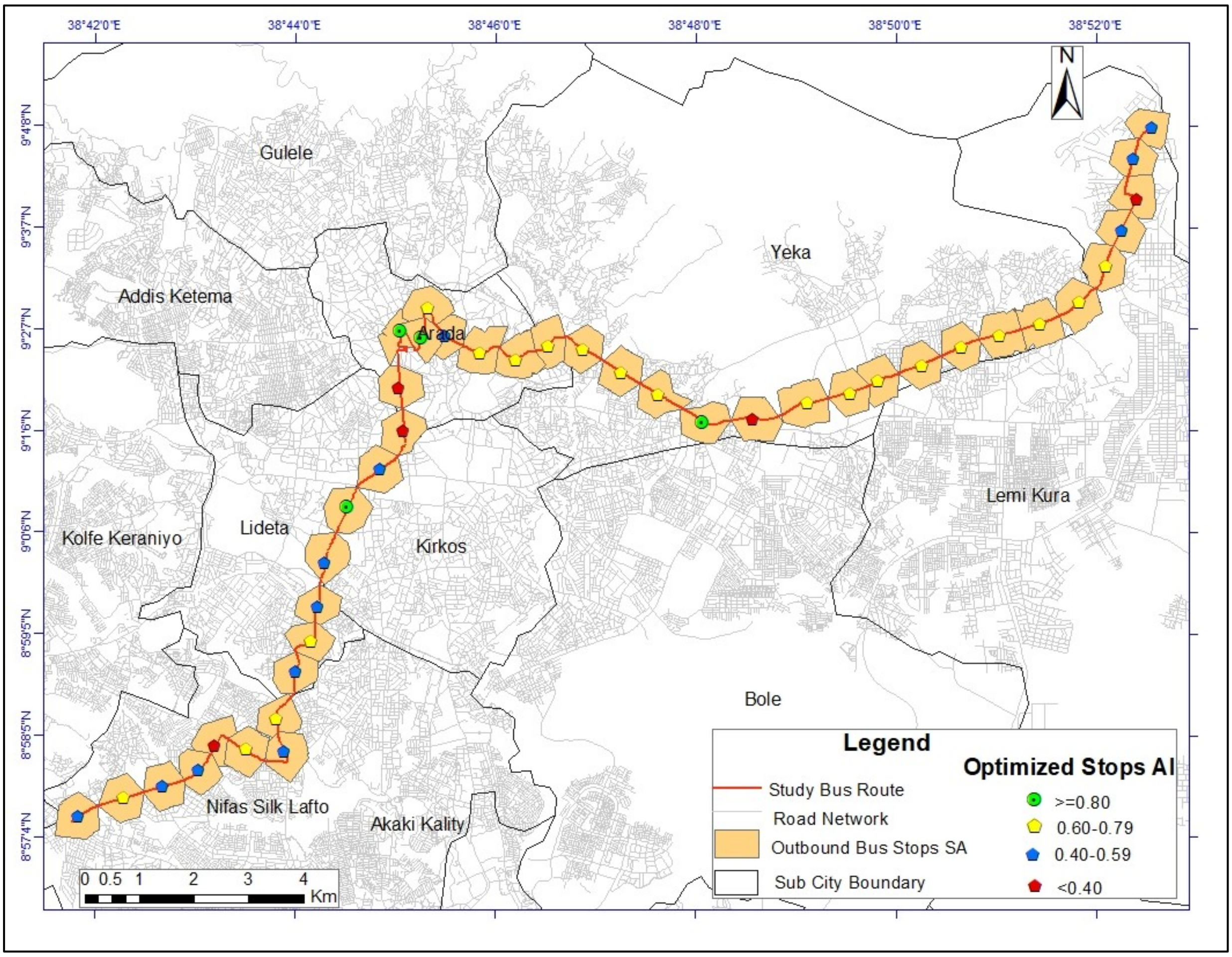

Figure 4.12: Proposed Outbound Bus Stops Accessibility Index
Source: GIS Output (2022)

Optimization of outbound bus stop increased good & moderate bus stop accessibility by 71.7% (from 47.4 to 81.4%) and decreased poor bus stop accessibility by 74.1% (from 44.7% to 11.6%), as presented in Table 4.18.

Table 4.18: Proportion of Proposed Outbound Bus Stops Accessibility

Category	Range of Accessibility Index	Existing Bus stops		Proposed Optimal bus stops	
		Number of Stops	%	Number of Stops	%
Excellent	>=0.8	3	7.9	3	7.0
Good	0.60 – 0.79	8	21.1	22	51.2
Moderate	0.4 – 0.59	10	26.3	13	30.2
Poor	< 0.4	17	44.7	5	11.6
Total		38	100.0	43	100.0

Source: GIS Output (2022)

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1. Conclusion

The physical condition of bus stops facilities and the location of bus stops significantly influence the transit system efficiency and customer satisfaction. Thus, this research is aimed to assess the physical condition of bus stops, the spatial accessibility of the bus stops and to optimize the bus stops' physical condition and their accessibility to the residents.

The result revealed that most of the existing bus stops in the study area are in poor condition where 71.8% of the sample respondents agreed or strongly agreed that the overall qualities of the bus stops are poor. The result is also supported by t-test result, which is statistically significant with p value less than 0.05 for all the parameters used to evaluate the existing bus stops' physical condition. In this sense, many of the bus stops are inconvenient to persons with disability and the elders due to the potholes and obstructions, lack adequate shades, seating chairs, and boarding and alighting space with safety and security concerns. The result also revealed that majority of the inbound (51.4%) and outbound (50.0%) bus stops were beyond the bus stops spacing standard (>800 meter); which implies that more than 50% of the bus stops are large service gaps for the residents to easily access bus stops.

The accessibility of existing bus stops was evaluated based on the combined accessibility index of three parameters: road density, population served, and trip generation. The result indicates that the 36.0% of the inbound bus stops and 44.7% of the outbound bus stops were with poor accessibility index respectively that needs the bus stop locations to be optimized for better accessibility.

The optimal locations for bus stops are thus proposed based on the combined accessibility index of the three parameters and the consideration of a bus stop spacing standard of 600-800 meters. The existing bus stops with excellent, good, and moderate categories are kept in their location as far as they comply with the stops spacing standard. The bus stops with spacing intervals below and above the standard with poor and moderate accessibility index were relocated and dissolving. The proposed optimal location of the bus stop thus increased good & moderate bus stop accessibility by 58.1%. It decreased the poor accessibility of both inbound and outbound bus stops by 68.3%.

5.2. Recommendation

This research tried to address the physical condition and spatial accessibility of bus stops in Addis Ababa city, taking Sheger bus stops in selected two bus routes. To ensure bus stops' maximum accessibility, the following recommendations were forwarded:

- As the majority of the bus stops are with poor physical condition coupled with lack of proper planning, continuous follow up and maintenance, Addis Ababa City Transport Bureau in general and Sheger Mass Transit Enterprise in particular should give due consideration for bus stop facilities with appropriate planning and placement of bus stops together with continuous follow-up.
- The city transport bureau should also consider bus stop accessibility optimization as it is a crucial element in improving the quality of bus services. Poorly accessed bus stops need to be relocated to the optimum locations where the stops can facilitate better accessibility. In this regard, proper planning and placement of bus stops should have considered achieving a careful balance according to the demand to optimize accessibility and travel time.
- Although this research is conducted on Sheger bus stops in two selected bus routes as a case study, it would also apply for bus stops other than Sheger and thus the transport bureau of Addis Ababa should consider standardization of bus stops spacing intervals for all the city buses considering the parameters of road density, trip generation and population served.
- As there is lack of well-organized trip generation data for each of the bus stops, the transport bureau needs to make survey of trip generation capacity of bus stops citywide and further studies need to be conducted for all the bus networks in the city for better future decision making.

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Annexes

Annex I: Questionnaire to Passengers (Sheger Bus Users)

Dear Respondents,

I am Yibeltal Dubale from Addis Ababa University, Department of Geography and Environmental Studies conducting a research for the partial fulfillment of Master's Degree in GIS, Remote Sensing and Digital Cartography. The purpose of this questionnaire is thus to gather data for my research project entitled ***"GIS-Based Spatial Optimization of Sheger Bus Stops Accessibility in Addis Ababa: the Case of Piassa - Yeka Abado and Piassa - Jemo Bus Routes"*** and the researcher wants to assure you that the data collected will be used only for academic purposes. Thanking you in advance for your cooperation!!!

Instruction:

- Do not write your name.
- Please tick the "√" mark for the appropriate choice and write your answers to the open-ended questions in the space provided.

Part I: Background Information about the Respondents

1. Sex: ☐ Male ☐ Female	**2.Age:** ☐ Below 18 Year ☐ 18-25 Year ☐ 26-35 Year ☐ 36-45 Year ☐ 46-55 Year ☐ Above 55Year
3. Level of Education: ☐ Illiterate ☐ Read and Write ☐ Elementary School ☐ Secondary School ☐ TVET/Diploma ☐ Degree and above	**4. Occupation:** ☐ Government ☐ Private sector ☐ NGO ☐ Self-employed ☐ Unemployed ☐ Student
5. Monthly Income: ☐ Less than 2500 ETB ☐ 2500-5000 ETB ☐ 5000-7500 ETB ☐ 7500-10000 ETB ☐ Above 10000 ETB ☐ Others	**6. Family Size**___________ **7. Car Ownership:** ________

Part II: Questions Related to Travel Characteristics

1. Which mode do you frequently use? ☐ Minibus Taxi (White & Blue taxi) ☐ Midi-bus (Higer & Kitkit) ☐ City bus (Anbessa, Sheger & Alliance bus) ☐ LRT ☐ Others	**2.** What is your frequent travel purpose? ☐ Work ☐ Education ☐ Shopping ☐ Recreation ☐ Others
3. How much is the average walking time from home to the nearest bus stop? ☐ Less than 5 min of walking (<400m) ☐ 5-10 min of walking (400-800m) ☐ 10-15 min of walking (800-1200m) ☐ More than 15 min of walking (>1200 m)	**4.** How long do you wait at the bus stops? ☐ Less than 10 minutes ☐ 10-20 minutes ☐ 20-40 minutes ☐ 40 minutes to 1 hour ☐ More than 1 hour

Part III: Questions Related to the Perception of Respondents on Bus Stops

5. How do you evaluate the quality of the bus stops?

☐ Very Poor
☐ Poor
☐ Moderate
☐ Good
☐ Very Good

6. What is your agreement or disagreement on the mentioned bus stop-related issues? Accordingly, please express your perception about the following bus stops attributes in the table. (Use √ a sign to indicate your level of agreement/disagreement).

No.	Characteristics	Strongly Disagree (1)	Disagree (2)	Neutral (3)	Agree (4)	Strongly Agree (5)
6.1.	The bus stops are **convenient** for people with disability, the elder, and women	☐	☐	☐	☐	☐
6.2.	The bus stops area is sufficient for boarding and alighting passengers/ **not crowded**	☐	☐	☐	☐	☐
6.3.	The bus stops have adequate **seating arrangements** /benches	☐	☐	☐	☐	☐
6.4.	The bus stops have adequate shelters to protect passengers from sun, rain and dust	☐	☐	☐	☐	☐
6.5.	The bus stops area are safe	☐	☐	☐	☐	☐
6.6.	The bus stops are secured for passengers with adequate lighting	☐	☐	☐	☐	☐
6.7.	The bus stops have trash bins	☐	☐	☐	☐	☐
6.8.	The bus stops have appropriate signage	☐	☐	☐	☐	☐
6.9.	The bus stops are unobstructed to the passengers and drivers	☐	☐	☐	☐	☐
6.10.	The bus stops are well connected with the pedestrian walkway	☐	☐	☐	☐	☐
6.11.	The bus stops are easily accessible to the residential and business area	☐	☐	☐	☐	☐
6.12.	The bus stops have appropriate surface markings for buses	☐	☐	☐	☐	☐

Thank You So Much for Your Precious Time in filling out this Questionnaire!!!

Annex II: Interview Guide

The purpose of this interview is to collect data for the research to be conducted to partially fulfil the requirement for a Master's Degree in GIS, Remote Sensing & Digital Cartography at Addis Ababa University. The researcher assures you that the data collected will be used only for academic purposes. The response you provide will have paramount importance for the successful accomplishment of this study. Therefore, you are kindly requested to give your genuine response, and your answer will be kept confidential.

Thank you in advance for your cooperation!

Name: ____

Position: ____

Organization: ______________________________________

Email Address: _____________________________________

Phone Number: _____________________________________

1. Is there any bus stop design and placement guideline? --
2. How far is the spacing between consecutive bus stops? --
3. How do you evaluate the accessibility of the bus stops to the residents? ----------------------
4. Do you believe the bus stops are at the optimum location for the residents? ----------------
5. What are the major factors to be considered in bus stop placement? --------------------------
6. What are the major problems related to the physical condition of the existing bus stops? --
7. Do you believe the bus stops have adequate shelters, benches for seating, and a signage/information guide? --
8. Do you believe bus stops are convenient and comfortable for people with disability, elders, and women? --
9. Are there any safety and security problems on the bus, and why? -----------------------------
10. Do you have any additional comments/suggestions? ---

"Thank you so much, and your participation is appreciated!!!"

Annex III: Outbound Bus Stops Physical Condition

Stop Id	Bus Stop Name	Shade shelters	Seating benches/chair	Convenience for a wheelchair user	Audible sign	Lighting	Surface markings	Trash bins	Bus information board	Connectivity to a pedestrian walkway	Proximity to pedestrian crossings
1	Piassa (Jemo St.)	√	√	×	×	√	√	√	√	√	√
2	Tewodros Square	√	√	×	×	√	√	√	√	√	√
3	Tikur Anbesa	√	√	√	×	√	√	√	×	√	√
4	National Theater	√	√	√	×	√	×	√	×	√	√
5	Mexico Federal Police	√	√	×	×	√		√	×	√	√
6	Africa Union	√	√	×	×	×	×	√	×	√	√
7	Sarbet Bridge	√	√	√	×	√		√	×	√	√
8	Vatican Embassy	√	√	√	×	√	×	√	×	√	√
9	Mekanisa Abo	√	√	√	×	√	√	√	×	√	√
10	Mekanisa	√	√	×	×	√	√	√	×	√	√
11	German Square	√	√	√	×	√	×	√	×	√	√
12	Jemo Michael Bridge	√	√	×	×	√	√	√	×	√	√
13	Jemo Michael Square	√	√	√	×	√	√	√	×	√	√
14	Jemo 1	√	√	√	×	√	√	√	√	√	√
15	Jemo 2	×	×	√	×	×	×	×	×	√	√
16	Jemo 3	×	×	√	×	√	×	×	×	√	√
1	Piassa (Abado St.)	√	√	√	×	√		√	×	√	√
2	Seba Dereja	√	√	×	×	√	×	√	×	√	√
3	Ras Mekonen	√	√	×	×	√	√	√	×	√	√
4	4 Killo Silasie	√	√	×	×	√	√	√	×	√	√
5	Aware	√	√	×	×	√	×	√	×	√	√
6	Bylier	√	√	√	×	√	√	√	×	√	√
7	Kokebe Tsibha	√	√	×	×	√	√	√	×	√	√
8	British Embassy	√	√	√	×	√	×	√	×	√	√
9	Sholla	√	√	√	×	√	√	√	×	√	√
10	Megenagna	√	√	×	×	√	√	√	√	√	√
11	Abyssinya	√	√	√	×	×	×	√	×	√	√
12	Lamberet	√	√	×	×	√	√	√	×	√	√
13	Ethio-china	√	√	√	×	√	√	√	×	√	√
14	Hillside School	×	×	√	×	×	×	×	×	√	√
15	St. Michael	√	√	×	×	√	√	√	×	√	√
16	Wesen Grossery	√	√	√	×	√	×	√	×	√	√
17	Abem	√	√	√	×	√	√	√	×	√	√
18	Kara Square	×	×	√	×	√	×	√	×	√	√
19	Kara Michael	×	×	×	×	×	√	×	×	√	√
20	Gedera	×	×	√	×	×	×	×	×	√	√
21	Cross	×	×	√	×	√	×	×	×	√	√
22	Yeka Abado 13	×	×	√	×	√	√	×	×	√	√

Annex IV: Inbound Bus Stops Physical Condition

Stop ID	Stop Name	Shade shelters	Seating benches or chair	Convenience for wheelchair users	Audible sign	Lighting	Surface markings for buses	Trash bins	Bus information board	Connectivity to a pedestrian walkway	Proximity to pedestrian crossings
1	Jemo 3	√	√	√	×	√	√	√	×	√	√
2	Jemo 2	√	√	×	×	√	×	√	×	√	×
3	Jemo 1	√	√	√	×	√	√	√	√	√	√
4	Jemo Michael Square	√	√	×	×	√	×	√	×	√	√
5	Jemo Michael Bridge	√	√	×	×	√	×	√	×	√	√
6	German Square	√	√	√	×	√	√	√	×	√	√
7	Mekanisa	√	√	×	×	√	√	√	×	√	√
8	Mekanisa Abo	√	√	√	×	√	√	√	×	√	√
9	Vatican Embassy	√	√	×	×	√	×	√	×	√	√
10	Sarbet Bridge	√	√	√	×	√	√	√	×	√	√
11	African Union	√	√	×	×	√	×	√	×	√	√
12	Mexico Federal Police	×	×	√	×	√	√	√	√	√	√
13	National Theater	√	√	√	×	√	√	√	×	√	√
14	Tikur Anbesa	√	√	√	×	√	×	√	×	√	√
15	Tewodros Square	×	×	×	×	√	×	×	×	√	×
16	Piassa (Jemo End)	×	×	√	×	√	√	×	×	√	√
1	Yeka Abado 13	√	√	√	×	√	√	√	×	√	√
2	Cross	√	√	√	×	√	√	√	×	√	√
3	Gedera	√	√	×	×	√	×	√	×	√	√
4	Kara Michael	√	√	×	×	√	×	√	×	√	√
5	Kara Square	√	√	×	×	√	×	√	×	√	√
6	Abem	√	√	×	×	√	√	√	×	√	√
7	Wesen Grossery	√	√	×	×	√	√	√	×	√	√
8	St. Michael	√	√	√	×	√	√	√	×	√	√
9	Hillside School	√	√	×	×	√	√	√	×	√	√
10	Ethio China	√	√	×	×	√	√	√	×	√	√
11	Lamberet	√	√	√	×	√	×	√	×	√	√
12	Abyssinya	√	√	√	×	√	√	√	×	√	√
13	Megenagna	√	√	√	×	√	√	√	√	√	√
14	Sholla	√	√	√	×	√	√	√	×	√	×
15	British Embassy	√	√	√	×	√	×	√	×	√	√
16	Kokebe Tsibha	√	√	√	×	√	√	√	×	√	√
17	Bylier	√	√	√	×	√	√	√	×	√	√
18	Aware	√	√	√	×	√	×	√	×	√	√
19	4 Killo Silase	√	√	√	×	√	√	√	×	√	√
20	Tourist Hotel	√	√	√	×	√	√	√	×	√	√
21	St. Mariam Mezoria	√	√	√	×	√	√	√	×	√	√
22	Seba Dereja	√	√	√	×	√	×	√	×	√	√
23	Piassa (Abado End)	×	×	√	×	√	√	×	×	√	√

Annex V: Inbound Bus Stops Accessibility Indices

Stop ID	Bus Stop Name	Service Area (Km2)	Road Length (Km)	Road Density	Population Served	Trip Generation	Road Density Index	Population Served Index	Trip Generation Index	Combined Accessibility Index
1	Jemo 3	0.47	17.12	36.43	1155	641	0.62	0.79	0.19	0.62
2	Jemo 2	0.41	15.98	38.98	892	778	0.66	0.61	0.23	0.60
3	Jemo 1	0.48	22.34	46.54	1428	1922	0.79	0.97	0.57	0.81
4	Jemo Michael Square	0.53	16.88	31.85	972	1922	0.54	0.66	0.57	0.57
5	Jemo Michael Bridge	0.48	20.85	43.44	1228	2196	0.74	0.84	0.65	0.75
6	Germen Square	0.46	19.51	42.41	956	2379	0.72	0.65	0.70	0.70
7	Mekanisa	0.45	14.27	31.71	975	2379	0.54	0.67	0.70	0.59
8	Mekanisa Abo	0.41	16.03	39.10	1468	2379	0.66	1.00	0.70	0.75
9	Vatican Embassy	0.47	8.24	17.53	612	2379	0.30	0.42	0.70	0.37
10	Sarbet Bridge	0.54	19.00	35.19	1264	2379	0.60	0.86	0.70	0.68
11	African Union	0.54	6.11	11.31	476	2608	0.19	0.32	0.77	0.28
12	Mexico Federal Police	0.48	18.90	39.38	1184	2608	0.67	0.81	0.77	0.71
13	Natonal Theater	0.53	9.86	18.60	484	3020	0.32	0.33	0.89	0.38
14	Tikur Anbesa	0.47	7.12	15.15	945	1052	0.26	0.65	0.31	0.36
15	Tewodros Square	0.48	4.99	10.40	1352	1052	0.18	0.92	0.31	0.38
16	Piassa (Jemo End)	0.43	18.98	44.14	1455	3386	0.75	0.99	1.00	0.84
1	Yeka Abado 13	0.43	25.38	59.02	1465	1114	1.00	1.00	0.33	0.93
2	Cross	0.54	20.20	37.41	1152	1114	0.63	0.79	0.33	0.64
3	Gedera	0.52	10.81	20.79	480	1400	0.35	0.33	0.41	0.35
4	Kara Michael	0.48	11.44	23.83	412	1400	0.40	0.28	0.41	0.37
5	Kara Roundabout	0.47	18.24	38.81	1284	1400	0.66	0.88	0.41	0.69
6	Abem	0.48	15.84	33.00	1120	987	0.56	0.76	0.29	0.59
7	Wesen	0.5	21.66	43.32	1335	987	0.73	0.91	0.29	0.74
8	St. Michael	0.48	18.19	37.90	1144	987	0.64	0.78	0.29	0.64
9	Hillside School	0.48	12.00	25.00	1024	987	0.42	0.70	0.29	0.48
10	Ethio-china	0.48	11.24	23.42	416	987	0.40	0.28	0.29	0.36
11	Lamberet	0.53	8.21	15.49	1015	987	0.26	0.69	0.29	0.38
12	Abyssinya	0.47	8.17	17.38	875	1400	0.29	0.60	0.41	0.39
13	Megenagna	0.45	20.00	44.44	1460	1973	0.75	1.00	0.58	0.80
14	Sholla	0.48	18.33	38.19	870	1973	0.65	0.59	0.58	0.63
15	British Embassy	0.48	12.66	26.38	1120	1973	0.45	0.76	0.58	0.54
16	Kokebe Tsibha	0.55	9.98	18.15	1260	1973	0.31	0.86	0.58	0.48
17	Bieler	0.5	8.11	16.22	832	1241	0.27	0.57	0.37	0.36
18	Aware	0.46	10.77	23.41	1016	1241	0.40	0.69	0.37	0.47
19	4 Killo Silase	0.55	14.60	26.55	1276	1241	0.45	0.87	0.37	0.55
20	Tourist Hotel	0.49	9.02	18.41	745	891	0.31	0.51	0.26	0.36
21	St. Mariam Mezoria	0.48	14.31	29.81	656	891	0.51	0.45	0.26	0.47
22	Seba Dereja	0.53	5.62	10.60	1175	891	0.18	0.80	0.26	0.35
23	Piassa (Abado End)	0.43	18.98	44.14	1460	2037	0.75	1.00	0.60	0.80

Annex VI: Outbound Bus Stops Accessibility Indices

Stop ID	Bus Stop Name	Service Area (Km2)	Road Length (Km)	Road Density	Population Served	Daily Trip Generation	Road Density Index	Population Served Index	Trip Generation Index	Combined Accessibility Index
1	Piassa (Jemo St.)	0.37	15.55	42.03	1450	1098	0.82	0.99	0.53	0.83
2	Tewodros Square	0.52	8.23	15.83	755	1327	0.31	0.52	0.64	0.39
3	Tikur Anbesa	0.49	8.13	16.59	640	1327	0.32	0.44	0.64	0.38
4	National Theater	0.54	7.45	13.80	485	1922	0.27	0.33	0.93	0.35
5	Mexico Federal Police	0.50	15.41	30.82	890	1601	0.60	0.61	0.78	0.62
6	Africa Union	0.48	5.84	12.17	650	1601	0.24	0.44	0.78	0.34
7	Sarbet Bridge	0.48	13.87	28.90	680	1647	0.56	0.46	0.80	0.56
8	Vatican Embassy	0.47	6.26	13.32	755	1601	0.26	0.52	0.78	0.38
9	Mekanisa Abo	0.41	8.31	20.27	855	1601	0.39	0.58	0.78	0.48
10	Mekanisa	0.46	15.81	34.37	770	1601	0.67	0.53	0.78	0.64
11	Germen Square	0.49	12.37	25.24	896	1601	0.49	0.61	0.78	0.55
12	Jemo Michael Bridge	0.55	9.21	16.75	525	1876	0.33	0.36	0.91	0.39
13	Jemo Michael Square	0.53	22.31	42.09	965	1876	0.82	0.66	0.91	0.79
14	Jemo 1	0.54	11.37	21.06	1325	1876	0.41	0.90	0.91	0.59
15	Jemo 2	0.48	18.06	37.63	885	778	0.73	0.60	0.38	0.66
16	Jemo 3	0.53	13.89	26.21	1140	641	0.51	0.78	0.31	0.56
1	Piassa (Abado St.)	0.37	15.55	42.03	1450	1264	0.82	0.99	0.61	0.84
2	Seba Dereja	0.41	5.46	13.32	750	1397	0.26	0.51	0.68	0.37
3	Ras Mokenn	0.45	5.45	12.11	895	1397	0.24	0.61	0.68	0.38
4	4 Killo Silasie	0.57	12.84	22.53	1960	1630	0.44	1.34	0.79	0.71
5	Aware	0.49	7.16	14.61	706	1630	0.28	0.48	0.79	0.39
6	Bylier	0.52	6.22	11.96	852	1630	0.23	0.58	0.79	0.38
7	Kokebe Tsibha	0.54	6.41	11.87	675	2063	0.23	0.46	1.00	0.37
8	Abebie Suk	0.53	6.18	11.66	735	2063	0.23	0.50	1.00	0.38
9	Sholla	0.49	11.24	22.94	1090	2063	0.45	0.74	1.00	0.58
10	Megenagna	0.47	24.19	51.47	1105	2063	1.00	0.75	1.00	0.94
11	Abyssinia	0.52	5.06	9.73	1055	1464	0.19	0.72	0.71	0.38
12	Lamberet	0.43	4.57	10.63	845	1031	0.21	0.58	0.50	0.33
13	Ethio-china	0.54	8.12	15.04	850	1031	0.29	0.58	0.50	0.39
14	Hillside School	0.50	10.92	21.84	1445	1031	0.42	0.99	0.50	0.58
15	St. Michael	0.53	18.34	34.60	1350	1031	0.67	0.92	0.50	0.72
16	Wesen	0.50	16.62	33.24	1434	1031	0.65	0.98	0.50	0.72
17	Abem	0.53	13.20	24.91	1305	1031	0.48	0.89	0.50	0.59
18	Kara Square	0.48	20.99	43.73	280	1464	0.85	0.19	0.71	0.66
19	Kara Michael	0.51	9.14	17.92	545	1464	0.35	0.37	0.71	0.39
20	Gedera	0.47	7.24	15.40	270	1464	0.30	0.18	0.71	0.31
21	Cross	0.52	15.03	28.90	875	1165	0.56	0.60	0.56	0.57
22	Yeka Abado 13	0.48	12.24	25.50	1150	1165	0.50	0.78	0.56	0.58

Annex VII: Optimized Bus Stops Spacing (Both Inbound and Outbound)

Inbound Bus stops			Outbound Bus stops		
Stop Id	Stop Name	Bus Stops Spacing (m)	Stop Id	Stop Name	Bus Stops Spacing (m)
1	Jemo 3	0	1	Piassa (Jemo St.)	0
2	Jemo 2	785	2	Tewodros Square	879
3	Jemo 1	817	3	Tikur Anibesa	895
4	Jemo Yetebaberut	800	4	National Theater	887
5	Jemo Michael Square	813	5	Mexico Federal Police	820
6	Jemo Michael Bridge	795	6	Africa Union	823
7	Germen Square	794	7	Sarbet Bridge	776
8	Mekanisa Abo	762	8	Vatican Embassy	790
9	National Alcohol	745	9	Mekanisa Abo	756
10	Mekanisa Abo	750	10	National Alcohol	780
11	Vatican Embassy	812	11	Mekanisa Abo	758
12	Sarbet Bridge	765	12	Germen Square	815
13	Africa Union	815	13	Jemo Michael Bridge	765
14	Mexico Federal Police	807	14	Jemo Michael Square	811
15	Mexico Shebele	682	15	Jemo Yetebaberu	763
16	National Theater	645	16	Jemo1	789
17	Tikur Anbesa	728	17	Jemo 2	815
18	Tewodros Square	815	18	Jemo 3	856
19	Piassa (Jemo End)	751	1	Piassa (Abado St.)	0
1	Yeka Abado 13	0	2	ETHOF Store	605
2	Cross	775	3	Seba Dereja	610
3	Gedera	810	4	Ras Mekonn	653
4	Kara 1	715	5	4 Killo Silasie	716
5	Kara Michael	753	6	Aware	753
6	Kara Square	703	7	Bylier	685
7	Kara 2	800	8	Kokebe Tsibha	825
8	Abem	812	9	British Embassy	778
9	Wesen Grocery	800	10	Sholla	802
10	St. Michael	810	11	Megenagna	813
11	Hillside School	785	12	Abyssinia	821
12	Ethio-china	768	13	Lamberet	825
13	Lamberet	810	14	Ethio-china	800
14	Abyssinia	760	15	Hillside School	702
15	Megenagna	795	16	St. Michael	830
16	Sholla	832	17	Wesen Grocery	792
17	British Embassy	815	18	Abem	770
18	Kokebe Tsibha	825	19	Kara 1	812
19	Bylier	780	20	Kara Square	831
20	Aware	718	21	Kara Michael	702
21	4 Killo Silase	808	22	Kara 2	631
22	St. Mariam Mezoria	825	23	Gedera	765
23	Seba Dereja	816	24	Cross	800
24	Piassa (Abado End)	780	25	Yeka Abado 13	765
	Total	31976		Total	31864

Annex VIII: Sheger Mass Transport Service Enterprise Trip Data (Regular Buses)

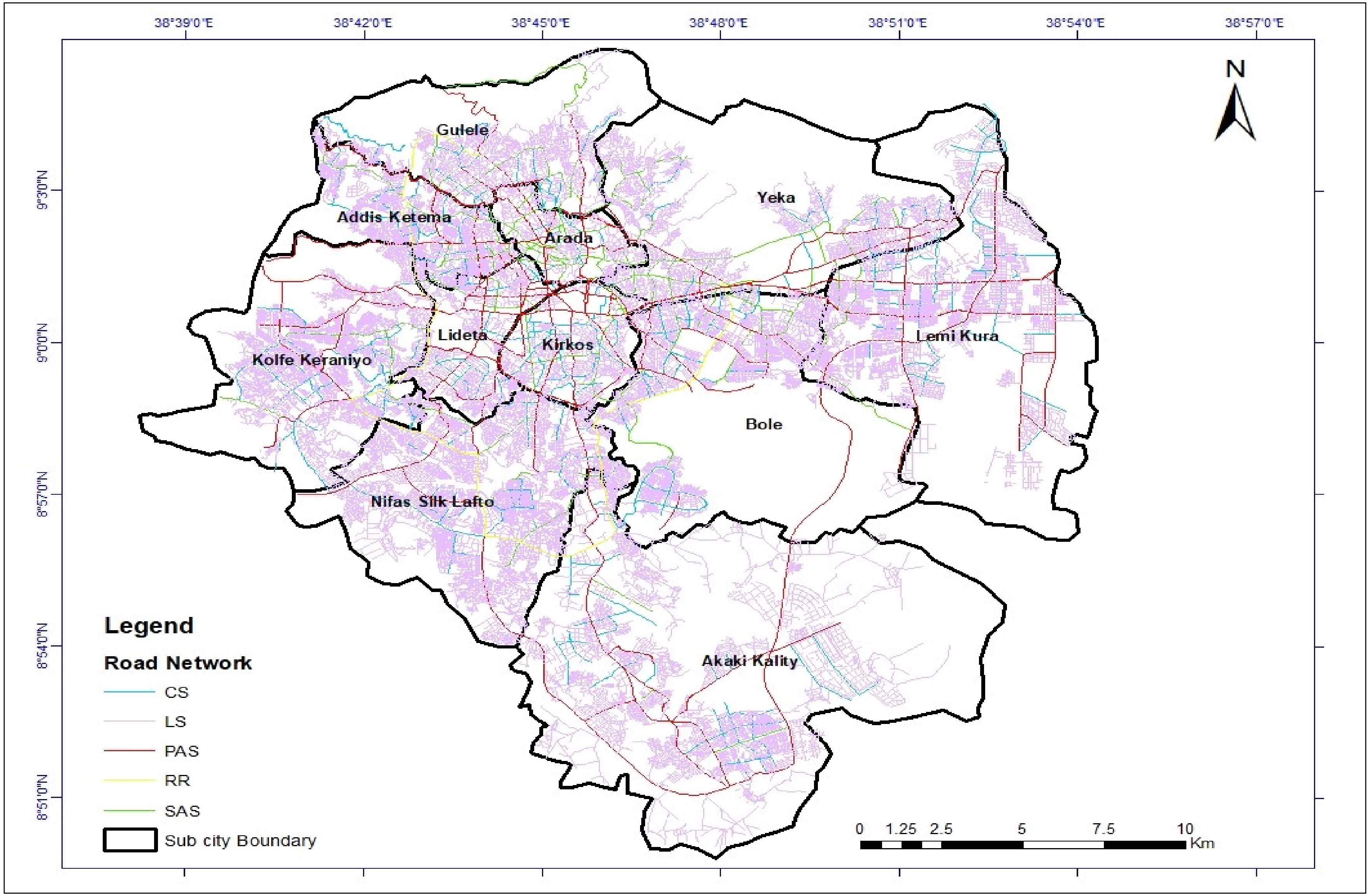
Depo		Megenagna				
No.	Route	Number of Operating Buses	Trip		Passenger	
			Standard Trip/Vehicle/ Day	Performance Trip/Veh/day	Standard Number of Pass/Vehicle/day	Performance in Number of Pass/Vehicle/day
1	Yeka Abado – Megenagna	35	14	12	770	930
2	Megenagna -- Arabsa	14	12	10	660	704
3	Yeka Aabado—Mexico	1	12		660	
4	Arabsa -- Mexico	2	10		550	
5	Arabsa – Piassa	-	10		550	
6	Megenagna-- Tafo	-	14		770	
7	Megenagna – Semmit	13	12	9	660	682
8	Yeka Aabado – Piassa	6	12	8	660	670
Total		**71**	**12**	**9.7**	**666**	**747**
Depo		**Kality**				
1	Mexico-- Jemo 1	17	14	10	770	685
2	Mexico--Jemo 2	14	13	13	715	829
3	Saris—Piassa	13	12	9	660	695
4	Mebrathail—Piassa	4	11	10	605	688
5	Megenagna—Saris	3	12	10	660	688
6	Mexico –Lafto		12		660	
7	Jemo 1—Piassa	5	11	10	605	672
8	Jemo 2—Piassa	1	11	7	605	508
9	Shiromeda--Saris	2	10	3	550	260
10	Mexico--Jemo 3	2	12	6	660	384
11	Ayertena-- Saris Abo	2	10	11	550	712
12	Megenagna -Haile Garment	4	10	18	550	1336
13	Hanamariam - Mexico	1	12	6	660	365
Total		**68**	**11.5**	**9.4**	**589**	**652**
Depo		**Shegole**				
1	Mexico—Shiromeda	20	15	15	825	960
2	Addisu Gebya-Megenagna	9	13	17	715	1192
3	Megenagna—Shiromeda	4	14	12	770	749
4	Piassa-- Megenagna	4	16	11	880	766
5	Piassa-- Bole	7	14	16	770	1039
6	Megenagna—Ferensay	3	13	14	715	895
7	Piassa-- Ferensay	3	16	9	880	500
8	Awtobstera – Asko	1	12	31	660	1682
9	Mexico—Ferensay	2	13	18	715	1183
10	Piassa-- Addisu Gebya	2	16	12	880	669

11	4 Killo -- Ferensay	3	13	13	715	696
12	Shiromeda--- Bole	3	12	13	660	866
13	4 Killo -- Bole	3	14	11	770	692
Total		**64**	**14**	**15**	**766**	**915**
Depo		**Mekanisa**				
1	Ayertena-Saris		10		550	
2	Awtobstera- Kela	1	10	2	550	114
3	Piassa- Ayertena		10		550	
4	Piassa- Betel		11		605	
5	Mexico - Alembank	4	12	14	660	625
6	Ayertena- Mexico	3	12	23	660	1050
7	Awtobstera-Saris		10		550	
8	Awtobstera - Jemo 1		10		550	
9	Awtobstera - Karakore	1	10	2	550	84
10	Mirab Hotel – Alembank		10		550	
11	Awtobstera –Spain		12		660	
12	Awtobstera – Alembank	5	12	5	660	231
13	Awtobstera—Ayertena	5	12	12	660	596
14	Mercato - Ayertena	1	12	3	660	129
15	Mercato - Alembank	2	12	50	660	2311
16	Mercato-Yeshidebele	3	12	7	660	289
17	Mercato - Karakore	1	10	1	550	48
18	Alembank- Piassa	1	10	21	550	1000
19	Torhailoch- Mexico	1	14	0	770	2
Total		28	11	12	580	540
Grand Total		**231**	**12**	**11**	**650**	**713**

Annex IX: Sheger Transport Trip Data (Cross Country Supportive Buses)

Depo		Megenagna		
No.	Route	Number of Operating Buses	Trip/Vehicle/ Day	Performance in Number of Pass/Vehicle/day
1	Mgenagna - 44 Mazoria	4	4979	5051
2	Megenagna – 49	4	1971	1534
3	Megenagna --Mision	-	-	-
4	Megenagna – Gelan	6	161	116
5	Megenagna – Kotebe	8	1531	1029
6	Megenagna --Kara	8	2681	1864
7	Megenagna – Goro	4	2262	1865
8	Megenagna – Arabsa	6	7061	5146
9	Megenagna --Abado	4	14704	10597
10	Megenagna --Tafo	5	3554	2635
11	Ferensay- Mexico	4	1706	1218
12	Abado – Piassa	5	1591	1223
13	Summit – Bole	-	-	-
14	Megenagna –Mexico	6	4754	3944
Total		64	46955	36222
Depo		**Kality**		
1	Mexico- Jemo 1	8	7000	5461
2	Mexico- Jemo 2	4	808	681
3	Hana-Mexico	3	1160	973
4	Hana - Ayer Tena	-	-	-
5	Garment –Mexico	8	3235	2580
6	Garment-Megenagna	2	381	282
7	Garment- Ayertena	2	292	288
8	Mexico – Lafto	2	1946	1588
9	Saris – Piassa	2	465	444
10	Mebrat – Piassa	2	1615	1571
11	Kality – Stadium	2	2248	2206
12	Kality – Piassa	2	419	457
13	Koyefeche - Kality	2	1021	1121
14	Kilinto – Kality	1	14	10
15	Tuliudimtu – Kality	2	801	777
16	Kality – Saris	4	143	135
17	Kilinto – Saris	5	2554	2538
18	Yeshitotal – Kality	5	826	773
19	Kality-Megenagna	5	378	330
Total		59	25306	22215
Depo		**Shegole**		
1	Addisugebya – Kera	-	-	-
2	Addisugebya –Bole	4	2292	2370
3	Piassa – Sansusi	3	11167	7542
4	Awutobstera – Kazanchis	5	1700	1113
5	Piassa—Ferensay	4	3751	2384
6	Megenagna - Piassa	4	5640	4950
7	Piassa – Bole	6	2182	1686
8	Piassa – Likuanda	7	4221	2649
9	Addisugebya – Sululta	5	7197	6617
10	Ferensay – Mexico	5	3075	2727
Total		43	41225	32037
Depo		**Mekanisa**		
1	Alembank – Piassa	8	3371	2046
2	Alembank – Mexico	4	1355	785
3	Alembank –Awutobstera	6	747	443
4	Tiorhailoch - Wolete	6	2444	1441
5	Kara - Awutobstera	5	1495	922
6	Kara – Piassa	5	1284	802
7	Yeshidebele – Merkato	4	3253	1928
8	Yeshidebele – Mexico	5	615	387
9	Ayertena -Mexico	8	5782	3531
10	Mexico—Kara	6	1049	661
11	Ayertena - Mirab Hotel	4	287	164
12	Kela - Awtobstera	8	3756	2852
13	Ayertena – Awtobstera	8	3895	2222
14	Sebeta – Ayertena	5	1570	1070
Total		79	30904	19255
Grand Total		248	144390	109730

Annex X: Road Network Map of Addis Ababa



Annex XI: Parcel Map of Addis Ababa