Evaluation of Existing Bus Stop Accessibility and Determination of Optimal Location For Bus Stops Using GIS Techniques: A Case Study of Yeka Sub City, Addis Ababa

By

Mohammed Gezie Dawd

A Thesis Submitted to Geomatics Engineering Department

School of Civil and Architecture

Office of Graduate Studies

Adama Science and Technology University

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Mohammed Gezie Dawd

Advisor (s): Dr. Daniel Alemayehu

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Approvals of the Board of Examiners

We, the undersigned, members of the Board of Examiners of the final open defense by Mohammed Gezie have read and evaluated his/her thesis entitled "EVALUATION OF EXISTING BUS STOP ACCCESSINBILITY AND DETERMINATION OF OPTIMAL LOCATIONS FOR BUS STOP, USING GIS TECHNIQUES: A CASE OF YEKA SUB CITY, ADDIS ABABA" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Degree of Masters in Geo-informatics Engineering.

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Name: Mohammed Gezie

Signature: __________

This MSc Thesis has been submitted for examination with my approval as thesis advisor.

Name: Daniel Alemayehu (PH.D)

Signature: __________

Date of submission: ___________

Advisor's Approval Sheet

To: Geomatics Engineering department

Subject: Thesis Submission

This is to certify that the thesis "EVALUATION OF EXISTING BUS STOP ACCCESSINBILITY AND DETERMINATION OF OPTIMAL LOCATIONS FOR BUS STOP, USING GIS TECHNIQUES: A CASE OF YEKA SUB CITY, ADDIS ABABA" submitted in partial fulfillment of the requirements for the degree of Master's in Geo informatics Engineering, the Graduate program of the department of Geomatics Engineering, and has been carried out by Mohammed Gezie Id. No A/pr15402/10, under our supervision. Therefore, we recommend that the student has fulfilled the requirements and hence hereby he can submit the thesis to the department.

______________________	__________	__________
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Abstract

Accessibility is, "The ease of reaching some destination, and include real or perceived costs in terms of time or money, distance travelled, level of comfort, availability and reliability of public transport, or combination of these". Addis Ababa is one of the fastest growing cities in the world, yet is constrained by poor accessibility of City Bus Services and people spend more time and money on travel due to inadequate infrastructures such as public transport routes and bus stop location, road network, poor transport operation, bus stop spacing, limited extent of Anbessa bus service coverage had resulted inaccessible service to the users. The current study identified a problem of lack of spatial information on Anbessa Bus Service Accessibility for each bus stop in Yeka Sub City, Addis Ababa City that peoples spend more time & money on travel is becoming a serious problem nowadays. The current study focused on evaluating accessibilityof existing bus stop and identify the spatial information of bus stop location and determine the best locations of bus stops in order to serve most users in its urban setting and to ensured optimum accessibility.*The two important factors of accessibility index, which was measured based on three criteria: Road Density, Population Served and Trip Generation and bus stop spacing standard of 800meters are considered in the current study to identify the optimal locations of bus stops. GIS based service area analysis was used to evaluate bus stop accessibility and identify bus stop locations based on actual geography of pedestrian road network, road length within realistic bus stop service area. The current study focused on evaluating the accessibility of existing bus stops with its location and standard stop spacing and determined the optimal location of bus stops to ensure bus service accessibility. The evaluation of existing bus stops accessibility results in Yeka Sub City generally poor in status that most of the bus stops more than 70% in both inbound and outbound direction are categorized as poor & provide comparatively less accessibility. Determination of optimal location for bus stop accessibility by applying four mitigation measures of creating new bus stops, keeping bus stops in their original location, relocating and dissolving unnecessary bus stops were better than the existing once which increased by more than 60% in both directions of bus stops. Generally, after proposed optimal locations, the inbound and outbound good and moderate bus stop accessibility were improved to (62.21% and 75.59%) respectively. Besides poor accessibility of bus stop was diminished to less than of 30% in both directions of bus stops. Similarly, 13,552 populations for proposed inbound and 11, 298 for proposed outbound direction bus stop are included and they could be served by bus.*

***Keywords**: Accessibility index, GIS, Optimal Locations, Bus Stops and Addis Ababa City*

List of Acronyms:

AAC………………………Addis Ababa City

AAVAI…………………….Afternoon Average Accessibility Index

ACBSE……………. …….Anbessa City Bus Service Enterprise

ACRA…………………..……Addis Ababa City Road Authority

ACTA……………….…....Addis Ababa City Transport Authority

AI……………………….....Accessibility Indices

ALA…………………..…..…Addis Ababa Land Administration

ASAI ………………...…..Actual Stop-Accessibility Indices

ATG …………………….. Afternoon collected trip generation

DAP………………………Detail Area Plan

ECSA ………………...…..Ethiopian Central Statistical Agency

EGA…………………..…Ethiopian Geo-spatial Agency

FAVAI…………………..……Final Average Accessibility Index

GIS…………………..…. Geographical Information System

ISAI…………….. …..… .Ideal Stop-Accessibility Indices

MAVAI…………………. Morning Average Accessibility Index

MTG. …………………..…… Morning collected Trip generation

SCRI………………….. .Stop Coverage Ratio Index

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CHAPTER ONE

1. Introduction

1.1. Background of the Study

In the public transport industry, the public bus is an important component, which provides access to facilities, and contributes to social inclusion, thus becoming the backbone to a city performance (Yaakub et al., 2011) which is provided with the aim of improving social welfare. Simmonds (1998) defined accessibility as ‘‘a way of measuring the ease with which a particular category of persons can reach a defined set of destinations, from a given origin (origin accessibility), or the ease with which a given destination (destination accessibility) can be reached by a particular set of potential individuals.’’ As Ross (2000) defined accessibility, “The ease of reaching some destination, and include real or perceived costs in terms of time or money, distance travelled, level of comfort, availability and reliability of public transport, or combination of these”.

Providing and improving urban public transport service was becoming highly important to meet the demand of rapidly growing mass mobility due to high population growth and galloping urbanization in and around the city of Addis Ababa (Berhan, 2013). Due to the limited extent of Anbessa bus, in sufficiency of public bus route network and deficiency of Anbessa service people spend more time and money on travel as (Demelash, 2007) reported in Addis Ababa. According to Aklilu (2018) reported, the design of infrastructures such as public transport routes and stops, road network and availability of various land use destinations strongly influence the use of accessibility. Addis Ababa is one of the fastest growing cities in the world, yet it is constrained by poor accessibility of city bus services due to inadequate infrastructure, poor transport operation and ineffective performance of stakeholders had resulted in inaccessible service to the users (Kelbesa, 2017).

Therefore with increased city size and population in developing country, the travel demand is increased very fast which calls for an efficient and effective transit to fulfill the demand of travelling public, accessibility is one of the most alarming factors in these cases and due to this, the spatial accessibility index factors of walking distance and walking time, public transport routes, road network and bus stop locations were considered as Balya1 et al. (2016) and Aklilu (2018) reported.

Addis Ababa is one of the fastest growing cities in the world by increasing city size horizontally and increasing population from year to year due to high migration from surrounding areas of Addis Ababa & the travel demand is increased very fast and lower income peoples spend more time & money on travel which calls for an efficient and effective transit to fulfill the demand of travelling public, accessibility is one of the most alarming factors in these cases Balya1 et al. (2016). But, there is no clearly stated spatial information about the inaccessibility of Anbessa Bus Service for each bus stop in Yeka Sub City was an influenced to evaluate existing bus stop accessibility and determination of optimal location for bus stops by considering the spatial accessibility index factors of walking distance and walking time, public transport routes, road network and bus stop locations to ensure and address optimal bus service accessibility to most users in its urban setting and minimizing user cost.

The location and spacing of bus stops and walking distance to transit stops significantly affect bus service performance and passenger satisfaction (with in cost of time and money), because they influence travel time (Foda and Ahmed, 2010). Therefore, an average distance of 800 meters was considerd for bus stop spacing within 4oom reasonable & comfortable universally accepted Threshold walking distance in densely populated areas of Yeka Sub City; any passenger located within the spacing distance of 800 meter can easily reach any of the two bus stops.

The purpose of current study was to evaluate existing bus stop accessibility and identify the spatial information of bus stop location and to determine the best locations of bus stops based on these three defined parameters where optimum accessibility could be ensured. The outcome of this research will help ACTA and ACBSE to plan the optima location of new bus stops or to modify their locations in order to serve most users in its urban setting.

1.2. Statement of Problem

The efficiency and effectiveness of transport accessibility is an important driver of urban growth and key to sustainable development of city to ensure quality of urban life (Alistair Dawson, 2015). Anbesa Public Bus is the main mode of mass transit system in Addis Ababa City on which the low-income people heavily rely on. In public transportation system, reducing travelling time is an important and one-way to reduce its cost due to distance between bus stops and to optimize public bus stop location problem (Ziari et al., 2007). Due to the limited extent of Anbessa service coverage, in sufficiency of public bus route network and deficiency of Anbessa service people spend more time and money on travel as reported by (Demelash, 2007)**.** Addis Ababa is one of the fastest growing cities in the world, yet it is constrained by poor accessibility of City Bus Services due to inadequate infrastructure, poor transport operation and ineffective performance of stakeholders which resulted in inaccessible service to the users (Kelbesa, 2017). Providing and improving urban public transport service is becoming highly important to meet the demand of rapidly growing mass mobility due to high population growth and galloping urbanization in and around the city of Addis Ababa (Berhan, 2013), although the enterprise has large coverage in and around the city of Addis Ababa, it faces a lot of challenges in providing adequate service. According to Aklilu (2018); the design of infrastructures such as public transport routes and stops, road network and availability of various land use destinations strongly influence the high accessibility.

Ziari et al. (2007), Demelash (2007) and Aklilu (2018) analyzed the bus stop location and bus service accessibility based on travel time and costs due to walking distance, bus stop spacing, limited extent of Anbessa and thus they, confirmed that there is insufficiency of public bus route network and deficiency of bus service in Addis Ababa City. However, there is no clearly stated spatial information about the inaccessibility bus stops which served by Anbessa Bus Service for each bus stops in Yeka Sub City of Addis Ababa. Therefore, the current study identified a problem on the lack of this spatial information on Anbessa Bus Service Accessibility for each bus stop in Yeka Sub City, Addis Ababa City in which people are spending more time & money on travel is becoming a serious problem nowadays. From the interview of Anbesa City Bus Service Enterprise (ACBSE) managers in 2019, 550 buses are serving on 124 limited routes and accessed 400,000 peoples on the day that is 11.6% of people get bus service from the total population which indicated that few number of populations could get service by bus.

The current study is focused on evaluating the accessibility of existing bus stops with its location and standard stop spacing and determine the optimal location of bus stops to ensure bus service accessibility. The three parameters of interest in the current study are road density, trip generation and population served for evaluation of accessibility index. Therefore, evaluating accessibility of existing bus stop is important to identify the spatial information of bus stops locations and determine the optimal locations of bus stops.

1.3. Research Questions

- What is the current status of existing bus stop accessibility of Yeka Sub City in Addis Ababa?
- Which factors could be considered to proposed optimal locations for bus stops?
- What could be the optimal location of bus stops of Yeka Sub City of Addis Ababa City?

1.4. Objectives

1.4.1. General Objectives

- To evaluate the accessibility of existing bus stop and determine optimal locations for bus stops using GIS techniques in Yeka Sub City.

1.4.2. Specific Objectives

- To evaluate accessibility index value for existing bus stops.
- To determine optimal locations for bus stops.
- To evaluate the accessibility of optimal bus stops.
- To recommend mitigation measures for inaccessible nodes on the bus route.

1.5. Scope of the Study

The current study was focused on specific areas of Addis Ababa City specifically in Yeka Sub-City and did not consider the other Sub Cities of the City becuase of Yeka Sub City was selected based on two point of veiw. The first was officially interviewed ACBSE managers, in Yeka Sub City the traffic flow was very crowded and the bus was spend more time to travelled from origin to destinations. Second selection criteria was reclassifying of population density, bus route and bus stops with in three classes of low, medium and high within equal interval method and perform weighted overlay analysis, Yeka Sub City was located in high ranks on three data of population density, bus route and bus stops. Based on the two criterias,Yeka Sub-City was selected for this study.The scope of the current study is focused on only on Anbessa City Bus public transport mode system and analyze & recommend based on these assumptions. It will not consider the competition, contribution and effect of the service provided by taxi or private sectors and other public services. The study evaluated Anbessa City Bus Service based only on its provision of accessibility to the users and optimize the optimum bus stops on each node.

1.6. Significance of the Study

This study will be important for different organizations such as Anbessa City Bus Service Enterprise, Addis Ababa City Transport Authority (ACTA), Addis Ababa City Road Authority(ACRA) and City Municipality either directly or indirectly.

Anbessa City Bus Service Enterprise – could get spatial information on the distribution of routes, bus stops, service accessibility and optimal bus stops for planning purpose

Addis Ababa City Transport Authority (ACTA) – could get awareness about city bus service in particular & can identify where feeder services are required to alleviate the problem of spatial equity

City Municipality**,** as owners of the city bus organization, they could get insight into the operational characteristics of the bus service from this paper.

Addis Ababa City Road Authority (ACRA) could get spatial information from the current papers to investigate the possibility of providing separate bus lanes with taxi and it gives an opportunity for further research by individuals and organizations. Therefore, the enterprise should design an optimum bus assignment and bus scheduling system, so as to serve passengers' need with maximum satisfaction and minimum operating costs.

1.7. Organization of the Thesis

The whole study has been presented in five chapters which represent the followings:

Chapter 1 elaborates the necessity of *background of the study and stated the problems, Research question, objectives of the study, scope of the study and Significance of study* and finally the judgment why the study should be carried out in respect of Yeka Sub City. *Problems of the study* elaborates the reasoning for which the study should be conducted. Research question states thequestions what will be solves. *Objectives of the study* state the two (main and specific) aims of the study. *Scope of the study* represents what opportunities could be availed if the study is taken place. All the organization of the study could be justified and the opportunities of the study and extent were described.

Chapter 2 literature review was carriedout to have a clear understanding about the study. The chapter summarizes the list of the literatures that are reviewed to develop the concepts and presents the theoretical and empirical framework; all the theories that are used and considered are elaborated in this chapter.

In Chapter 3, all methodology of the study that denoted step by step procedure following which the study was conducted. In this section the data collection, processing and analysis techniques will be elaborated. In addition, the procedures of data analysis and validation will be briefly discussed.

Chapter 4 represents the whole data analysis part *such as Evaluation of Bus Stop Accessibility* and *Optimal Locations for Bus Stops*. In this section all the analyzed parts could be described along with the necessary maps and findings at the end which elaborates the results of existing bus stops and optimal location of bus stop that have been found from the analysis.

Chapter 5 *conclusion and Recommendation* includes the recommendations that are stated considering findings of the study and finally the conclusion which is drawn through the whole research.

CHAPTER TWO

2.1. LITERATURE REVIEW

2.1.1. Concepts of Accessibility

There are many definitions of accessibility in literature. According to Litman (2003) cited in Muhammad et al. (2013), "Accessibility (or just access) refers to the ease of reaching goods, services, activities and destinations, which together are called opportunities". According to Simmond (1998) asserted in Muhammad et al.(2013), accessibility can be examined primarily from two viewpoints: that of the individual (origin), and that of the service provider (destination). In case of considering people, accessibility is "the ease with which any individual or group of people can reach an opportunity or defined set of opportunities"; it is often referred to as origin accessibility. On the other hand, in case of considering service providers, accessibility is "the ease with which a given destination can be reached from an origin or set of origins"; which is usually referred to as destination accessibility, catchment accessibility or facility accessibility. Ross (2000) defined accessibility as, "The ease of reaching some destination, and may include real or perceived costs in terms of time or money, distance travelled, level of comfort, availability and reliability of public transport, or any combination of these". Therefore, accessibility refers to physical access to goods, services and destinations, which is what people usually mean by transportation. Foda and Osman (2010) exhibited a way to assess the bus stop accessibility in their research. The accessibility is assessed in the research based on actual pedestrian road network which is more accurate compared to the prior assessment of accessibility based on ideal road network. Ideal road network was estimated based on a circular buffer analysis with a radius of the access threshold around the transit stop in order to identify its coverage area. However, the estimation based on circular buffer is unrealistic and have potential for error by measuring the access distance in terms of a rectilinear distance and ignoring the actual geography of the pedestrian road network surrounding the stops (Muhammad et al., 2013). The most limitation of this assessment is that it causes an overestimation of the stop access coverage. On the other hand, Foda and Osman (2010) assessed the accessibility by identifying all the pedestrian road network links that lie within the specified maximum walking distance measured along the network paths around the bus stop. In this assessment, overestimation of the stop access coverage can be mitigated.

However, it is noted for this research that the accessibility is measured based on only one criterion which is an accessibility index measure through the surrounding road network. Other criteria, which affect accessibility, were ignored in their research. Salvo and Sabatini et al. (2005) proposes a methodology in their research to assess public transportation access in urban area by using a geographical information system (GIS) based on pedestrian network with the presence of obstacles. The researchers plan the methodology to find out the "optimal location" of the new bus stops or to modify their location so as to serve most of users in the urban area. Optimal locations were evaluated in their research by considering walkable catchments, which are mapped based on a five-minute walking distance from a bus stop or ten minutes from any major transportation stop such as a rail station. However, the researchers propose three ways of determining catchment areas as (Muhammad et al., 2013) reviewed and cited.

a. The simplest approach of building transit catchment areas is to create a buffer around an entire route. The buffer is centered on the route of interest and is defined by the maximum distance that riders find convenient to walk to and from the system. In the analyses of this research, a distance zone of 300 meters has been used, which corresponds roughly to a 5 minute walk at 4.5 km/h. This approach assumes that all locations within the buffer area accessible to the route.

b. The second empirical approach is to create a buffer around each individual bus stop with radius as walking distance. It's shown as a circle with a radius of 300 m drawn around a bus stop and requires the availability of coordinate locations for each bus stop. However, the limitation of the analysis is that though the approach improves the accuracy of the analysis, it doesn't take into account the connectivity of pedestrian network and may make a mistake as well as route buffer approach. The approach is commonly used, for example, to design future transit routes for which bus stop locations are not yet known or when bus stop locations are not available in the GIS.

c. The other approach is to identify all links in the pedestrian network around bus stop that can be reached by walking along the network for less than the specified maximum walking distance. This approach requires network analysis tools and an accurate knowledge of network condition which are used in this study to determine an realistic service area analysis around each bus stop. The network analyses (topological and metric) of the routes were carried out to determine their connectivity, accessibility. The GIS can then estimate potential people and jobs within walking distance of a bus stop based on the fraction of each demographic area. Muhammad et al. (2013) classified the approaches GIS into:

I. Travel-cost approach – which reflects the “spatial separation” characteristics of a transportation network, i.e., distance, time, generalized cost, etc;

II. Gravity approach –derived from the gravity model formula, it reflects both the attractiveness of zones and the quality of the transportation system that connects them;

III. Constraints-based approach – it reflects the number of activities (or opportunities) that can be reached from an origin point within a certain time limit;

IV. Utility-based approach–developed based on disaggregate/behavioral approach originally proposed by (Ben-Akiva et al., 1978) and therefore they reflect the characteristics of the transportation system and the utility that havd different alternatives of facilities to the users;

V. Composite approach – developed by combining the space-time and utility based models and it assumes uniform travel speed. Approaches 1 have been acknowledged by (Arentze et al., 1994) and used in this current study.

Balya1 et al. (2016) was conducted on Indian bus stops to present the spatial transit accessibility index modeling with due consideration factors with walking distance and walking time. Therefore, the spatial accessibility is measured on GIS base to develop “Accessibility Catchments” through buffering process for different accessibility scales of radius of 400m and the catchment areas marked provide the scope to identify “Accessibility Thirst Areas” (Balya1 et al., 2016). The distance walked by a passenger to get transit stop is a key indicator of a transit system ability to attract people in its service area Hoback et al. (2008) cited by Muhammad et al. (2013). The presence or absence of transit service near user’s origin and destination is a key factor in user’s choice to use transit service (Jumsan *et al*., 2005). Strategic planning to improve transit system coverage in order to increase the total population served by suitable transit stop locations and route network can contribute to the efficiency and sustainability of a public transport system *(*Murray *et al.*, 1998). The marginal walking distance to transit stop is a basic parameter to estimate transit service coverage area in certain region (Jumsan *et al*., 2005). Walking or Physical access to a transit stop is interpreted in terms of the proximity of the passenger’s origin or destination to the nearest transit stop (Foda and Osman, 2010). Among transit planners and researchers, it is nearly universally accepted that a 400m walking distance and a mean walking speed between 80-95 m/minute is the maximum distance that most potential users are willing to travel to reach their nearest transit stop (Finnis and Walton, 2008) and (Foda and Osman, 2010). Therefore, according to above researchers, the 400m walking distance and a mean walking speed between 80-95 m/minute is used to analyze bus stop service area. The researcher was conducted on Portland by Robert L and Bertini (2011), With the availability of high resolution archived stop-level bus performance data, it is shown that a bus stop spacing model can be generated and tested with the aim of minimizing the operating cost while maintaining a high degree of transit accessibility. In their studies, two cost components are considered in the stop spacing model including passenger access cost and in-vehicle passenger stopping cost, and are combined and optimized to minimize total cost. The bus stop accessibility and to describe the application of an optimal stop spacing model within the constraints of access and riding costs for minimizing the total user cost.

Other researchers conducted on Helsinki, Finland and Tallinn, Estonia by Henrikki et al. (2016), to model more realistic urban accessibility patterns at any given point of time. In their presentation of a generic framework for dynamic urban accessibility modeling, the three core components of accessibility - spatial population distribution, transportation network and service network change used as a function of time. Ziari et al. (2007), analyzed and discussed the sensitivity of the total travel time, access, speed and the effect of the parameters on the optimum stop location. He stated that in public transportation system, reducing travelling time is one way to reduce its cost. There are various methods, to determine the distances between stations and optimize stop location for improved accessibility of bus stops.

Kelbesa (2017) conducted a research on Addis Ababa to examine the factors affecting the accessibility of Anbessa City bus service in Addis Ababa through an analysis of the stakeholders' opinions. The study found that inadequate infrastructure, poor transport operation and ineffective performance of stakeholders have resulted in inaccessible service to the users. Another research was conducted on Addis Ababa City by Demelash (2007) to investigate Anbesa City Bus Transport Service efficiency and bus route network deficiency, aiming for equitable bus service to all group of society in Addis Ababa City. Therefore, the network, service deficiencies under current physical, financial and institutional constraints have to be investigated to improve the bus service affordable transport, enhanced, access and mobility.

2.1.2. Accessibility Measures

Al Mamun and Lownes (2011) considered three primary components of accessibility viz. (1) trip coverage – travelers would consider public transit accessible when it is available to and from their trip origins/ destinations, (2) spatial coverage – travelers would consider public transit accessible when it is within reasonable physical proximity to their home/destination, and (3) temporal coverage - a service is accessible when service is available at times that one wants to travel. Spatial accessibility i.e. walking distance and walking time is only considered for the present research work. From these literatures reviewed above it is clear that most of the researchers assess the coverage area of bus stops as a circular buffer area around bus stops though it contains potentiality of errors. It is mainly dependent on the researchers aim, point of view and the parameters that, the researchers consider to assess the accessibility. The assessment of accessibility is depending on the spatial accessibility i.e. walking distance and walking time would be considered for the present research work. The parameters of road network, trip generated by bus and population density within spatial coverage area of bus stop will be considered to evaluate accessibility of bus services.

2.1.3. Factors Affecting Accessibility

There are number of factors that affect accessibility. Some of these factors tend to be overlooked or undervalued, particularly non-motorized travel demand, alternative mode service quality, user information, integration, affordability, prioritization and the value of inaccessibility.

Table .2.1: Summary of factors affecting accessibility

Name	Description	Current Consideration
Transport Demand	The amount of mobility and access that people and businesses would choose under various conditions (times, prices, levels of service, etc.).	Motorized travel demand is well studied, but non-motorized demand is not. Travel demand is often Considered exogenous rather than affected by planning decisions.
Transportation Options	The quantity and quality of access options, including walking, cycling, ridesharing, transit, taxi, delivery Services, and telecommunications.	Motor vehicle options and quality are usually considered, using indicators such as roadway level of-service, but other modes lack such

	Qualitative factors include availability, speed, frequency, convenience, comfort, safety, price and prestige.	indicators and some important Service quality factors are often overlooked.
Integration	The degree of integration among transport system links and modes, including terminals and parking Facilities.	Automobile transport is generally well integrated, but Connection between other modes are often poorly evaluated.
Affordability	The cost to users of transport and Location options relative to incomes.	Automobile operating costs and transit fares are usually considered.
Land Use Factors	Degree that factors such as land use Density and mix affect accessibility.	Considered in land use planning, but less in transport planning.
Transport Network Connectivity	The density of connections between roads and paths, and therefore the directness by which people can travel between destinations.	Conventional planning seldom Considers the effects of roadway connectivity on accessibility.
Inaccessibility	The value of inaccessibility and isolated.	Not generally considered in Transport planning.

Source: (Litman, 2012) cited in (Muhammad et al., 2013).

2.2. THEORETICAL FRAMEWORK

2.2.1. Accessibility

There are many definitions of accessibility in literature. According to Simmonds (1998) asserted in Muhammad et al. (2013), accessibility can be examined primarily from two viewpoints: that of the individual (origin), and that of the service provider (destination). In case of considering people, accessibility is “the ease with which any individual or group of people can reach an opportunity or defined set of opportunities”; it is often referred to as origin accessibility. On the other hand, in case of considering service providers, accessibility is “the ease with which a given destination can be reached from an origin or set of origins”; which is usually referred to as destination accessibility, catchment accessibility or facility accessibility. Ross (2000) defined accessibility as, “The ease of reaching some destination, and may include real or perceived costs in terms of time or money, distance travelled, level of comfort, availability and reliability of public transport, or any combination of these". Therefore, generally accessibility refers to physical access to goods, services and destinations, which is what people usually mean by transportation. Therefore, accessibility measures in general use the impedance effect of distance, time or generalized transport costs and the spatial distribution of urban opportunities to produce numerical indices of accessibility for each location. Murray et al. (1998) cited in Muhammad et al. (2013) distinguishes between the terms 'access' and 'accessibility'. Access is the opportunity for systematic use based on the proximity to the service and its cost. Accessibility is the suitability of the Public Transport network to get individuals from their system entry point to their system exit location in a reasonable amount of time. Ingram (1971) cited in Balya1 et al. (2016)**,** stated that accessibility may be defined as "the inherent characteristic (or advantage) of a place with respect to overcoming some form of spatially operating source of friction (for example, time and/ or distance)". Therefore the interaction between travel time/cost and the travel behavior of people at the origin and the interaction with the opportunities at the destination are insignificant then this can be an acceptable simplification. In practice travel behavior is highly dependent on accessibility (time, cost, comfort, safety, distance, etc.), and service provision at destinations interacts with transport in many ways. Travel time and cost are often used in transport planning as a proxy for accessibility (Derek Halden, 2009). According to Litman (2003), Ross (2000) and Simmonds (1998 accessibility is the suitability of the Public Transport network to get individuals from their system entry point to their system exit location in a reasonable spatial accessibility i.e. walking distance and walking time would be considered for the present research work. From these literatures reviewed above it is clear that most of the researchers assess the coverage area of bus stops as a circular buffer area around bus stops though it contains potentiality of errors. Furthermore, different researchers in assessing the accessibility use various methods. The network analysis tools and an accurate knowledge of network condition which are used to determine an realistic service area analysis around each bus stop (Muhammad et al., 2013). Therefore, service area network analysis tools would be used for this current study. The spatial accessibility i.e. walking distance and walking time were considered for assessing of accessibility in this current study. The parameters of road network, trip generated by bus and population density within spatial coverage area of bus stop were considered to evaluate accessibility of bus services.

2.2.2. Estimating Bus Stop Access Coverage

Although pedestrian access to a bus stop was achieved through the pedestrian road network surrounding each stop, previous research has not focused on the interaction between bus stop locations and their surrounding pedestrian road networks.

Bus Stop access coverage would be estimated using a network analysis with a radius of the 400m access threshold around the transit stop in order to identify its coverage area. Among transit planners and researchers, it is nearly universally accepted that a 400m walking distance and a mean walking speed between 80-95 m/minute is the maximum distance that most potential users are willing to travel to reach their nearest transit stop (Finnis and Walton, 2008). Therefore, according to above researchers, the 400m walking distance and a mean walking speed between 80-95 m/minutes used to analyze bus stop service area.

2.2.3. Actual Pedestrian Road Length and Actual Pedestrian Road Network

Actual pedestrian road length is the parcel of the specific length of a pedestrian road that measured from the originate of bus stop. In a road network, the length of the parcel may be equal to the specific length or may be less (if the road ends before completing the specific length). In this research, the specific length is considered as 400 meter pedestrian road length from bus stop. A number of actual pedestrian road lengths which originates from the same bus stop create the Actual Pedestrian Road Network. Examples of Actual pedestrian road length, Actual pedestrian road network and Actual bus stop access coverage source Muhammad et al. (2013) (Figure 2.1).

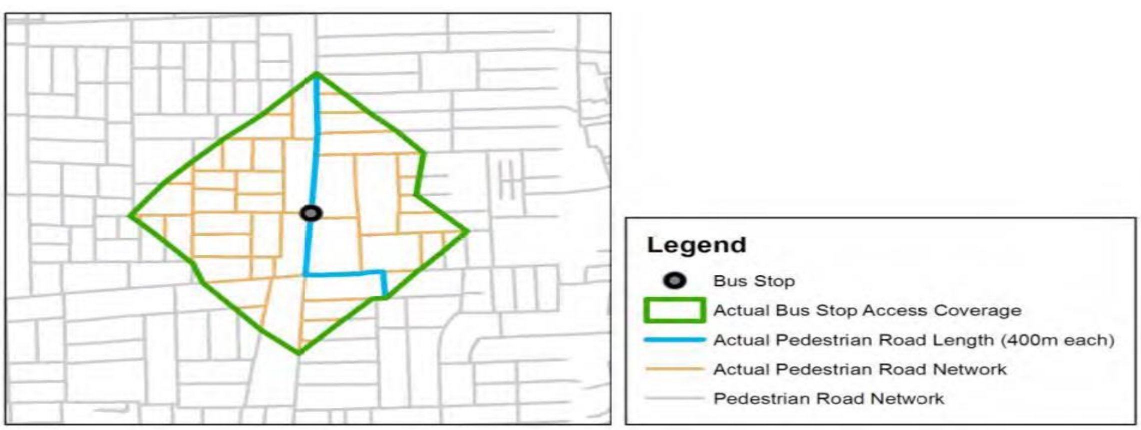


Figure 2.1: Actual Pedestrian Road Length and Actual Pedestrian Road Network.

2.2.4. Concept of Actual Bus Stop Access Coverage

Coverage area of bus stop was measure from actual pedestrian road network. Coverage area derived from actual pedestrian road network gives more accurate service area compared to the earlier method from which coverage area is considered creating a circular buffer around a bus stop which contains error of overestimation. However, bus stop access coverage is a critical measure for evaluating the stop location and accessibility by estimating the covered area and population lying within a suitable access distance from the bus stop (Foda and Osman, 2008). However, many previous researchers treated stop coverage as a simple circular buffer with a radius of the 400meter access threshold around each stop, which causes an error overestimation of the stop access coverage (Foda and Ahmed, 2010).

The reason for such an overestimation is the implied assumption that passengers can reach the bus stop from any location within the circular buffer (ideal case), and neglecting the actual geography of the pedestrian road network surrounding the bus stop. Salvo and Sabatini (2005) proposed a methodology to assess public transportation access coverage in urban areas using a geographical information system (GIS) based on a pedestrian network with the presence of obstacles. In this study, using the benefits of the GIS based service area network analysis approach is presented for estimating transit stop access coverage based on the Actual Pedestrian Road Network surrounding the bus stop. The idea means that to identify all the pedestrian road network links that lie within the specified maximum walking distance of the 400m access threshold, measured along the network paths around the bus stops. Joining the ends of those links creates a polygonal area, which is referred to as the “Actual Bus Stop Access Coverage” for the bus stop. This polygonal area is considered more representative than a 400m circular buffer for measuring the access coverage of a bus stop. Figure 2.2 shows the difference between the ideal access coverage (circular area) and the actual access coverage (polygonal area), which causes an overestimation in assessing the access coverage of a bus stop at a given location (Figure 2.1) (Foda and Ahmed, 2010).

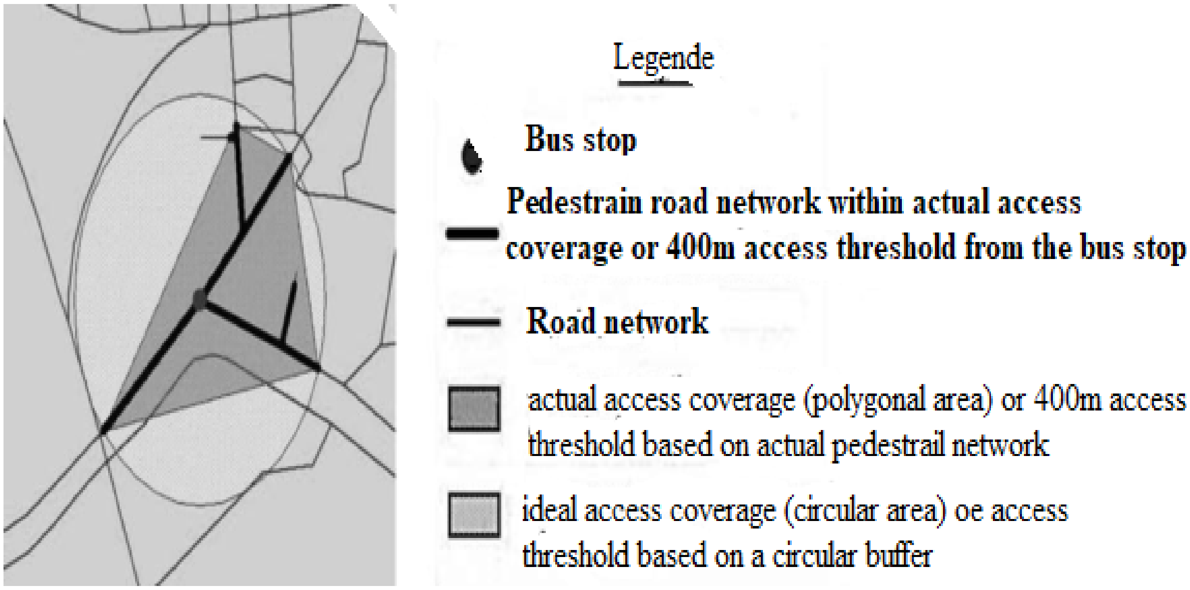


Figure 2.2: Actual Bus Stop Access Coverage.

As Foda and Ahmed (2010) interpreted, accessibility to a bus stop from within the circular buffer zone and through the intersected road network located inside the buffer (service) area can be divided into two parts: the first is within the specified limit buffer length (400m) is used in this paper, and the other exceeds the limit will be ignored.

2.2.5. Ideal and Actual Stop-Accessibility Indices (ISAI and ASAI)

The determination of ISAI and ASAI) values are more important to measure and identify more accurate bus stop accessible locations (Foda and Ahmed, 2010). The Accessibility indices (AI) can be developed and used to evaluate both the accessibility to a bus stop through the surrounding pedestrian road network and the ratio of actual access coverage to the ideal access coverage of a bus stop. First, the Ideal Stop-Accessibility Index (ISAI) can be used to evaluate the accessibility to a bus stop through the surrounding pedestrian road network. This is obtained by dividing the total length of the pedestrian road network links lying within a walking distance of 400m measured along the network paths (Km) by the ideal access coverage area of the bus stop measured as a circle or service area with a radius of 400m and having the bus stop as its center (km2) (Figure 2.3) (Foda andAhmed, 2010).

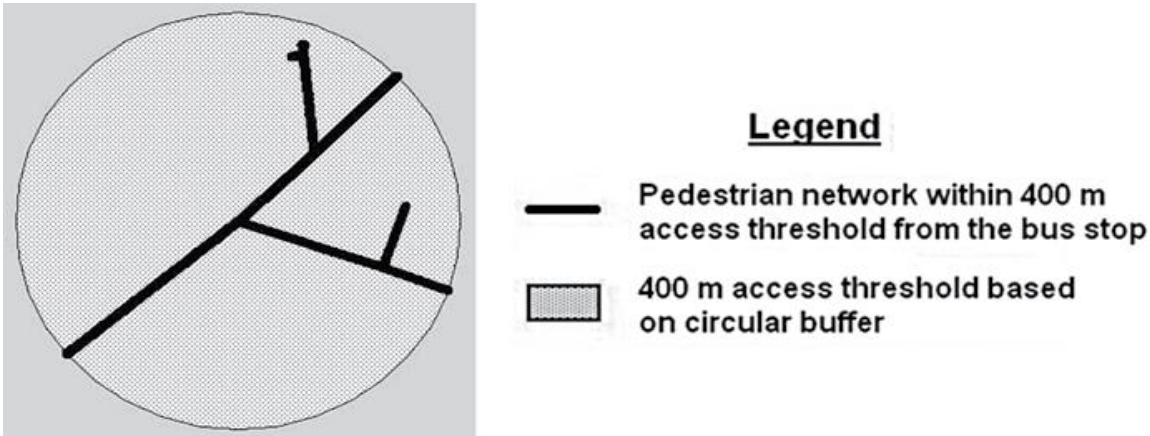
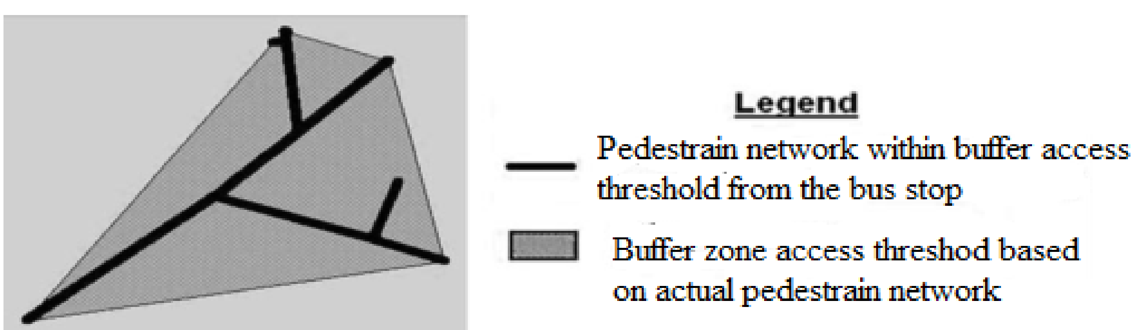


Figure .2.3: Ideal and Actual Stop-Accessibility Indices (ISAI and ASAI).

The denominator value is then the area of a circle with a radius of 400m, which is a constant equal to ($\pi r^2 = \pi \times (0.4)^2 = 0.503$ Km^2), in which the resulting value of such an index represents the ideal pedestrian road network density within the access threshold from a bus stop (Km/Km^2). An increment in the index value means that the ideal pedestrian road network density is higher, which is interpreted in terms of a better connectivity between the bus stop and the surrounding pedestrian road network. Means the higher value of the ISAI, the more accessible the bus stop location. Second, the Actual Stop-Accessibility Index (ASAI) can be used as a more accurate measure of bus stop accessibility through the surrounding pedestrian road network. The ASAI provides a more accurate measurement than the ISAI to the pedestrian road network density around a bus stop, where the denominator represents the actual access coverage area for the bus stop within the 400m limit of walking. The ASAI is obtained by dividing the total length of the pedestrian road network links lying within a walking distance of 400m measured along the network paths (Km) by the actual access coverage area of the bus stop measured on basis of the pedestrian road network serving the same stop (km^2) as shown in Figure below (Foda and Ahmed, 2010).



The value of ASAI represents the actual pedestrian road network density within the access threshold from a bus stop (Km/Km2). While the ASAI value estimates the actual pedestrian road network density within the access threshold from a bus stop, it may be misleading if used to compare the accessibility of different bus stop locations, as the denominator is not constant and depends on the surrounding road network formation. Therefore, in this study the ASAI had been considered than of ISAI which more accurate measure of bus stop accessibility through the surrounding pedestrian road network.

2.2.6. Measuring Bus Stop Accessibility

Foda and Ahmed (2010) asserted, the provision of bus-based transit service where accessing a bus stop is considered to be achieved mainly by walking. They considered spatial attributes, both the location and the spacing of bus stops significantly affect transit service performance and passenger satisfaction, as they influence travel time in addition to their role in ensuring reasonable accessibility. They considered that knowing every transit trip begins and ends with pedestrian travel, access to a bus stop is considered as critical factor for assessing the accessibility of bus stop location. The accessibility indices are calculated for each bus stop which has been derived from the only parameter-the density of pedestrian road. Density of pedestrian road around bus stops was an important parameter to assess accessibility in the way that it shows the amount of pedestrian roads which can be used to reach the bus stops. According to Muhammad et al. (2013), studied in Dhaka, asserted that only road density cannot ensure the accessibility of bus stops, the trip generation and population served are also affect the accessibility of bus stops. The trip generation is one parameter because there are locations where road density may be comparatively lower but may create large number of trips examples of commercial place or a large shopping center, marketing area. Bus stops beside a commercial place or shopping center, schools, hospital, & recreational areas may not have high density of pedestrian roads, but they generate large number of trips than any other places. These stops generally facilitate comparatively higher accessibility because they serve large number of people by ensuring direct access to these bus stops. Another parameter is the population one bus stop serve. Because each bus stop has a coverage area where the stop can serves its users. Coverage area of each bus stop indicates that people resides inside that coverage area has direct access to that bus stop. The bigger the coverage area, the more people will have the access to that bus stop which will indicate the affluence of accessibility. The bus stop located in a densely populated area will have more accessibility than that located in a less densely populated area though they have the same coverage area. Because the stop located in the densely populated area would serve more people. Besides these three parameters, some other parameters such as gender, age, disability and safety issues affect accessibility. Some bus stops may be less accessible for women, baby, elders & people with disabilities when the bus stops are always crowded or buses are packed, they may prefer to use another mode of transport to reach the destination, because these stops become uncomfortable to them and force to use them other mode.

In this current study, three parameters of Road Density, Trip Generation and Population Served are used to evaluate bus stop accessibility and located optimal location of bus stops others are omitted. All these parameters are calculated based on the coverage area of each bus stop. Coverage area is calculated based on reasonable walking distance of 400meters. Although the acceptable walking distances varies from person to person depending upon his trip purpose, age, and gender, elders, disables threshold distance of 624 m or walk time of 8 minute with average walking speed of about 78 m/minute or 1.3 m/s (second) is used to find transit stop service in urban areas, which are about 400meters in terms of walking distance as Levinson (1992); Foda and Ahmed (2010) and Finnis and Walton (2008) reported. Most transit firms consider 400 meter as an acceptable access standard (Ammons, 2001). In 'Transport for London, 2006', the ideal spacing for bus stops is also specified as 400 meter. In Columbus, Ohio, it is stipulated that passengers do not exceed walking distances of 400m to transit stops in urban areas Central Transit Authority (1999). Therefore, accordingly to Levinson (1992); Foda and Ahmed (2010), coverage area is measured based on 400 meter average acceptable walking distance or speed of about 1.3m/s will be considered in this current research paper. Coverage area (actual bus stop access coverage) of bus stops is derived from the road network of the study area and is measured using Network Analyst tool of ArcGIS software. Data of three parameters (road density, trip generation & population served) for each bus stop are derived based on coverage area. The data sets of parameters are stored in different shape files and contain different units of measurements (Road Density is stored as km/km^2 and population & trip generation are stored as numbers. The Accessibility Index model is used to identify bus stop accessibility conditions. The accessibility is primarily classified into 8 categories based on the evaluated accessibility index for displaying the map and further classified into 4 categories shown in (Table.2.2) for understanding the accessibility condition **(**source**:**Muhammad et al., 2013).

Table.2. 1: Categorization of accessibility index

Bus stop category	Accessibility index
Poor	3-6
	7-9
Moderate	10-12
	13-15
Good	16-18
	19-21
Excellent	22-24
	25-27

2.2.6.1. Road Density

Road density is measured based on the coverage area. Total road length fall inside the coverage area of each bus stop (within service area) is measured and then calculated the road density by dividing by the coverage area of that bus stop. Road Density in bus stop coverage area Sum of Road Length inside Coverage Area (L) in Km/ Coverage Area (A) in Km^2 = L/A for each bus stops.

2.2.6.2. Population Served within Bus Stops Coverage Area

Coverage area of each bus stop indicates that people reside inside that coverage area has direct access to that bus stop. The mobile peoples coming from any directions will be considered as peoples of residing inside of coverage area of bus stops. Mobile peoples are not considered because of the various number of incoming people from any directions & difficult to count it. The bigger the coverage area, the more people will have the access to that bus stop which will indicate the affluence of accessibility. Moreover, accessibility of bus stops having same coverage area can differ if they are located in different locations having different population density. For instance, the bus stop located in a densely populated area will have more accessibility than that located in a less densely populated area though they have the same coverage area. Because the stop located in the densely populated area will serve more people.

2.2.6.3. Trip Generation

Trip generation by bus is another criterion to evaluate the accessibility of bus stop. It is directly related to the land use of an area. For example, commercial and business area will produce more trips than any other zones. However, in order to attain the accessibility, trip generation by

public bus is to be calculated for each bus stop. Therefore, coverage area of each bus stop is used to attain the trip generation of public bus stops. So in order to obtain accessibility more accurately, trip generation is considered.

2.2.7. Optimal Locations of Bus Stops

In this current study, optimal locations for bus stops are denoted those locations where passengers can get highest accessibility compared to other adjacent locations. There are two important factors which were to be considered to identify optimal locations for bus stop in that bus stop coverage area.

2.2.7.1. Bus Stop Accessibility

Optimal locations of bus stops are identified based on accessibility index which is measured based on three criteria: Road Density, Population Served and Trip Generation. The measured accessibility of total bus stop was classified into four categories: Excellent, Good, Moderate and Poor. These four categorization is taken place in comparative basis for these three parameters. For instance, the ideal bus stops are considered which have maximum accessibility index (i.e. the stop which ensures maximum road density, served maximum population and ensure maximum trip generation). Therefore, excellent and good categorized stops are marked as those stops which provide comparatively best accessibility to the users and poor stops are those which provide least accessibility and required relocation. Therefore those categorized as excellent or even good have highest accessibility indicating an optimal location of bus stops.

2.2.7.2. Stop Location and Spacing

Another important factor which considered to determine optimal locations is bus stop spacing which has a major impact on transit vehicle and system performance. The operational effect of bus-stop spacing has been a critical issue Li et al. (2011), Moreover, closely spaced bus stops disrupt the traffic flow on the bus route, particularly during peak hours because buses make frequent stops to provide services to customers.

Closely spaced bus stops provide short distances for passenger access (Wirasinghe, 1981) but increase trip times Van Nes and Bovy (2000) and Large bus stop spacing minimizes passenger in-vehicle time but reduces the accessibility of the system. Stop spacing has been studied in terms of minimizing transit user's time, and evaluating trade-offs between access and in-vehicle time Li et al. (2011). However, the standard for bus stop spacing varies from country to country. Different transport authority uses different standard stop spacing in urban areas and rural area according to the demand. According to Ammon (2001) studied, bus stop spacing standards for a number of agencies and found that stop spacing typical ranges from 656 - 1968 feet (200-600 meters) in urban areas. European transit agencies have different standards for bus stop spacing, for each mile of distance there are at least 3 to 4 bus stops (2 to 3 stops per kilometer), but in United States where stops are placed so that each mile contains at least from 7 to 10 stops (4 to 6 stops per kilometer) Reilly (1997) cited by Muhammad et al. (2013).

Anthony (2001) built a model for Determining Optimum Bus-Stop Spacing in Urban Areas cited by Li et al. (2011). His proposed model was derived from the fundamental relationships that exist among velocity, uniform acceleration and deceleration, displacement, and among the average bus operating speed, headway, required fleet size, and potential system capacity.

Optimal location of bus stops identification is clearly studied in Muhammad et al. (2013). So, there are two concepts to specify bus stop spacing. Close stop spacing will provide denser bus stops which will facilitate short walking distance and hence will increase accessibility. But it will increase travel time considerably.

Van Nes and Bovy (2000) introduced a set of formulas for optimizations when designing new bus routes. Their conclusion is based on measuring costs of various bus stop spacing policies on both passengers and agencies. They compared their estimates of optimum stop spacing to average stop spacing which range between 9,144 to 13,716 feet (300 to 450 meters) and recommended an increase in spacing from 15,240 to 24,384 feet (500 to 800 meters). An average distance of 800 meter will be suitable for spacing distance between two bus stops within 400 meter is a reasonable & comfortable walking distance; any passenger located within the spacing distance of 800 meter can easily reach any of the two bus stops. Therefore, an average distance of 800 meter is considered for bus stop spacing within 4oom reasonable & comfortable walking distance in densely populated areas of Addis Ababa city. In this study, the model concept of bus stop spacing will be used to locate optimum bus stops for the goal of minimizing user cost. Four mitigation measures will be used to improve the accessibility of existing bus stops and determine optimum bus stop such as stops kept as it is if the bus stop provided high accessibility and keep standard stop spacing, creating new stops where there is no existing bus stop along with long distance between stop more than 800m, relocate where the existing bus stops nearest to optimal locations they will be relocated and other option is dissolving which is done when the bus stop is situated un confortable area and very closed to other stops.

2.2.8. Problems Associated with Present Bus Service

Bus is the only mode of mass public transit available in Addis Ababa City. However, according to Olsson and Thynell (2004).the service is in unsatisfactory condition due to lack of proper maintenance, planning and management, and uncontrolled development. Some problems that are faced by the bus riders are presented in the below.

2.2.8.1. Overcrowded Buses

Overcrowded buses and traffic are a common sight in Addis Ababa city. The passengers loses forces to hang out the door frames in the most extreme conditions. Among all the public buses, local buses almost always get crowded, and it is due to their passenger collection method. Overcrowded bus is one of the main drawbacks in providing an effective bus service. It impedes certain types of passenger, specially woman and elder people to use public buses. The buses can travel on the road in greater than or equal to 7m width. But these roads at the morning time and after noon (10 to 12hrs) are crowed by individual motorized services in Yeka sub city. In this case one side of the road is crowed but opposite side is almost free. This indicates are the over flow of motorized population at morning and afternoon are almost in the same direction. Often the bus is so crowded that it becomes impossible for elder people or women or children to get a seat or even a space inside the bus. Generally, the standing passengers congregate around the door of the bus for which extra delay can happen during the stop, because passengers need to push through large groups of people to alight and board. So, the overcrowded bus routes are the main case in Addis Ababa city. Consequently, these groups of vulnerable people do not have access to bus service during rush hours Karim and Mannan (2008).

Overcrowd mainly happens when insufficient buses cannot meet the demand. So, adequate buses to be added with the existing service according to the demand. Faulty boarding and alighting system should be rearranged to more disciplined way. Number of seats reserved for women should be increased and maintained to increase accessibility for women.

Figure.2.4: Overcrowded buses:

2.2.8.2. Problematic Boarding and Alighting Facilities

The bus delay occurs at bus stoppages due to the way of boarding and alighting of passengers. It is mainly due to the overcrowding conditions inside the bus. Besides, higher vertical steps of the buses, higher deck to pavement height, inefficient width of doors of buses, etc. together increase boarding and alighting time Hasnine (2011). Most of the buses have only one door and mainly large buses have two doors. In most cases, the second door is not used for the boarding and alighting of passengers due to presence of one conductor to check the ticket in the front door. Moreover, the doors are narrow compared with the width of doors of standard buses used in developed countries. As simultaneous boarding and alighting is not possible through single narrow door, it however increases the delay at bus stoppages.

Figure.2.5: Problematic boarding and alighting into bus

2.2.8.3. People with Disability

To be truly accessible, public transport must be safe, reliable, and affordable for those who need to use that transport. Accessible public vehicle has no value unless associate infrastructures (footpath, bus stop etc.) are accessible Abir and Hoque (2011). Peoples with disability need special provisions in transport system to travel easily from one place to another in safely and comfort. Peoples with disability can find some facilities like reservation of seat and grab rail.

Therefore, necessary measures should be taken while designing bus stops to facilitate disables in order to board to and alight from buses comfortably and easily. For an example, the use of low floor buses can improve the accessibility for passengers with disabilities, including wheelchair users (Figure 2.6) :Source (Hoque and Abir, 2011).

Figure.2.6: Peoples With Disability

2.2.8.4. Fare Affordability

Dagnachew (2007) indicate that 20 per cent of the population of Addis Ababa is still too poor to afford the standard bus fare (In contrast, the stakeholders believe that the fare of Anbessa city bus is affordable to the lower and middle-income group of the users that allows them to transit long distances between two corners of the city and neighboring towns.

Figure.2.7: Fare Affordability

According to Muhammad et al., (2013) the problems associated with in bus services in chart are shown in Figure, 2.9 below

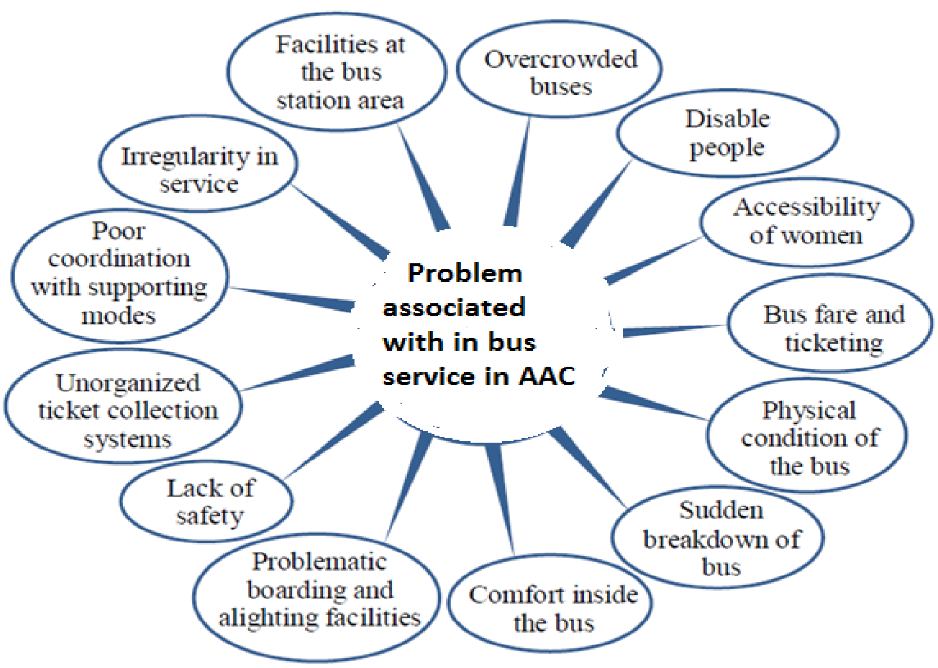


Figure.2.8: Problems associated with present bus service in city (Muhammad et al., 2013).

2.3. CONCEPTUAL FRAMEWORK

There are two main objectives and constraints in this current study that could be optimize the accessibility of bus stops. The first one was evaluating the existing bus stop accessibility and the next one is to locate optimal locations for bus stops based on three criteria: Road Density, Population Served and Trip Generation Muhammad et al. (2013). According to many researchers Li et al. (2011), Van Nes and Bovy (2000) and Li et al. (2011) which asserted that the standard bus stop spacing of 800meter within 400 meter universally accepted walking distance had been a critical issue in the current study to determine optimal location of bus stop and optimized its accessibility in terms of minimizing passengers user time and cost. Foda and Osman (2010) conducted a study in India to estimate stop access coverage using a circular buffer analysis with a radius of the access threshold around the transit stop in order to identify its coverage area. In the current study, the network analysis tools was used to determine kernel density service area analysis (actual access coverage area of bus stop) because of ASAI more accurate to estimates the actual pedestrian road network density, trip generation and population served within the access threshold from a bus stop, and identify all links in the pedestrian network around bus stop that can be reached by walking along the network for less than the specified maximum walking distance

In addition to this four mitigation possible options were used to identify the accessibility of existing bus stops and determined optimal bus stop such as stops kept as it is if the existing bus stops provided high accessibility and kept standard stop spacing, creating new stops where there is no existing bus stop along with long distance between stop more than 800m, relocate where the existing bus stops nearest to optimal locations they were relocated and other option is dissolving which is done when the bus stop was situated unconfortable area and very closed to other stops.

A clear understanding of the tool used in a study is essential for properly interpreting, analyzing and generation of new information on any subject or problem (Uddin, Amin and Rahman, 2004) asserted by (Muhammad et al., 2013). The current study involves the use of GIS software for analysis of bus stop accessibility and determined optimal locations. GIS allows mapping, modeling, querying, analyzing and displaying large quantities of such diverse data, all held together within a single database.

It is difficult to define GIS because there are many different ways of defining and classifying objects and subjects. Given the diversity of the field, many different methods had been applied to GIS. According to DoE (1987) and Parker (1988) reported by (Muhammad et al., 2013) "A system for capturing, storing, checking, manipulating, analyzing and displaying both spatial and non-spatial data which are spatially referenced to the Earth". In relation to public transport, researchers have used GIS technology to measure accessibility of public transport, creating public transport routes, identifying optimum route, optimizing bus stops and spatial analysis of service area, measuring spatial equity and public transport management (Demelash Abate Abreha, 2007).

Therefore, in the current study all the spatial data were analyzed, processed and mapped using ArcGIS software. In ArcGIS Software, Geo processing tools and Network Analyst Extension tools had been used for data inputting, analyzing, processing and mapping in order to obtain the result.

ArcGIS Network Analyst provides network-based spatial analysis, such as routing, travel directions, service area, and location-allocation using existing road network shape file data. The geometrically corrected network dataset build, the edge–node topology was incorporated into the road network dataset to remove Geometric errors through topological rule, define service areas based on travel time or distance and determine optimal locations for accessibility by performing a location-allocation analysis.

CHAPTER THREE
METHODOLOGY

3.1. Study Area Description

Addis Ababa lies at an altitude of over 2,300 meters above sea level and is located at 9°1'48"N and 38°44'24"E coordinates. The city has a population size of more than 3.8 million with 3.8% annual growth rate (Berhan. 2013). Addis Ababa City is one of the nine autonomous regions in the Ethiopian federal system, located in the heart of Oromia region (UN-HABITAT, 2011) as Kenea (2017) reported. Addis Ababa City was separated in 10 sub-cities such as Addis ketema, Akaki, Arada, Bole, Gulele, Kirkos, Kolfe, Lideta, Nifas silk & Yeka. To select study areas from these 10 sub cities two criterias was used. The first was officially interviewed ACBSE managers, in Yeka Sub City the traffic flow was very crowded. Second selection criteria was reclassifying of population density, bus route and bus stops with in three classes of low, medium and high within equal interval method and perform weighted overlay analysis, Yeka Sub City was located in high ranks on three data of population density, bus route and bus stops. Based on the two criterias, Yeka Sub-City was selected for this study.Yeka Sub-City is located in the north east part of Addis Ababa City. The total area of the sub-city is 85.98km square and 4,284.9 people live in one kilometer square. Moreover, its entire population of the area is 368,418 people. Yeka Sub City has 13 woredas.

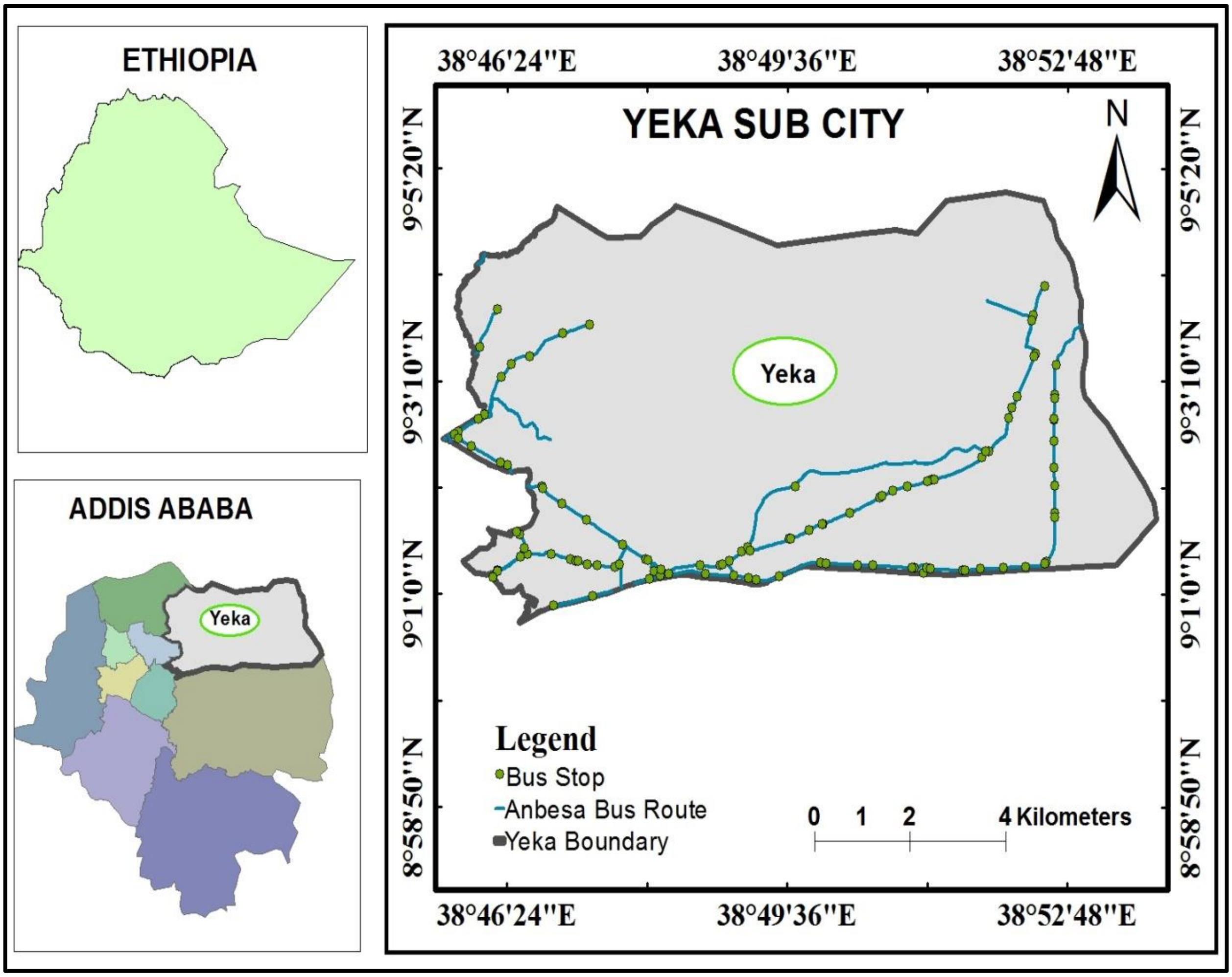


Figure.3.1. Location of Study Area

3.2. Data Source and Collection Techniques

3.2.1. Primary Data, Its Source and Collection Techniques

In the primary data collected method, two type of data collection tools, oral interview and observation checklist were used and see annex-D. The primary data were collected through interviews of officials of Anbessa City Bus Service Enterprise (ACBSE), Ticket Daily Service Officers, and including passengers, those expected to have high relevance to the problem of city bus accessibility (Table 3.1). These interviews were conducted thoroughly related to bus scheduling and frequency that provide access to the users, the passenger's time taken during waiting the bus and house hold incomes. Moreover, direct observation was conducted on the existing bus stops to count the bus trips on observed time and number of passengers on a certain bus was shown in annex-D.

Table.3.1: Primary data and Source

Primary Data	Source	Data Collection Techniques	Purpose
time interval, bus frequency	field	direct observation	For public affordability & income groups
Bus scheduling, No of passengers by bus, Number of buses & total daily trips by a certain bus on bus stops.	ACBSE & ticket lagoons	Through interview & direct observation	To know bus service access frequency, No of populations served by bus.

3.2.2. Secondary Data, Its Source and Collection Techniques

The secondary data required were Road Network of Addis Ababa City and Existing Land Use map, bus routes, location of bus stops, population data, and parcel data. These Secondary data were collected from different sources such as Addis Ababa City Road Authority, Addis Ababa City Transport Authority, Ethiopian Geo-spatial Agency, Anbesa City Bus Service Enterprise and Addis Ababa City Central Statistical Agency, using appropriate formal letters. Road Network of Addis Ababa City and Existing Land Use map was extracted from DAP (Detailed Area Plan) or line map by using select by attribute tools of ArcGIS software and export it, a soft copy of which could be collected from ACRA. Bus routes were collected from Addis Ababa City Road Authority (ACRA).Locations of bus stops are collected from (ACBSE). The population data of Yeka Sub City was collected from Central Statistical Agency of Addis Ababa City (CSAAC) These collected data, source and purpose was shown in the (Table 3.2).

Table.3. 2: Secondary Data and Source

Data	Scale	Source	Data collection techniques	Purpose
Boundary map of study area	1:50000	EGA of AA	Through formal letter	To determine the location of the study area
Existing Land Use map	1:50000	EGA or ALA	Through formal letter	To identify the condition of trip generation area.
Road network	DAP map or	ACRA	Through formal letter	To extract pedestrian road network and determine road density to

	line map			identify availability of road connections
Bus routes	shape file	ACRA	Through formal letter	To analyze & identify bus stop accessibility on bus routes in the study area
Locations of bus stops	shape file	(ACBSE)	Through formal letter	To fix service area around bus stops & identify the bus stop accessibility Index values.
Population data	2017	(CSAAC)	Through formal letter	To know population demand in surrounding bus stop access coverage area
Parcel data	AutoCAD	ALA	Through formal letter	To know the assumptions (average) number of Household living in each parcel by dividing total population by No of parcels.

3.3. Materials Used

3.3.1. Softwares Used

A clear understanding of the tool used in a study was essential for properly interpreting, analyzing and generation of new information on any subject or problem (Uddin et al. 2004) asserted by Muhammad et al. (2013). GIS allows modeling, querying, analyzing and mapping large quantities of such diverse data for better understanding transport process, all held together within a single database. In relation to public transport, researchers have used GIS technology to measure accessibility of public transport, creating public transport routes, identifying optimum route, optimizing bus stops and spatial analysis of service area, measuring spatial equity and public transport management (Demelash 2007). The study involves GIS software that are used to process the data. Therefore, in this current study, all the spatial data were analyzed, processed and mapped through Arc GIS. In ArcGIS Software, Geo processing tools and Network Analyst Extension tools have been used for data inputting, analyzing, processing and mapping in order to obtain the result. ArcGIS Network Analyst provides network-based spatial analysis, such as routing, travel directions, service area, and location-allocation.

3.4. Data Processing Techniques

In this section, the data were processed to prepare easily and to analyze the three parameters (road density, trip generation and population served). The AutoCAD data of parcels data land use map would be converted into ESRI shape file then converted into point feature and export these data into ArcGIS 10.3 for analysis using Geo-processing tools of ArcGIS 10.3.

Bus stop access coverage within a specified access threshold of 400m radius would be estimated in both directions using Network Analyst Extension. The pedestrian road network, bus route and bus stops are extracted using select by attribute and prepare their shape file. The Road Network could be split and identify road direction (F-T and T-F). Road Network Topology and Network Analysis would be used in order to build geometrically corrected network dataset, the edge–node topology was incorporated into the road network dataset and geometric errors were removed through topological rules. Then service coverage area (km^2) and sum of road length (km) within service area were determined. Each shape files of obtained data in different units could be converted into the same unit (in number) using manually determined in order to convert to raster files.

Table.3. 3: Data processing in the current study

Data	Processing	Purpose
Land use map	AutoCAD data of land use converted into ESRI shape file and exported into ArcGIS 10.3 Conversion to raster & reclassified	To identify trip generation & coverage area of bus stop conditions
Road network	Extracted pedestrian road network using “select by attribute”	For prepare road connection within bus stop access coverage, actual pedestrian road network, and actual pedestrian road length.
Parcel data	AutoCAD data of parcel converted into ESRI shape file, exported into ArcGIS 10.3, and converted into point feature. Then extracted parcel map of study area was clipped using clipping tools.	To determine the number of household in each parcel who were accessed by bus

3.5. Data Analysis Techniques

In the current study, there are two parts of the analysis are applied based on the objectives of the study. Firstly, the Accessibility of existing bus stops was evaluate and then using the result, the next step optimum locations of bus stops are determined using ArcGIS software.

The three criteria: Road density, Trip generation and Population served shape file data could be converted into the same unit (in number) using manually determined in order to convert raster files.

The three parameters of road density, trip generation and population served are calculated using field Calculator' in ArcGIS software. Road Density was derived by dividing total length of actual pedestrian road length by bus stop access coverage (km/km^2) as Foda and Ahmed (2010) and Muhammad et al. (2013) reported. Population served in bus stop service area = (Total number of population in Yeka Sub City / total number of parcels in Yeka Sub City) *Number of parcels in bus stop coverage area Muhammad et al., (2013).

Next, to obtained accessibility data, each parameter was reclassified into a specific scale (8 is considered for the current study) using geospatial tool 'Reclassify' tools of ArcGIS.

Accessibility Index was calculated by adding up of reclassified data of three parameters and was done by another geospatial tool 'Raster Calculator' of ArcGIS. Reclassify these raster data into 8 categories based on the evaluated accessibility index for displaying in the map and further classified into 4 categories for understanding the accessibility condition. The spatial accessibility i.e. walking distance and walking time (travel-distance) were considered in this study for assessing bus stop accessibility. For optimal location of bus stops generated nodes on bus routes an average distance of 800 meters was considerd for bus stop spacing within 4oom reasonable & comfortable universally accepted Threshold walking distance in densely populated areas any passenger can easily reach any of the two bus stops. Four mitigation possible option of (as it is, creating new stop, relocating and dissolvation) were applied to locate optimum stops based on accessibility value and stop spacing.

The Jaccard similarity index (Jaccard similarity coefficient) was used to compared similarity percentage between two sets (the existing bus stop and validated bus stop accessibility values) to see which members are shared and which are distinct using manually calculated in Microsoft excel 2010. The Jaccard similarity index formulas: Jaccard similarity Index = (The number in both sets)/(the number in either sets) *100. It measured the similarity for the two sets of data, with a range from 0% to 100%, the higher the percentage the more similar the two sets of data.

3.6. Validation Method

To apply validation of the current study, the primary data of trip generated by bus on selected bus stop, Number of buses and frequency could be collected for selected bus stops from passengers and ticket lagoon by interview and direct observations to identify the accessibility index value (annex-D). The validation of existing bus stop accessibility was taken on the days which have high traffic flows. These selected days that have high traffic flows at the working time were the working day. Because of these working days had high populations flow from home to working place. However, it has different working days, in this section; Monday and Tuesday were selected for the validation of existing bus stop accessibility because of having high population flows. On the day of Monday all outbound direction bus stops could be validated at the same observation time and on Tuesday all the inbound direction bus stops could be observed at the same observation time with the outbound. The validation of existing bus stop accessibility was identified for each selected validated bus stops depend on the observation time period chosen. The bus service frequency data and high frequency of population flow were selected from the morning peak period between 8:00 to 9:30 and after noon from 4:00 to 5:30 in both validation of inbound and outbound direction of bus stops.

The duration of observed time used for both direction bus stops was 1.5 hrs. From the result of existing bus stop accessibility index, 25 bus stops out of 120 for F-T (outbound road direction) and 26 out of 112 for T-F (inbound road direction) bus stops were taken used to validate existing accessibility values. Finally, the Accessibility Index was calculated for each validated bus stop from raster data of road density, trip generation by bus & population served within coverage area. Therefore, the validation accessibility value of selected bus stop could be much close to the existing bus stop accessibility values which indicated that the determination of existing bus stop accessibility would be satisfied.

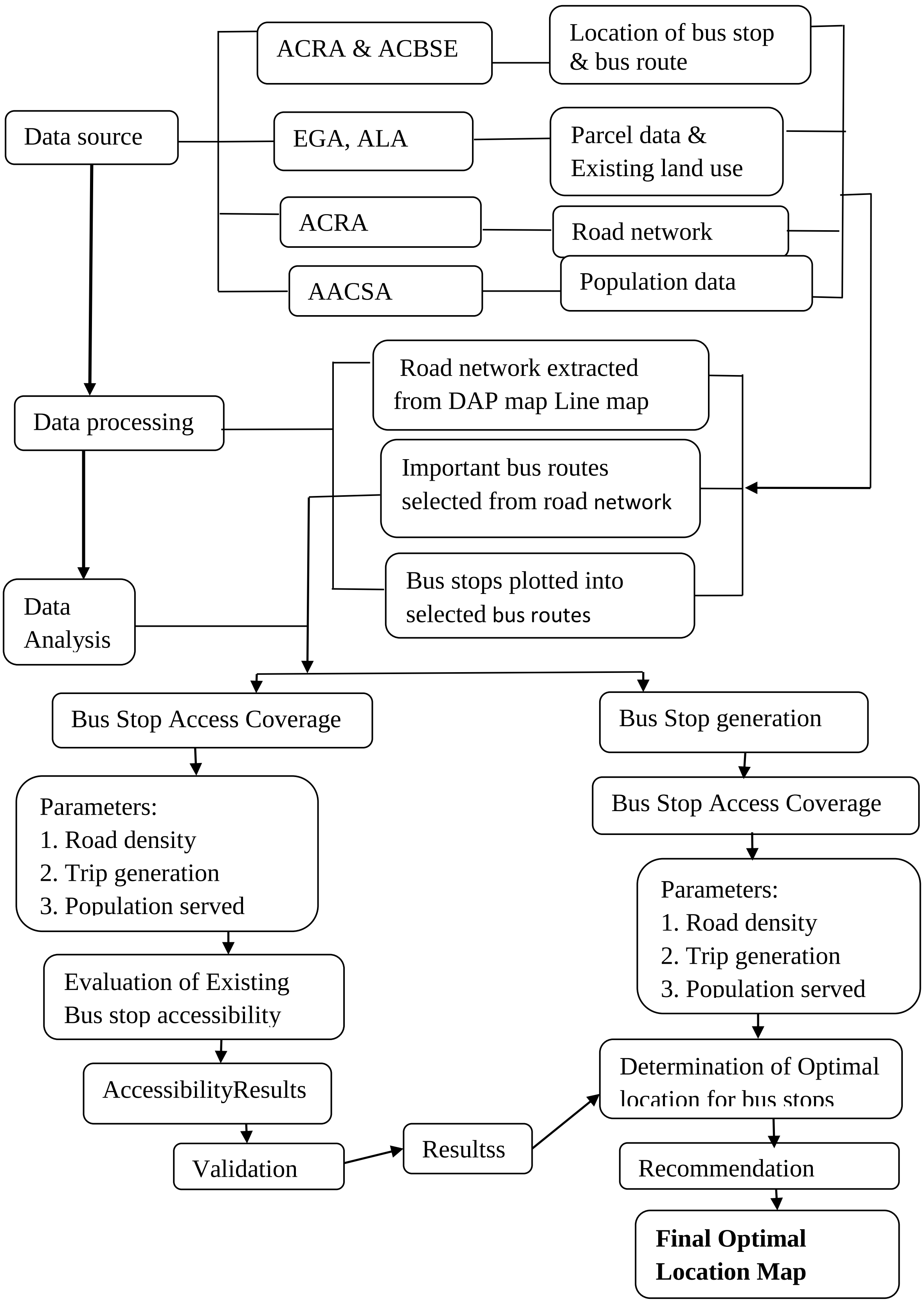


Figure.3. 2: Flow chart of the methodology of the study

3.7. Data Preparation

The data preparation is an important and first step to analyze bus stop accessibility. The data of road network, population, parcel, trip generation by bus and bus stops were obtained from Addis Ababa City Road Authority, Central Statistical Agency of Addis Ababa City and Anbesa City Bus Service Enterprise.

For ease of analysis, all bus stops and bus routes were categorized into two types based on traffic flow directions: Bus Stop (Inbound Direction) and Bus Stop (Outbound Direction**.** Bus stops which are located on Anbesa Bus Routes for the traffic flow started from any origins to destinations that travelled from the direction of North to West (F-T) direction of bus route, these sides of bus stops were considered as Bus Stop T-F (Inbound Direction). Bus stops which are located on Anbesa Bus Routes for the traffic flow started from any origins to destinations that travelled from the direction of West to North (F-T direction) of bus route, these sides were considered as Bus Stop F-T (Outbound Direction). For these prepared bus stops, 112 bus stops located on inbound direction and 120 bus stops were located on outbound direction bus routes.

Geometric errors were removed through topological rules e.g. must not Intersect or Touch Interior, must Not Have Dangles etc. to build geometrically corrected network dataset, the edge–node topology was incorporated into the road network dataset using topology tools which is one of the tools in ArcGIS Software. The road network was split on intersection points. Then, the network dataset included length of each road segment, walk speed, F-node, T-node, F & T Minutes and One-way restriction attributes to depict real time road network linkage in the study area using ArcGIS analyst tool. The network-distance based service areas for each bus stop were calculated according to polygons encompassing any edge within a 400-meter distance from the bus stop, by a specific GIS application of network analyst tool (the so-called *service area solver*). After this service area preparation, the three parameters of road density, trip generation by bus and population served was prepared and detailed described below. The prepared parameters were stored in separate shape files through ArcGIS to evaluate bus stop accessibility seen below.

a) Road Density for Bus Stop (inbound & outbound direction)

b) Population Served within bus stop service area for Bus Stop (inbound & outbound direction)

c) Trip Generation by Public Bus for Bus Stop (inbound & outbound direction)

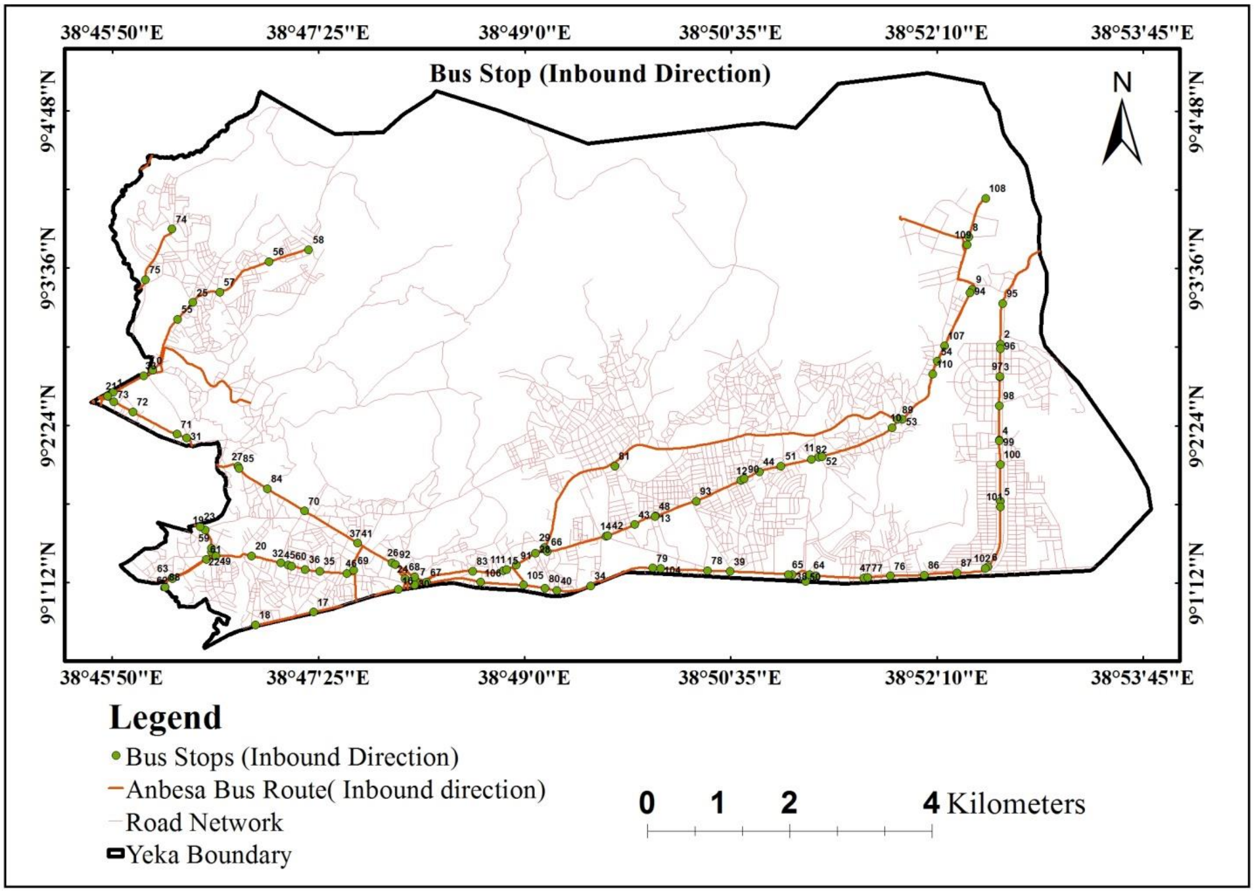


Figure.3. 3: Bus Stops T-F (inbound direction)

On the other hand, 120 bus stops were located on the outbound direction of bus routes which generated for buses moving from the direction of west to north direction which are an inverse of inbound direction, these bus stops were marked as Bus Stops F-T (outbound bus route direction) (Figure.3.4). Based on these bus stops, it prepared the data of three parameters such as road density, trip generation by bus and population served within bus stop coverage areas to evaluate the accessibility of existing bus stops in both directions.

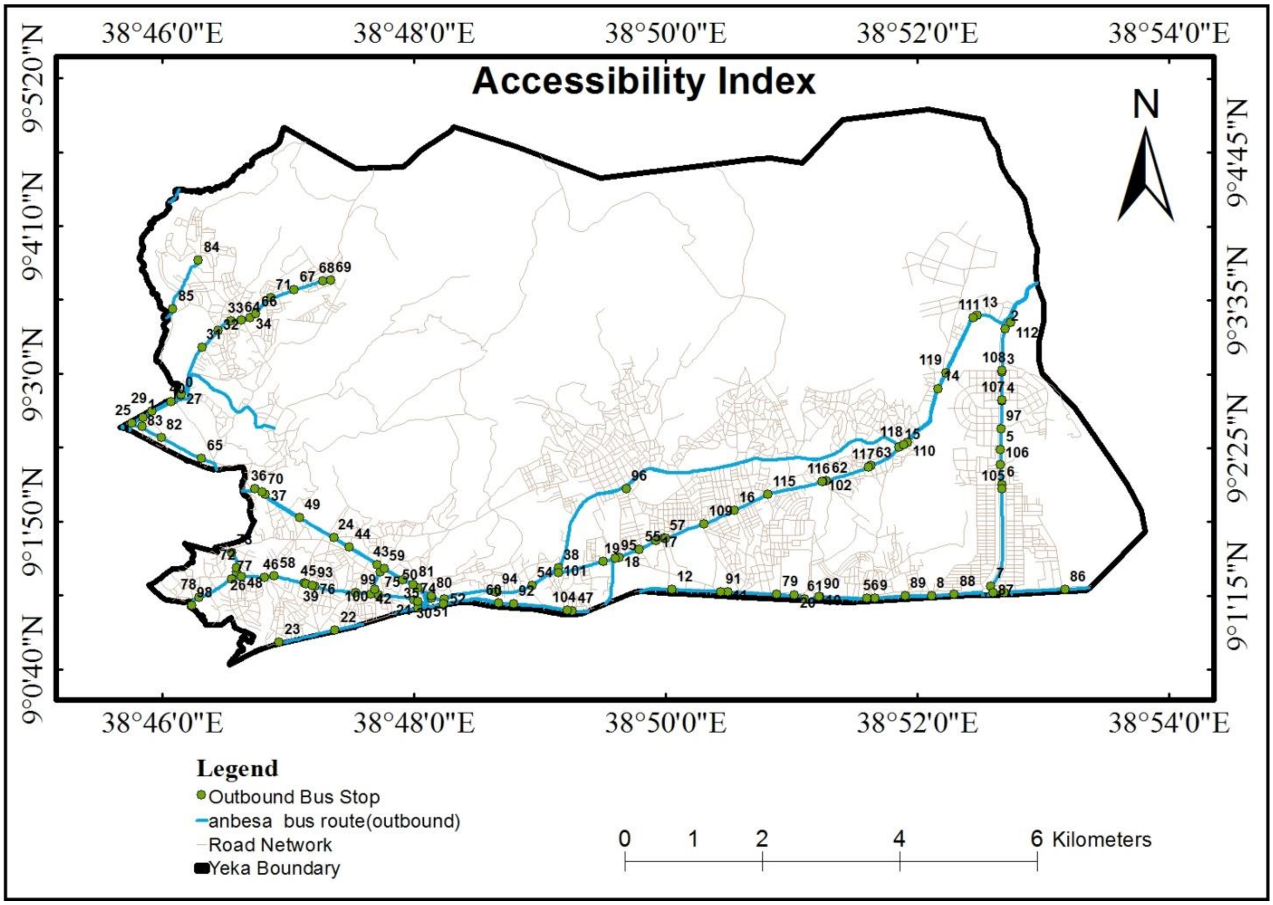


Figure.3. 4: Bus Stops F-T (Outbound direction)

3.7.1. Road Density

Density of pedestrian roads around bus stop is an important parameter to assess accessibility in the way that shows the amount of pedestrian roads which can be used to reach the bus stops. In order to determine road density using pedestrian road, the network analysis tool were used to develop bus stop service area around each bus stops at 400m threshold walking distance within 5minute impedance (i.e. walking time) (Levinson, 1992; Foda and Ahmed, 2010). To build geometrically corrected network dataset, the edge–node topology was incorporated into the road network dataset. Geometric errors were removed through topological rules e.g. must not Intersect or Touch Interior, must Not Have Dangles etc. The network dataset included length of each road segment, walk speed, F-node, T-node, F & T Minutes and One-way restriction attributes to depict real time road network linkage in the study area using ArcGIS analyst tool. The pedestrian road network was extracted by bus stop service area using clip tool, which is one geo-processing toolset in ArcGIS software. From these extracted road data, the attribute data of road density, the sum of road length in km and bus stop service area in square kilometer were calculated from extracted road clipped polyline feature field calculator option in the feature attribute. The road density was calculated by dividing the sum of pedestrian road length inside Kernel service area coverage by Kernel service area of that bus stop using field Calculator' in ArcGIS software. Total sum of road length that fallen inside the Kernel coverage area of each bus stop (within service area analysis) and service area of bus stop was calculated and taken from road statistical data in attribute table. Therefore Road Density was calculated from attribute table of road data using field Calculator in ArcGIS by using Equation 4.1:

Road Density = $\frac{\boldsymbol{L}\,(\boldsymbol{KM})}{\boldsymbol{A}(\mathbf{Km^2})}$ **---** Equation 4.1

Where: **L** is the sum of road length inside coverage of bus stop in km; A is coverage area of bus stop in $\mathrm{Km^2}$. The road density of 120 bus stops for F-T (Outbound) and 112 bus stops of T-F (Inbound direction) was prepared in the same way and presented the attribute results shown in Annex A1 and A2 respectively.

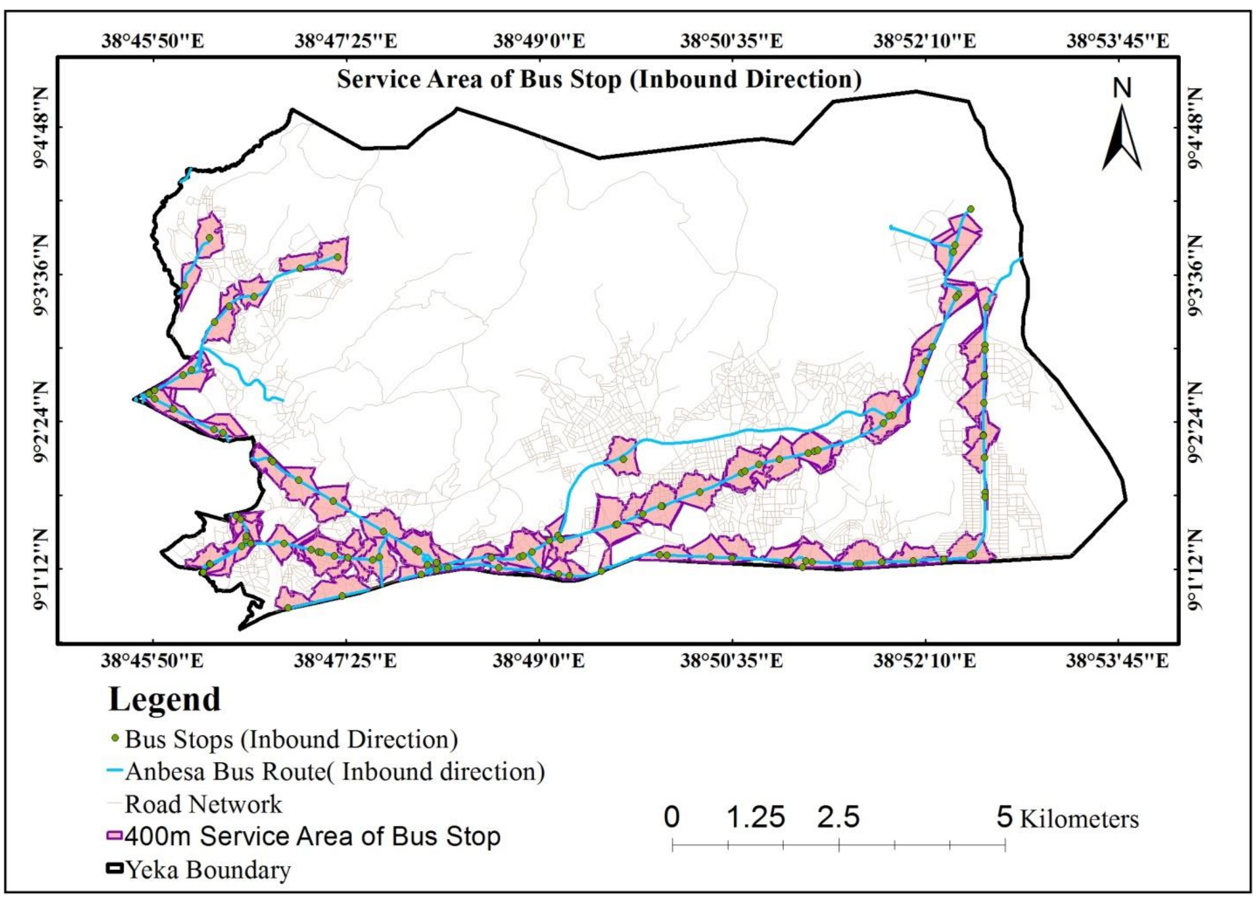


Figure.3. 5: Coverage area of Bus Stop T-F (Inbound direction)

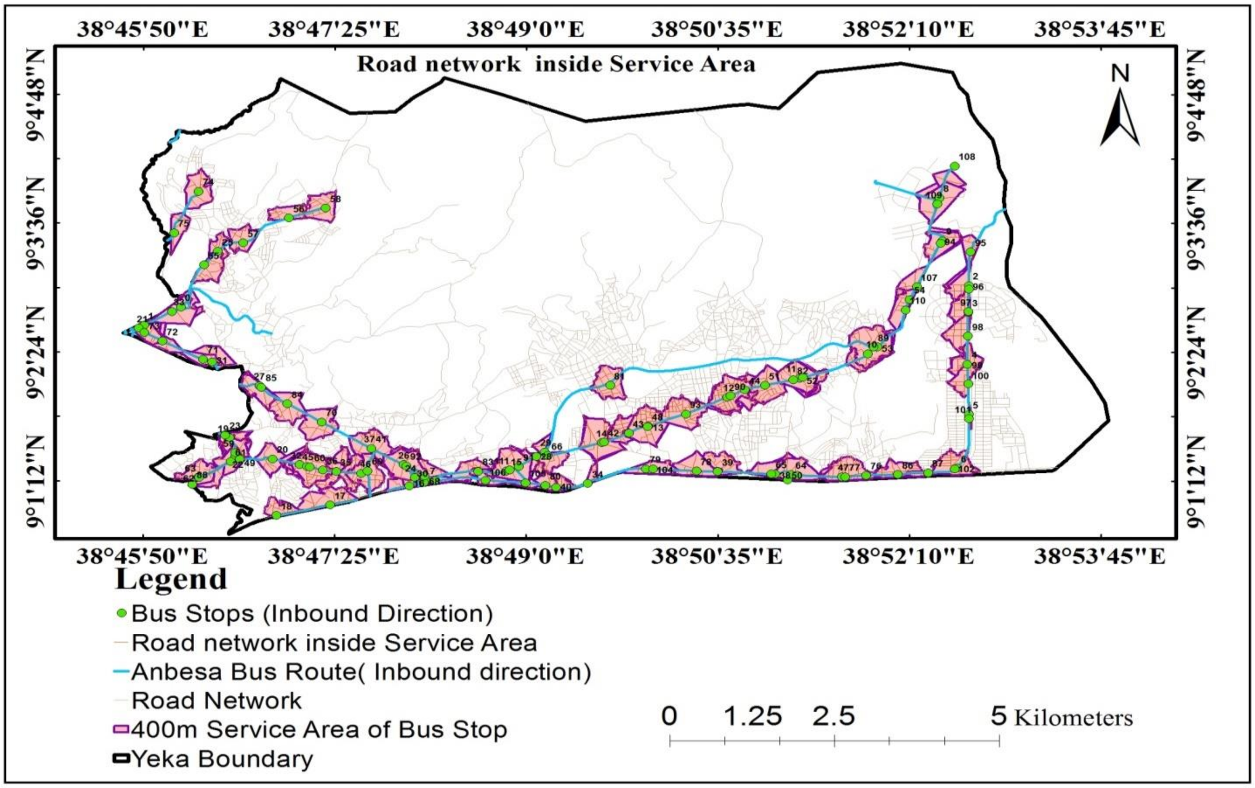


Figure.3. 6: Roads inside coverage area of bus stops T-F (Inbound direction)

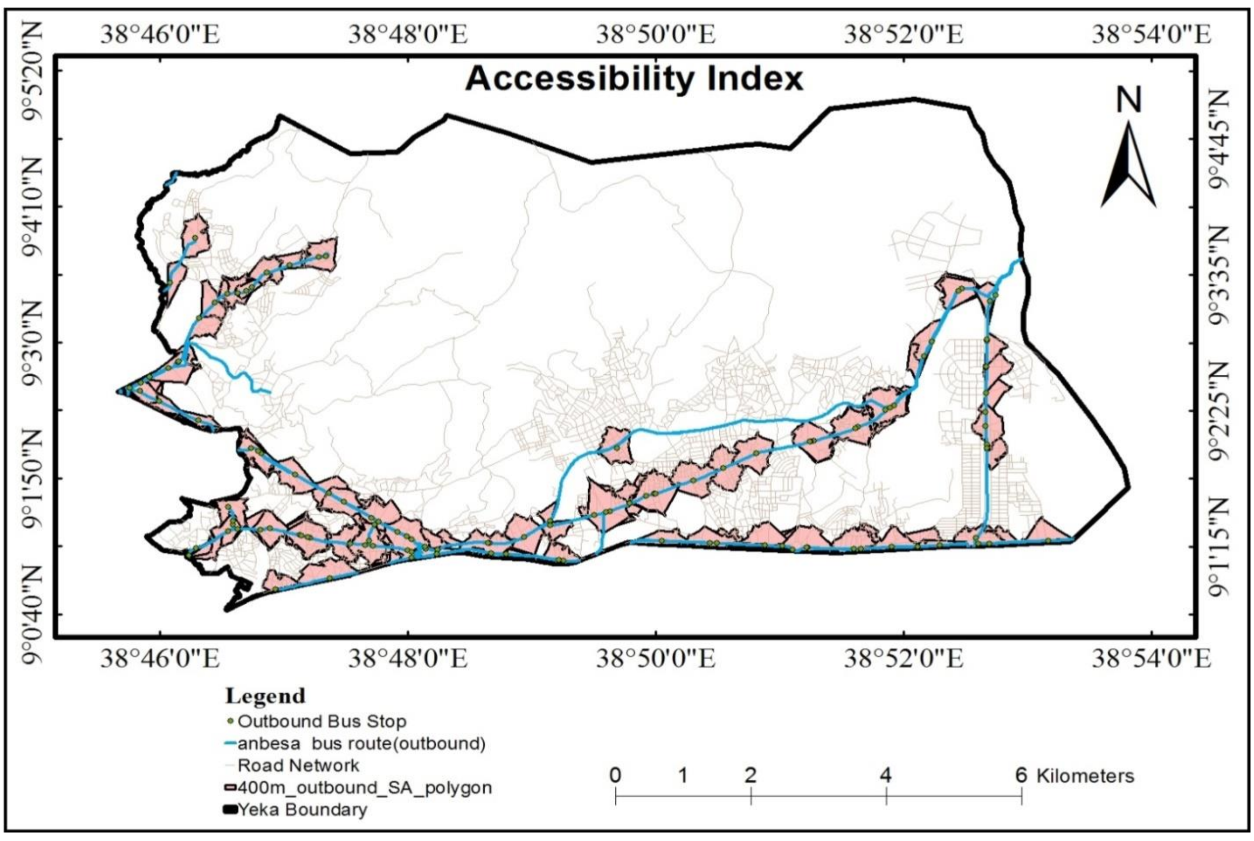


Figure.3. 7: Coverage area of Bus Stop F-T (Outbound direction)

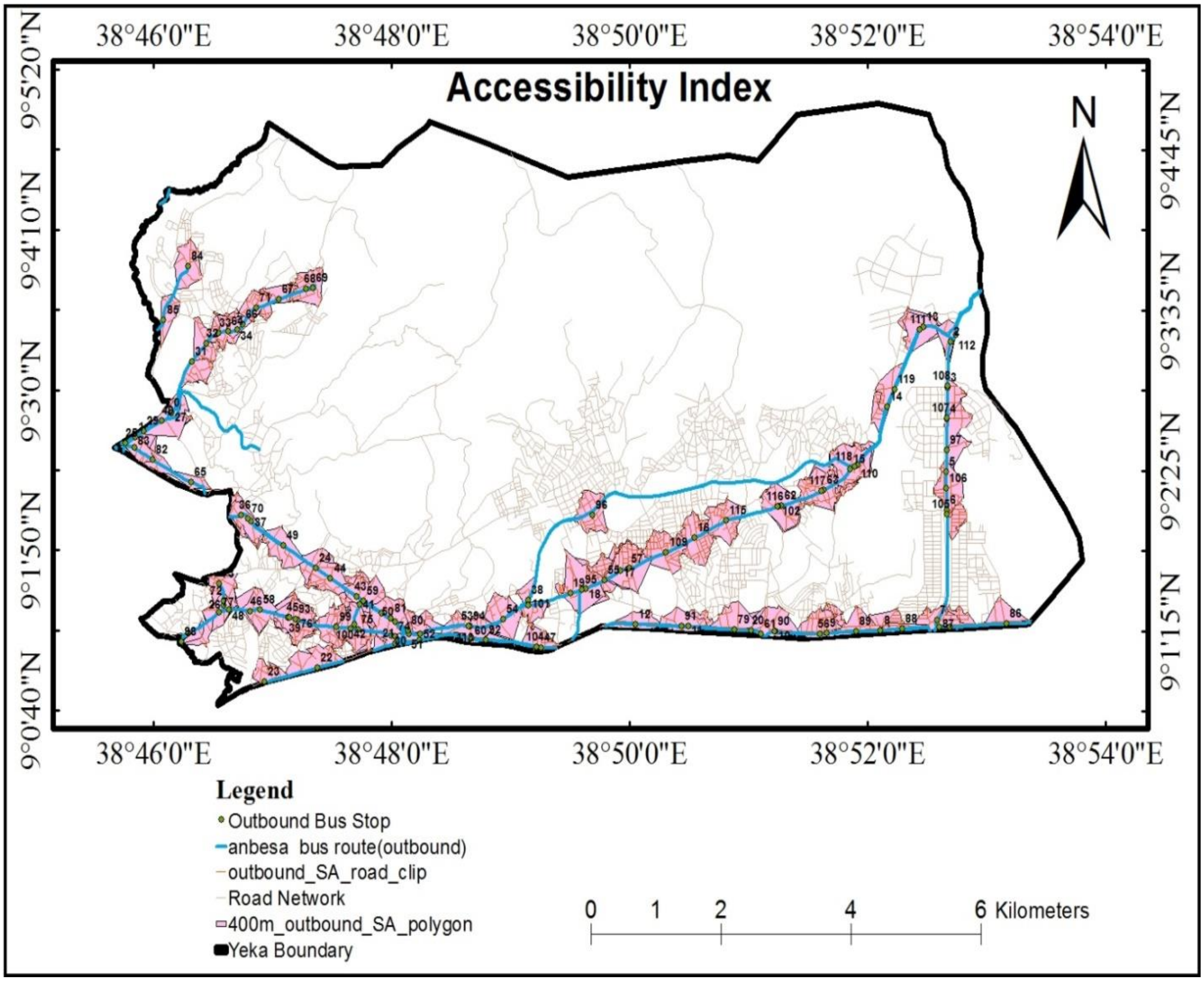


Figure.3. 8: Roads inside coverage area of bus stops F-T (outbound direction)

The results of road density of both directions of bus stops for example of inbound road data stop ID 5,7,32,89 and 101 (Annex A1) and for outbound stop ID 18, 51, 54, 59, 65 and 81 (Annex A2), which had high sum of road length which indicated that, the more road connectivity within small coverage area which provided the more road density which indicates the more connection of roads for surrounding bus stops, providing the more access to the users. Therefore, the stops having high road connections serve comparatively high number of people or the stops generates high number of trips by bus.

3.7.2. Trip Generation

The trip generation is the second parameter which affect accessibility of bus stops. Accordingly Md. Rezuanul Islam and Tanveer Rahman, (2014), land use condition analysis of primarily suitable location whether the identified area has the influence of economy, society and also demarcating the existing demand. Trip generation means that the sum of passengers per day who are served by any Anbesa Bus on one bus stop.

Anbesa Bus Service had four terminals, such as Megenagna, Addis Ketema, Legehar and Mexico from these terminals, megenagna was located in the current study area of Yeka Sub City. From the obtained data of Anbesa City Bus Enterprise (Annex E), the trip data was calculated manually. Bus Numbers of (2, 4, 5, 8, 10, 20, 23, 39, 43, 52, 57, 85, 96 and 137) were started from Megenagna. Other Anbesa Buses were started from Addis Ketema, Legehar and Mexico and served within Yeka Sub city. In general, about 124 Anbesa Buses are passing and serving in Yeka Sub City and therefore Anbessa public bus started from four originations and passed on yeka sub city at different destinations. So, in determination of trip generation in this current study was considered any Anbesa buses that originated from four terminals which served on bus stops within study area domain. More than one buses were passing on the same bus stops, the trip generation was the sum of travellers that accessed by these buses on one bus stops. Therefore to prepare the trip generation data, the following steps were used and the calculation was done manually.

The monthly trip generated by bus was converted to trip per day by divided the monthly trips by 30 days. The number of bus trips in one day was determined by dividing the number of passengers per day by number of bus trips. Trips per day = $\frac{\text{Number of trip per month}}{30 \text{ days}}$

Number of passengers on one bus stop who are served by a certain bus number = Trips per day/ No of bus stops. Therefore different buses are passing on the same bus stop, the total passengers by bus on each bus stop was calculated manually.

Trip generation by bus = Total sum of passengers per bus stop.

The sum of travellers that are served by different buses on the same bus stop. Therefore, trip generation on bus stops is the number of demands that were served by bus. The data of trip generation for both (inbound and outbound) directions bus stops were shown in Annex A3 and A4 respectively. The maximum of 1090 and minimum of 13 trip generations by bus was found for outbound direction. For outbound direction of bus stop the maximum of 1116 and minimum of 5 population was served by bus.

3.7.3. Population Served Both (Inbound and Outbound direction)

Another parameter was the population served within bus stop service area According to Muhammad et al. (2013), studied in Dhaka, asserted that only road density cannot ensure the accessibility of bus stops, the trip generation and population served also affected the accessibility of bus stops. Therefore, population served within bus stop service area was one parameter to evaluate accessibility. To prepare the population served by the bus stop within nearest service area coverage, an integrated of population density in Yeka Sub City, parcel map and service area of bus stop were used.

The total number of population was divided into number of parcels to assume that the number of households lived in each parcels. Network-distance based kernel service areas were calculated according to polygons encompassing any edge within a 400-meter distance from the bus stop, by a specific GIS application (the so-called *service area solver*) and clipped the parcels by these bus stops service area coverage. Then, number of clipped parcels within bus stop service area was counted from attribute table for each bus stop. Finally, statistically counted the number of populations in clipped parcels who were served within bus stop service area based on number of parcels which was clipped. Therefore, the population served in service area was calculated using field Calculator in ArcGIS by using Equation 4.2:

Population served = $\frac{\text{Total number of population}}{\text{total number of parcels}} * \text{N}\underline{\text{o}}$ of parcels ---------------------Equation 4.2.

So, the number of population served within bus stop service area at each bus stop was the sum of household who are living in parcels inside coverage area of the bus stop. From this formula both inbound and outbound direction of bus stop population served were computed in the same way and the data were shown in Annex A5 and A6 respectively. The parcel maps of both T-F (Inbound direction) and F-T (outbound direction) are shown in (Figure.3.9 and 3.10) respectively.

Population Served in T-F (Inbound Route Direction)

The detailed description about the formula how to determine the population served by bus within bus stop service area were described in above section 3.7.3. From the total population of 434,599, 122630 populations were counted within 61315 numbers of parcels inside coverage area of 112 bus stops on the inbound bus route direction.

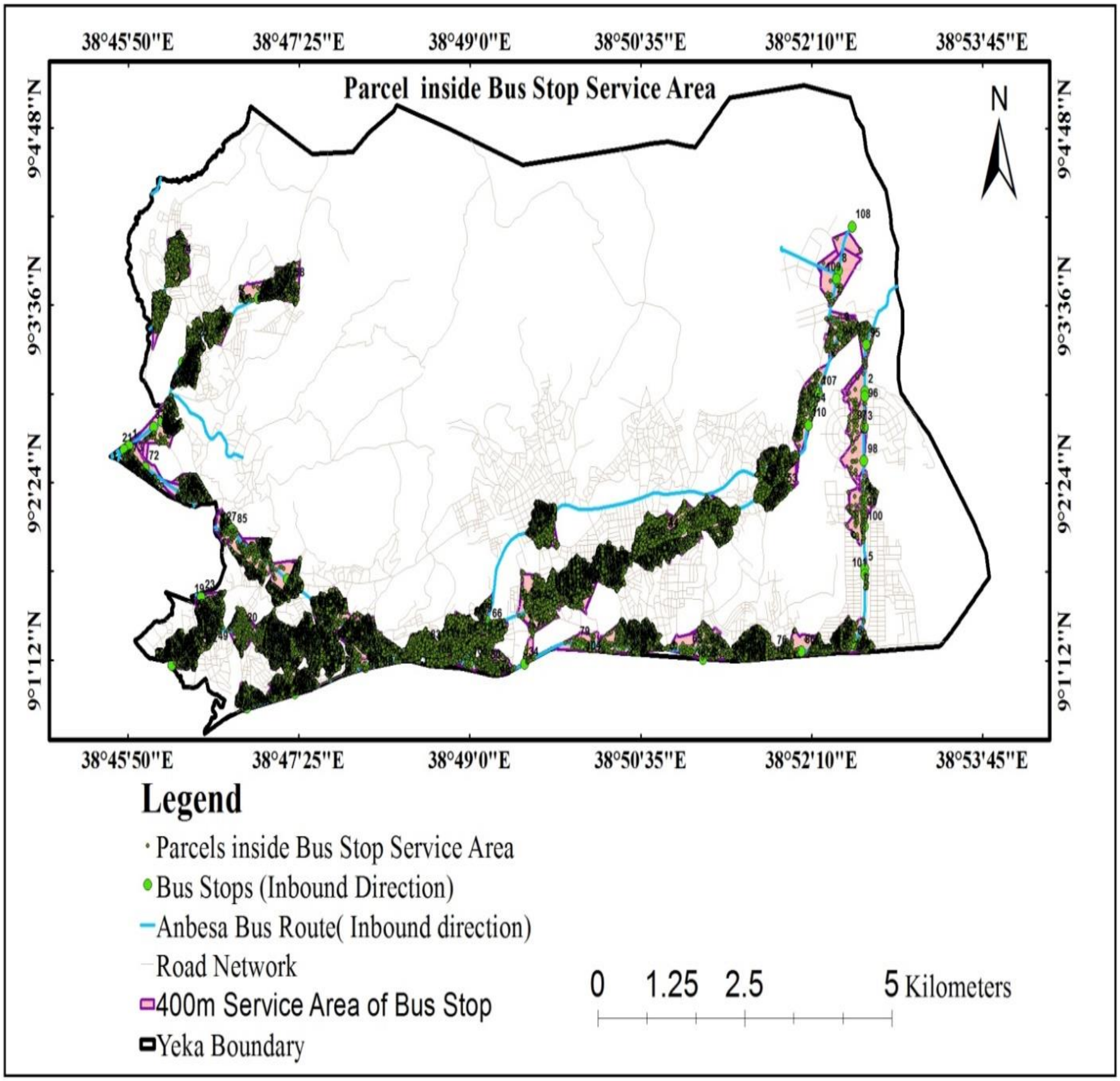


Figure.3. 9: Parcels inside coverage area of bus stops T-F (Inbound direction)

Population served in F-T (Outbound route direction)

From the total population of 434,599; 125076 populations were counted within 62538 numbers of parcels inside coverage area of 120 bus stops on the outbound bus route directions. From the outbound direction of bus stops population served data (AnnexA6), the maximum of 6116 and minimum of 46 populations were served and the graphical results of parcels are shown in (Figure 3.10).

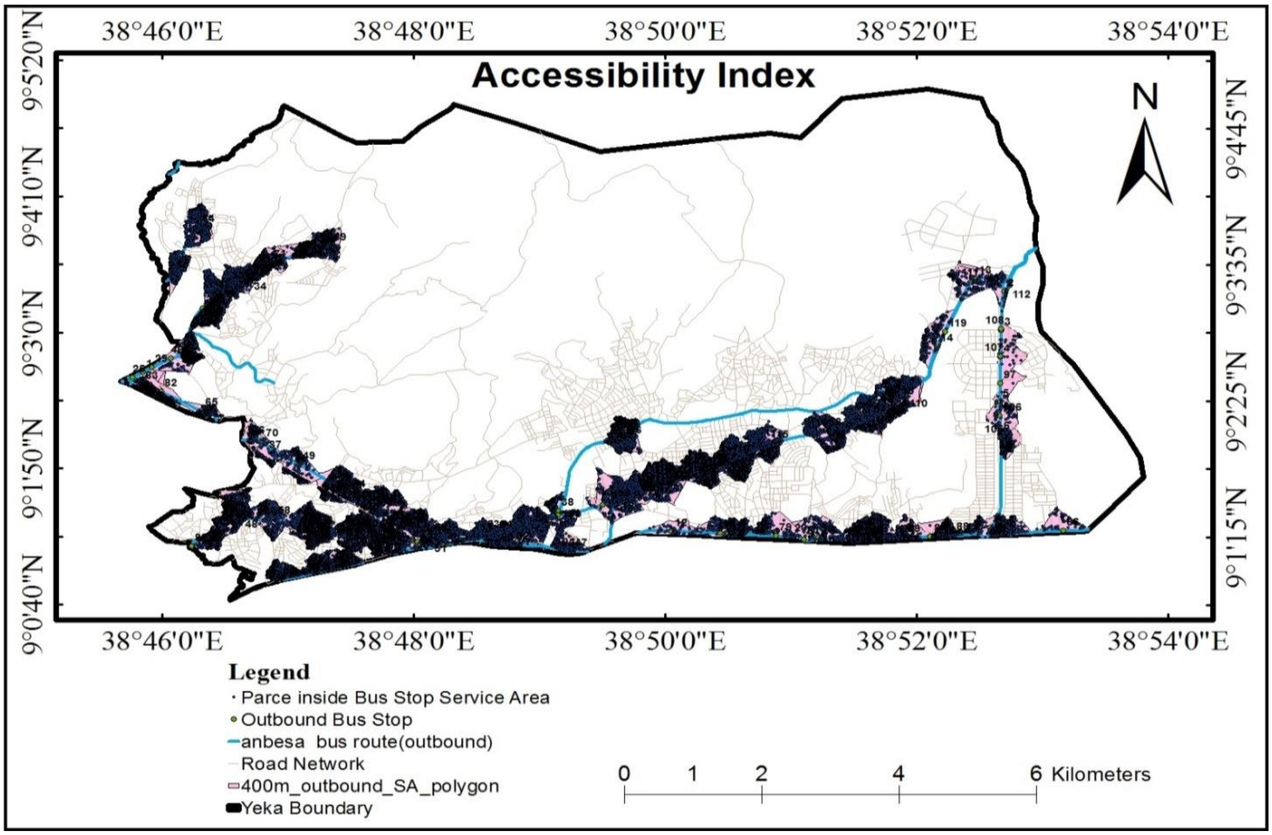


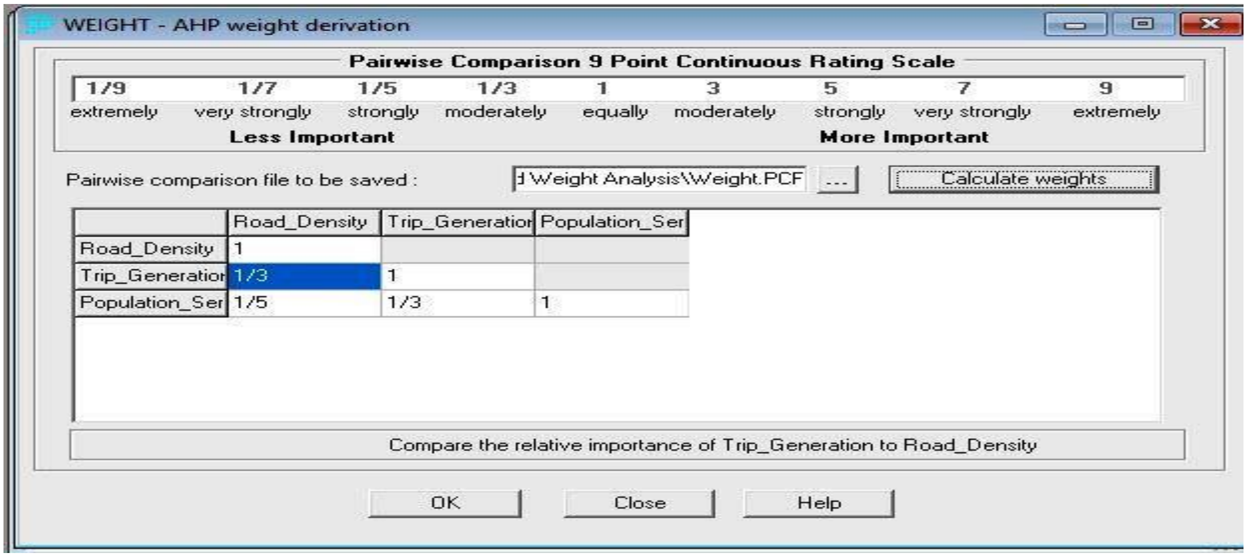
Figure.3. 10: Parcels inside coverage area of bus stops F-T (Outbound direction)

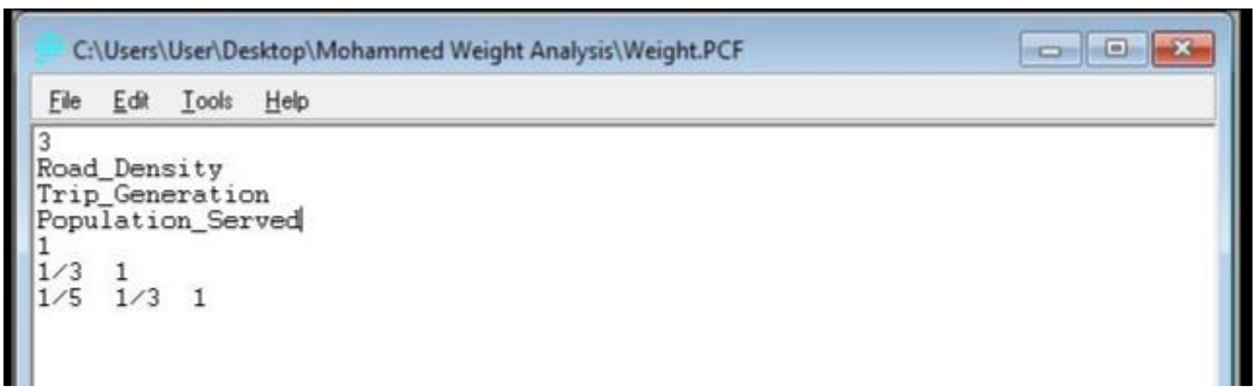
From the results above the attribute values (AnnexA5) for outbound direction of bus stop population served data, the maximum population served was 6324 and minimum of 6 peoples and for outbound direction (AnnexA6) maximum of 6116 and minimum of 46 populations were served which have very high variations.

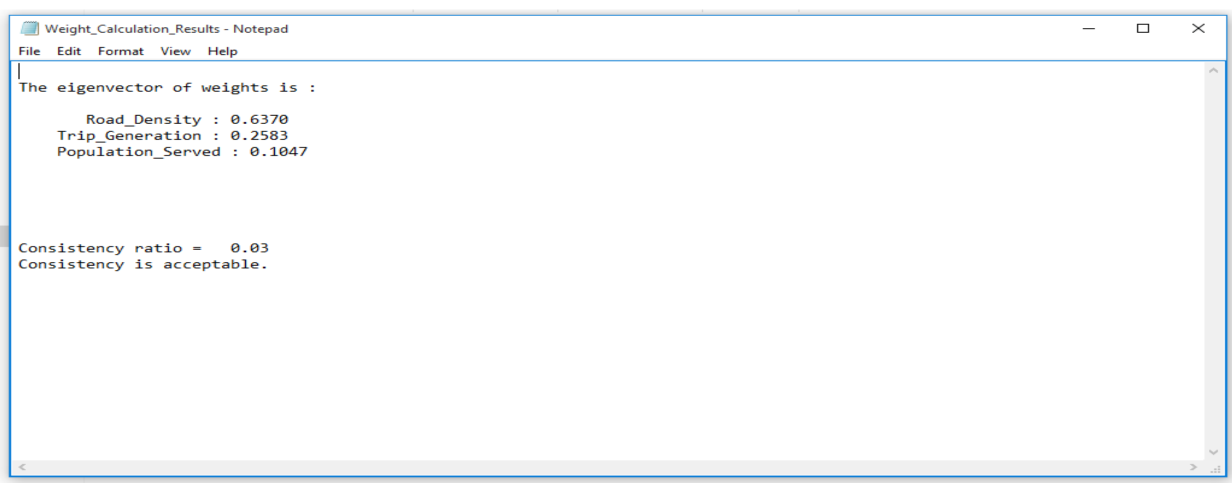
3.8. Analysis of Accessibility Indices

In this section, the analyzed and evaluated method of existing bus stop accessibility and the determined optimal locations were illustrated. The prepared data of road density (km/km^2), trip generation and population served by bus were converted into numbers. The prepared shape files vector data of three parameters (road density, trip generation by bus and population served) were converted to raster files. Next, data of each parameter was reclassified into a specific scale of 8 by using a geospatial '*Reclassify'* tool of ArcGIS. The accessibility of the three parameters was determined from these classified data. Accessibility Index of each bus stop was calculated from these three parameters accessibility result by multiplying each parameter accessibility index by their priority weight in the following order: Road Density (64%), Trip Generation

(26%) and Population Served (10%).and then add up of them by another geospatial tool *'Raster Calculator'* of ArcGIS. The priority weight of (64%), (26%) and (10%) were determine by using pairwise comparison by a giving order of road density, trip generation and population served.







The eigenvector of weights is: Road_Density: 0.6370, Trip_Generation: 0.2583 and Population Served : 0.1047. The Consistency ratio (acceptable) = 0.03.

The acquired Accessibility Index for both (Inbound) and (Outbound) directions of bus stops shown in (Figure 4.1 & 4.9) respectively and each of three parameters accessibility index of (inbound and outbound) direction were shown in Annex B.

The accessibility was primarily classified into eight categories based on the evaluated accessibility index models for displaying in the map and further classified into four categories: Excellent, Good, Moderate and Poor for understanding the accessibility condition (Table 4.1) Source Muhammad et al. (2013).

Table.3. 4: The accessibility index model

Bus Stop Category	**Accessibility Index**
Poor	3-6
	7-9
Moderate	10-12
	13-15
Good	16-18
	19-21
Excellent	22-24
	25-27

CHAPTER FOUR

RESULT AND DISCUSSION

4.1. Evaluation of Existing Bus Stop Accessibility

An evaluation of existing bus stop accessibility was an important issue to identify the bus stop accessibility in terms of accessibility index models. The existing bus stop accessibility were evaluated and categorized as excellent, good, moderate and poor based on accessibility index value. Where the stops which had the accessibility index value greater than or equal to 22 were categorized as excellent and less than 22 and greater than 15 as good. These excellent and good category of bus stops had the more road density, population served and the more trip generations, which indicated that high accessibility. The moderate bus stops had accessibility value less than 16 and greater than 9 were categorized as moderate which have moderate road connectivity, trip generation and population served within service area. Besides bus stops which have lower road connectivity,low trips generated by bus and the coverage area of bus stop is less and little peoples served within stop coverage area, which had low accessibility less than 10. These stops are categorized as poor.

4.1.1. Inbound Direction

4.1.1.1. Existing Bus Stop Accessibility

The result of accessibility analysis of existing bus stops shown in (Table 4.1) and (Figure.4.1) that indicated the existing inbound bus stop accessibility of three individual parameters and combination of them. The three parameters of accessibility value at the same bus stop had different results for examples stop ID 0 had high population served but have lower trip and road density, ID 5 had high road density but had low trip and population served and ID 27 had high trip generation with low road density and population served (Table 4.1). Therefore the accessibility of each bus stops were combination of the three parameters (i.e. road density, trip generation by bus and population served) accessibility index which provided bus stops good, moderate and poor accessibility the results (Table 4.1). The bus stops (26, 32, 36, 42, 46 and 91) which had more road density, densely population and the more trip generations had the more bus stop accessibility (Table 4.1). Because the high road density which indicates the high connectivity of road networks that are used to serve peoples easily to reach the nearest bus stops their by increasing the trip generated by bus. The more trip generation by bus and the more population served parameters, the more bus stop accessibility as can be seen from stop ID number of 31, 37, 41, 70, 71 and 72 in (Table 4.1). The bus stops for example stop ID number of 0, 10, 11, 12, 13, 14 and 17 had lower road density and low trip generation and high population served provided low accessibility. In same case, the more road density, the more bus stop accessibility (ID 5, 7 and 72). Generally, the combination of high road density,high trip generation and high population served with in service area, the accessibility of bus stop will also be very high. Therefore the road density and trip generation by bus were the main factor to provide good and moderate accessibility.

Table.4. 1: The combined 3 Parameter Accessibility Index for T-F (Inbound direction) Bus Stops

Bus Stop ID	Bus Stop-Name	Road density AI	Trip.Generated AI	Population Served AI	Accessibility Index
0	Jalmeda	3	4	17	5
1	6kilo	3	4	4	3
2	Amistegna Ber	4	4	3	4
3	Menafesha	5	3	3	4
4	Yeka 03	5	9	3	4
5	Zone 8	26	3	3	18
6	Hill Bottom	6	3	8	5
7	Megenagia	15	3	3	11
8	Meskelaga	3	3	3	3
9	Gedera	3	4	4	3
10	Kara	4	3	18	5
11	Kera Condominyam	4	3	11	4
12	Wesen	5	3	19	6
13	Hillside School	4	3	17	5
14	Condomineym	3	3	11	4
15	Lamberat	3	4	17	5
16	Megenaga	6	3	5	5
17	Haya Hulet	4	3	16	5
18	Zerihun	5	3	9	5
19	Aware	3	4	12	4
20	Aware Square	3	14	5	6
21	Anbessa Gebi	4	4	4	4
22	Aware	4	6	15	6
23	Aware	4	4	9	4
24	Megenagna Terminal	8	3	5	6
25	Kela	6	3	13	6
26	Megenagna	19	14	17	18
27	Kokeb Tsebay School	3	27	5	9
28	Lamberet	5	10	8	7
29	Lamberet	8	3	5	6
30	Megenagna	6	13	4	8
31	Menelik Hospitial	3	27	11	10

32	Misrak	20	13	15	18
33	Menelik Hospital	3	4	13	4
34	Salite Mehret	6	4	3	5
35	Signal	5	14	23	9
36	Signal	19	14	21	18
37	Shola	4	27	17	11
38	Yetebaberut Chaf	3	4	4	3
39	St Michale	4	4	15	5
40	Shola	5	4	6	5
41	Shola Gebeya	4	27	17	11
42	Cool Hintsa	21	13	12	18
43	Noc Chaf	5	3	16	6
44	Kotebe	5	3	15	5
45	Balderas	5	14	19	9
46	Shola Gebeya	18	14	21	17
47	Mere	5	3	27	7
48	Ethio China Mebrat Hayil	4	3	17	5
49	Women Square	5	14	9	8
50	Yetebaberut	4	3	4	4
51	Wesen	4	3	9	4
52	Condominium	4	3	10	4
53	Kera	4	3	16	5
54	Mikael	4	3	5	4
55	Mezan	5	3	17	6
56	Tena Tabea	5	3	10	5
57	Mazoriya	4	3	12	5
58	Gurara	4	3	11	4
59	Aware Dildiy	5	6	13	6
60	Dinberwa Hospital	5	14	20	9
61	Aware	5	4	13	6
62	Kazanchis / Meles Foundation	5	13	14	8
63	Kazanchis / Meles Foundation	5	4	8	5
64	Cmc Square	3	3	6	3
65	Cmc Square	3	4	4	3
66	Lamberet	4	3	6	4
67	Megenagna	6	3	5	5
68	Megenagna	5	4	7	5
69	Shola	5	4	17	6
70	British Embassy	3	27	11	10
71	Minilik School	5	27	5	11
72	6 Kilo Tele	4	27	10	11
73	6 Kilo	4	27	8	10
74	Eyesus	4	3	11	4
75	Hamle 19	5	3	9	5
76	Condominium	5	3	11	5
77	Meri	5	3	27	7
78	St. Micheal Church	3	4	6	4
79	Civil Service	3	4	3	3
80	Gurd Shola	4	4	6	4
81	Legehar	5	3	18	6
82	Yabem Hotel	4	3	10	4
83	Abisinia Cafe	4	4	16	5
84	Belgium Embassy	4	27	9	10

85	Kokebe Tsebah	4	27	5	10
86	Ayat Zone 2	5	3	7	5
87	Ayat Train Station	6	3	6	5
88	Kazzanchis	6	4	4	5
89	Kara	23	3	20	18
90	Wesen	5	3	18	6
91	Lamberet	21	10	17	18
92	Megenagna	4	4	16	5
93	Wesen Michael	5	3	21	6
94	Yeka Abado Megenteya	3	4	4	3
95	Tafo Square	4	3	3	4
96	Tafo Condominium 1	5	3	3	4
97	Tafo Condominium 2	4	3	3	4
98	Mebrat Hail	4	3	3	4
99	Tafo Gebrael	5	3	4	4
100	Maryam	6	3	3	5
101	Keste Demena	27	7	3	18
102	Ayat Square	6	3	9	6
103	Yetebaberut	4	3	7	4
104	Civil Service	4	4	3	4
105	Gurd Shola	3	4	4	3
106	Gurd Shola	5	4	11	5
107	Kara Condominum	4	3	4	4
108	Yeka Abado Condominum	3	10	3	5
109	Meskelegna Ababdo	3	3	3	3
110	Kara Condominum	4	4	5	4
111	Lamberet	3	4	17	5

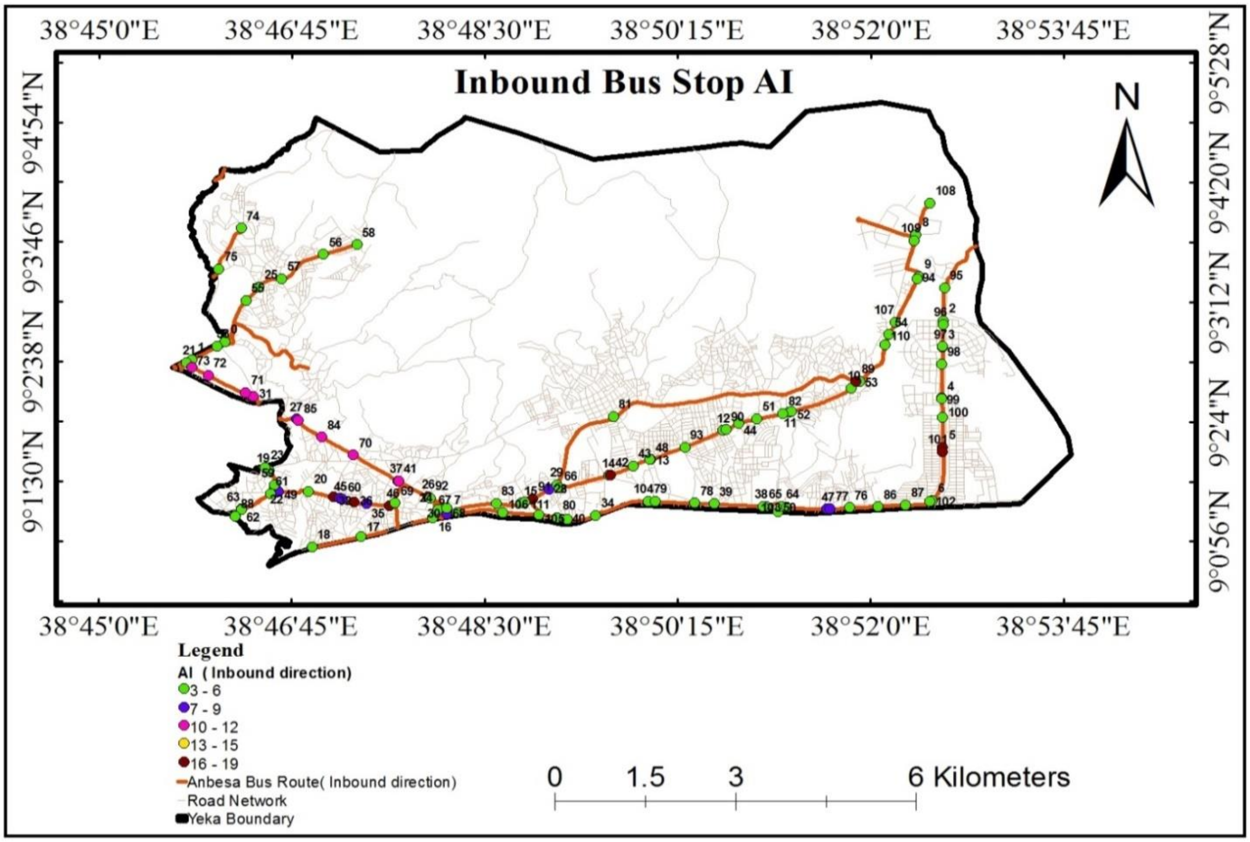


Figure.4. 1: The combined 3 parameters AI of bus stops T-F (inbound direction)

From the result of inbound bus stops attribute values (Table 4.2), it was found that, there was provided 8.036% (9 out of 112 bus stops) which have high accessibility and categorized as 'Good' (Table 4.3). On the other hand, a moderate number of bus stops were categorized as 'Moderate'. But it was noted that 8.929% bus stops (10 out of 112 bus stops) which have accessibility index greater than or equal to 10 and less than or equal to 15 were categorized as moderate (Table 4.4). Other remaining 83.04% of 112 bus stops (93 bus stops) were categorized as 'Poor' because of they have very low accessibility less than or equal to 9 (Table 4.5). However, there are no bus stops that satisfied an excellent accessibility index conditions.

Table.4. 2: Categorization of accessibility index for inbound bus stops in percentage

Number	Category	Range of accessibility index	Number of Stops	
		Value	Number	Percentage
1	Excellent	22-27	-	-
2	Good	16-21	9	8.036
3	Moderate	10-15	10	8.929
4	Poor	3-9	93	83.036
Total			112	100%

4.1.1.2. Good Accessibility of Bus Stops

The result of accessibility analysis of existing bus stops shows in (Table 4.3) and graphically shown in (Figure.4.2) that the more (*i.e. 6 bus stops out of 9*) good accessibility bus stops were located around Megenagna bus terminals. More of eight bus stops had similar accessibility values but bus stop ID 46 (Shola Gebeya) had 17 accessibility values. The bus stop ID 46 has equal values with the sub minimum road density value but had the maximum trip generation and population served within bus stop coverage area, which compared with the sub maximum and sub minimum statistical analysis (Table 4.3). Other eight (i.e. Bus Stop ID number of 26, 32, 36, 42and 91) bus stops which had high road density, trips and population served which greater than of their sub minimum and grand maximum values. But bus stop ID 89 (Kara) had minimum trips (i.e. sub minimum) but had maximum road density and population served compared with the sub-max and grand-max road density and population served values of Table 4.3. The bus stop ID 101 had less trip generation and population served which less than Sub Average and Grand Average values. In some case, it was evident that road density was the main parameter to provided high accessibility to the users because these nine bus stops had very high road density that approaches to grand maximum road density value compared with trip and population served values. The maximum road density was found in this good accessibility bus stop. In general, those nine bus stops had high road density that approaches to grand maximum road density, high trip generation and densely population served within stop coverage area were provided high accessibility which means that it gives good access to the users.

Table.4. 3: Bus stops categorized as 'Good' for T-F (Inbound direction)

Bus Stop ID	Stop Name	Road Density(km/ km^2)	Trip Generation by Anbessa in (No)	Population Served in (No)	Accessibility Index
5	Zone 8	158.420	309	417	18
26	Megenagna	113.257	528	3704	18
32	Misrak	117.283	455	3184	18
36	Signal	114.500	528	4702	18
42	Cool Hintsa	127.270	455	2370	18
46	Shola Gebeya	108.851	528	4670	17
89	Kara	139.063	51	4408	18
91	Lamberet	127.935	346	3636	18
101	Keste Demena	169.094	224	413	18
Sub Max.		169.094	528	4670	18

Sub Mini.		108.851	51	413	17
Sub Avg.		130.075	289	2542	18
Grand Max.		**169.094**	**1090**	**6324**	**18**
Grand Mini.		**13.972**	**13**	**6**	**3**
Grand Avg.		**33.1058**	**203**	**1024**	**11**

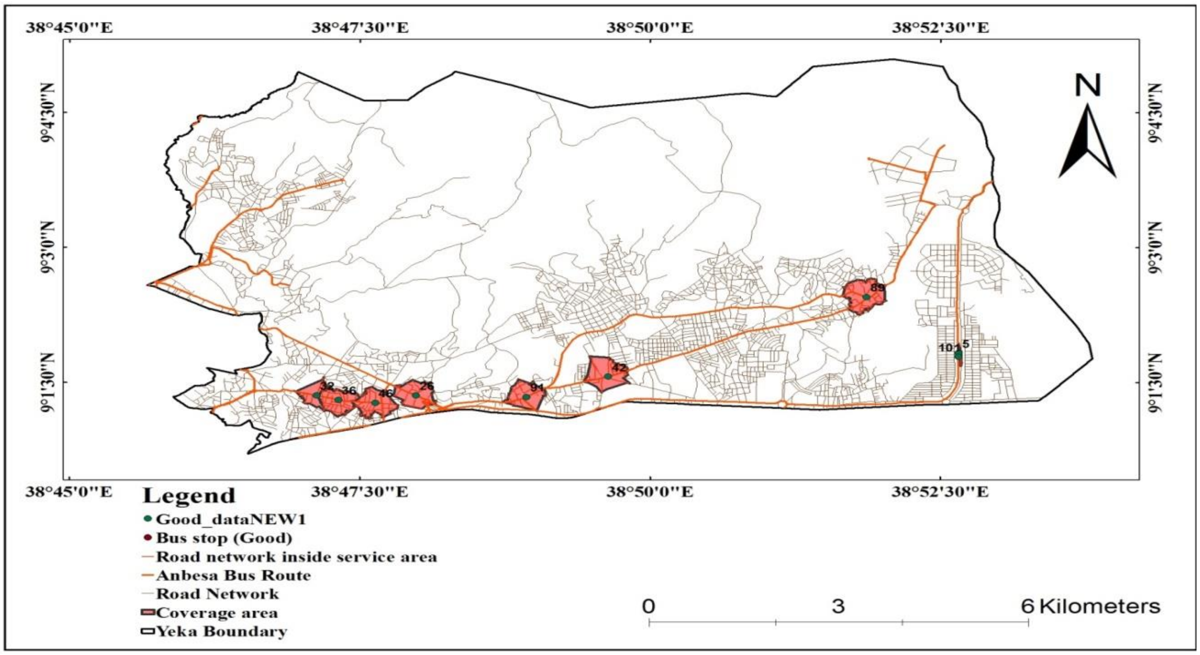


Figure.4. 2: Bus stops categorized as 'Good' (inbound direction)

4.1.1.3. Moderate Accessibility of Bus Stops

The result of accessibility analysis of existing bus stops attribute value shown in (Table 4.4) and graphical result shown in (Figure.4.3) that the all ten moderate bus stops were located from Megenagna to 6killo. This high trip data was indicated that the area was a commercial and institutional which had high travellers by bus. Bus stop ID-7 had high road density (i.e. Sub Max of 92.824) but low trips (i.e. Sub Min of 47) and population served (i.e. Sub Min of 192) which make high accessibility to users. It was evident that, the stop ID 7 had the high road density (i.e. grand max.) but had sub minimum trip and population served which indicated that the road density was the main factor for stop ID 7 to provided high accessibility to users. Although other bus stops ID number of (31,37,41,70,71,72,73,84 and 85) had low road density which were approach to sub mini road density comparatively with stop ID 7, but, served high number of population inside of coverage area which had greater than grand average value of 1024 and had very high number of trips that approach to the grand maximum trip values of 1090. Therefore each moderate bus stop except stop ID 7 and 71 were had road density value less than grand average road density value but in trip (except stop ID 7) and population served (except stop ID 71 and 85) were had the values greater than of the grand average value. In generally high trip generation by bus and population served were provided high accessibility to the users which are the main parameter to provided moderate bus stop accessibility. In some case, it was evident that trip generation was the main parameter to provided high accessibility to the users because of these all nine moderate accessibility bus stops except stop ID 7, had very high trip generation that approaches to grand maximum trip generation value compared with road density and population served values. The maximum trip generation (grand maximum value) was found in this moderate accessibility bus stop.

Table.4. 4: Bus stops categorized as 'Moderate' for T-F (Inbound direction)

Bus Stop ID	Bus Stop Name	Road Density in(km/km^2)	Trip Generation By Bus in (No)	Population Served in (No)	AI
7	Megenagia	92.824	47	192	11
31	Menelik Hospitial	17.783	1082	2170	10
37	Shola	22.863	1069	3626	11
41	Shola Gebeya	22.573	1069	3668	11
70	British Embassy	17.939	1069	2174	10
71	Minilik School	34.632	1090	664	11
72	6 Kilo Tele	21.782	1090	2020	11
73	6 Kilo	20.757	1090	1348	10
84	Belgium Embassy	20.922	1069	1744	10
85	Kokebe Tsebah	21.435	1069	694	10
Sub Max.		92.824	1090	3668	11
Sub Min.		17.783	47	192	10
Sub Avg.		55.3035	558	1930	11
Grand Max.		**169.094**	**1090**	**6324**	**18**
Grand Mini.		**13.972**	**13**	**6**	**3**
Grand Avg.		**33.1058**	**203**	**1024**	**11**

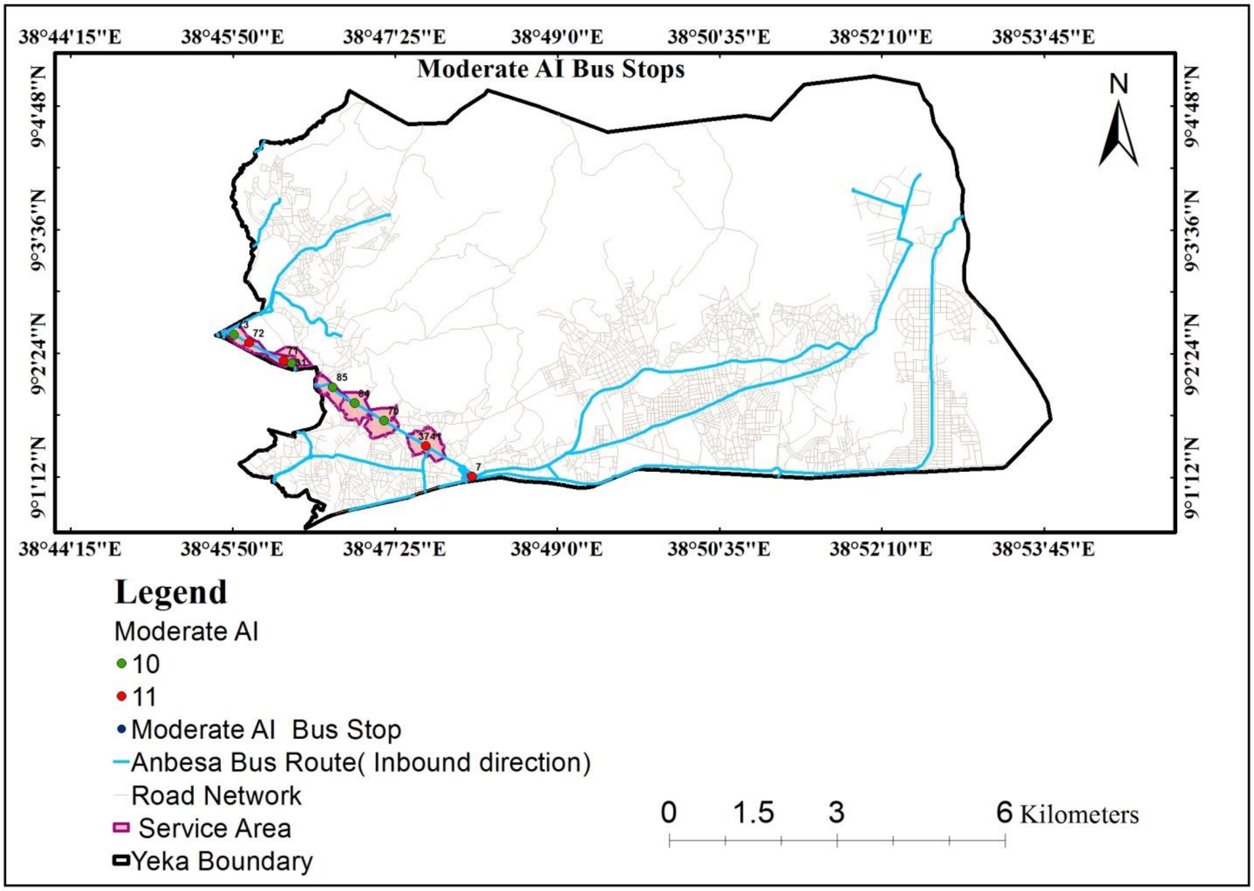


Figure.4. 3: Bus stop categorized as 'Moderate' inbound direction

4.1.1.4. Poor Accessibility of Bus Stops

The result of accessibility analysis of existing bus stops shows in (Table 4.5) and shown in (Figure.4.4) that the poor bus stops were located all parts of bus route lines. From 112 existing inbound direction Bus Stops 93 bus stops were categorized as 'Poor'. It was evident that bus stops ID number of (6, 24, 25, 29, 30, 34, 67, 87 and 102) were had road density greater than the grand average value of 33.1058, but its trip generation was very low which less than of sub maximum and grand average trip values that the lower trip generation value was influence the poor accessibility. The grand minimum trip value was found to be in this poor accessible bus stop. This result was leads to the bus stop provided poor accessibility values of less than 6. Other remaining bus stops (for example ID number of 1,4,9,15,19,23,38,43,55,82,86 and 93) were had very low trip generation and road density that less than sub and grand average values but had population served nearest to grand average values which provided poor accessible to the users. In some case, bus stop ID 77 was served maximum population (6324) within coverage area but had minimum trip by bus and lower road density. Therefore the bus stops for examples ID number of (0, 10, 11, 12, 13, 39, 43 and 77) had low road density and lower trip generation by bus but had high population served which provided poor accessibility which means that the road density and trip generation were the main factor for poor accessibility bus stops. Generally, the (Table 4.5) results were indicated that the road density, trip generation by bus and population served within bus stop coverage area were had very low accessibility index which provided poor accessibility.

Table.4. 5: Bus stops categorized as ‘Poor’ for T-F (Inbound direction)

Bus Stop ID	Stop-Name	Road in (km/km^2)	Trip Generation By Bus in (No)	Population Served in (No)	A I
0	Jalmeda	18.834	64	3760	5
1	6kilo	16.692	64	350	3
2	Amistegna Ber	21.770	64	51	4
3	Menafesha	27.350	47	56	4
4	Yeka 03	30.816	47	416	6
6	Hill Bottom	35.685	47	1274	5
8	Meskelaga	14.684	36	14	3
9	Gedera	15.517	66	400	3
10	Kara	22.072	36	4028	5
11	Kera Condominyam	24.151	36	2186	4
12	Wesen	30.509	36	4264	6
13	Hillside School	25.289	36	3666	5
14	Condomineym	18.536	36	2162	4
15	Lamberat	19.922	67	3552	5
16	Megenaga	32.631	41	708	5
17	Haya Hulet	22.466	41	3334	5
18	Zerihun	32.244	41	1598	5
19	Aware	19.507	58	2474	4
20	Aware Square	19.772	528	684	6
21	Anbessa Gebi	21.315	64	396	4
22	Aware	21.022	149	3116	6
23	Aware	25.268	58	1664	4
24	Megenagna Terminal	49.995	13	520	6
25	Kela	35.889	15	2552	6
27	Kokeb Tsebay School	19.813	1069	692	9
28	Lamberet	28.023	346	1406	7
29	Lamberet	47.297	37	643	6
30	Megenagna	36.639	451	472	8
33	Menelik Hospital	15.887	64	2714	4
34	Salite Mehret	38.019	74	80	5
35	Signal	28.732	528	5098	9
38	Yetebaberut Chaf	18.368	74	382	3
39	St Michale	21.609	74	3082	5

40	Shola	28.279	74	852	5
43	Noc Chaf	28.690	36	3394	6
44	Kotebe	29.888	36	3102	5
45	Balderas	30.399	528	4148	9
47	Mere	29.061	47	6190	7
48	Ethio China Mebrat Hayil	24.687	36	3744	5
49	Women Square	31.864	528	1636	8
50	Yetebaberut	22.512	27	508	4
51	Wesen	24.715	36	1604	4
52	Condominium	25.612	36	1896	4
53	Kera	23.793	36	3410	5
54	Mikael	24.494	46	586	4
55	Mezan	26.537	15	3748	6
56	Tena Tabea	27.866	15	1776	5
57	Mazoriya	23.536	15	2246	5
58	Gurara	24.698	15	2132	4
59	Aware Dildiy	27.111	149	2778	6
60	Dinberwa Hospital	28.974	528	4304	9
61	Aware	28.489	91	2604	6
62	Meles Foundation	31.087	470	2990	8
63	Meles Foundation	28.125	91	1434	5
64	Cmc Square	17.547	47	938	3
65	Cmc Square	18.237	74	296	3
66	Lamberet	25.762	36	892	4
67	Megenagna	37.898	47	688	5
68	Megenagna	32.273	67	1180	5
69	Shola	27.409	58	3636	6
74	Eyesus	22.337	25	2178	4
75	Hamle 19	32.384	25	1794	5
76	Condominium	32.585	47	2094	5
77	Meri	27.561	47	6324	7
78	St. Micheal Church	13.973	74	882	4
79	Civil Service	17.959	47	78	3
80	Gurd Shola	21.713	74	910	4
81	Legehar	26.967	37	4012	6
82	Yabem Hotel	22.837	36	1932	4
83	Abisinia Cafe	25.523	67	3526	5
86	Ayat Zone 2	27.382	47	1138	5
87	Ayat Train Station	38.512	47	770	5
88	Kazzanchis	37.060	91	288	5
90	Wesen	30.784	36	4016	6
92	Megenagna	23.990	77	3506	5
93	Wesen Michael	27.506	36	4594	6
94	Yeka Abado Megenteya	17.771	66	380	3
95	Tafo Square	24.175	47	200	4
96	Tafo Condominium 1	28.023	47	42	4
97	Tafo Condominium 2	25.816	47	62	4
98	Mebrat Hail	23.381	47	28	4
99	Tafo Gebrael	32.256	47	306	4

100	Maryam	33.975	47	180	5
102	Ayat Square	35.049	47	1538	6
103	Yetebaberut	20.611	47	1026	4
104	Civil Service	24.487	74	112	4
105	Gurd Shola	18.086	60	430	3
106	Gurd Shola	26.557	60	2092	5
107	Kara Condominum	24.131	36	328	4
108	Yeka Abado Condominum	16.632	336	6	5
109	Meskelegna Ababdo	14.578	36	66	3
110	Kara Condominum	22.466	66	548	4
111	Lamberet	17.715	67	3790	5
Sub Max.		49.995	1069	6324	**9**
Sub Min.		13.973	13	6	**3**
Sub Avg.		31.984	203	1024	6
Grand Max.		**169.094**	**1090**	**6324**	**18**
Grand Mini.		**13.972**	**13**	**6**	**3**
Grand Avg.		**33.1058**	**203**	**1024**	**11**

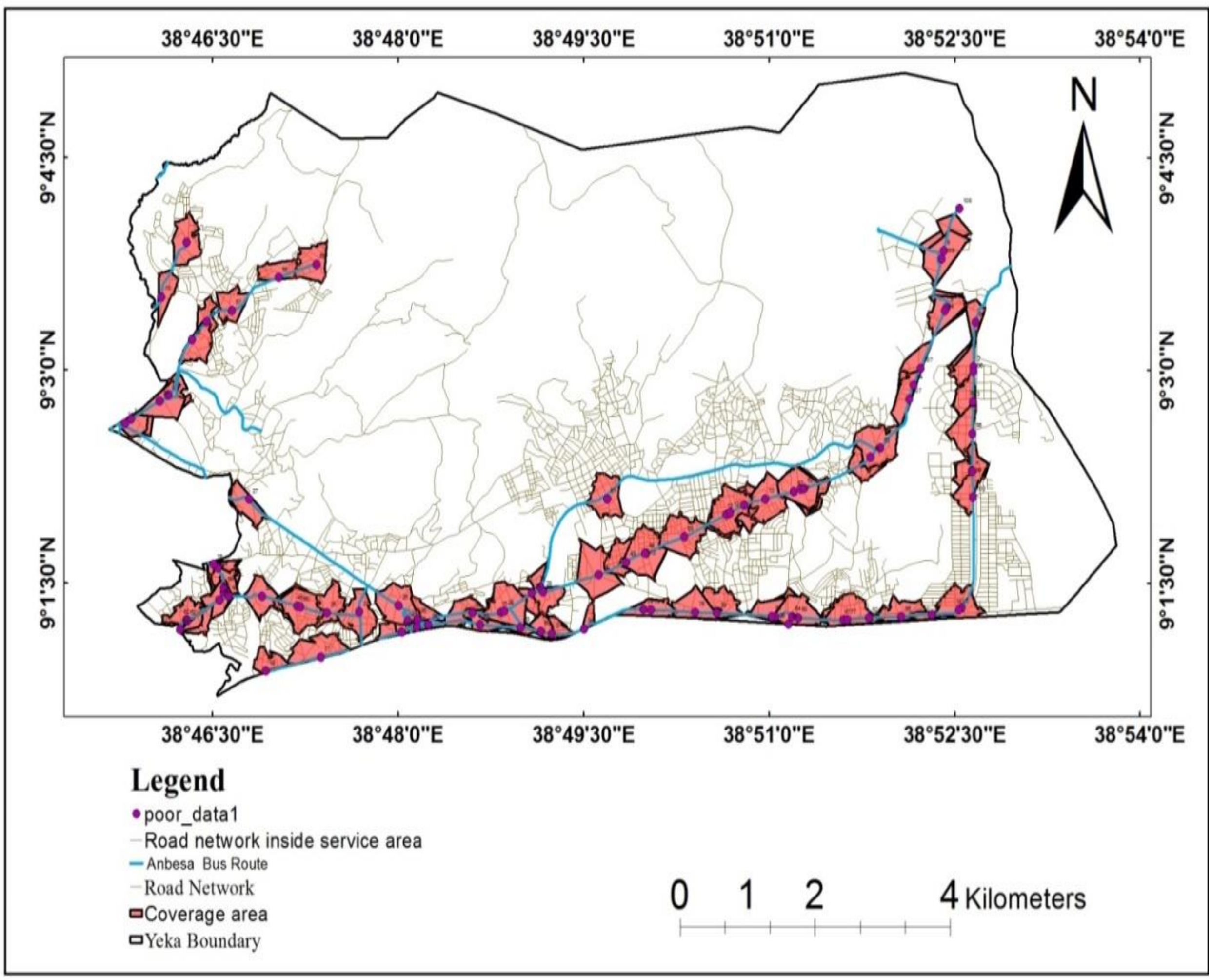


Figure.4. 4: Bus stop categorized as 'Poor' (inbound direction).

4.1.2. Outbound Direction

4.1.2.1. Existing Bus Stop Accessibility

The attribute values shown in (Table 4.6) and (Figure 4.5) indicated the existing outbound bus stop accessibility of the three parameters and combination of them. The three parameters of accessibility value at the same bus stop had different results for examples stop ID 0, 38 and 89 (Table 4.6). Therefore the accessibility of each bus stop is the combination of the three parameters i.e. road density, trip generation by bus and population served provided bus stops with good, moderate and poor accessibility (Table 4.6). The more road density and the more trip generation, the more bus stop accessibility as can be seen from bus stop ID number of 51, 54, 80, 88, 103 and 104 in (Table 4.6). Because the high road density indicated the high connectivity of road networks that serve people easily to reach the nearest bus stops which increase trip generation by bus. Similarly, the more road density and the more population served, the more bus stop accessibility as seen examples of stop ID 15, 16, 18 and 59 (Table 4.6). Therefore, the combination of high road density,high trip generation and high population served with in service area, provided very high (i.e. good and moderate) accessibility. Generally the three parameters had high accessibility, the bus stops provided good access to users because of its good road connectivity, densely populated served in stop coverage area and high passengers were generated by bus.

Besides bus stops for example bus stop ID number of 1, 2, 3, 4, 13 and 14 which had been low accessibilty, it had lower road connectivity,low trips generated by bus and the coverage area of bus stop were less and little peoples lived within stop coverage area (Table 4.6) .

Table.4. 6: The combined 3 Parameters AI for F-T (Outbound road direction) Bus stops

Bus Stop ID	Stop-Name	Road density AI	Trip generation AI	Population served AI	Accessibility Index
0	Jalmeda	4	6	18	6
1	6kilo	4	4	4	4
2	Tafo	7	6	3	6
3	Amistegna Ber	8	6	3	7
4	Menafesha	7	6	3	6
5	Gebriel	9	6	3	8
6	YekaNo 1condominume	11	6	7	9
7	Ayat Adebabay	12	6	6	10
8	Ayat	9	13	8	10
9	Meri	9	13	27	12
10	Yetebaberut	5	13	6	7

11	St Mikale	6	13	9	8
12	Civil Service	7	13	3	8
13	Gedera	3	8	5	4
14	St Mikale	7	8	5	7
15	Kara	22	4	20	17
16	Wesen	21	4	26	17
17	Hillside School	9	5	17	9
18	Condominyem	22	7	12	17
19	Lamberat	7	9	6	7
20	Yetebaberut	5	13	4	7
21	Megenaga	10	3	5	8
22	Haya Hulet	6	3	16	6
23	Zerihun	10	3	9	8
24	Abebe Suk	6	3	13	6
25	Anbessa Gebi	8	6	6	7
26	Aware	6	4	15	6
27	5	5	6	17	6
28	Ayat Adebabay	12	9	7	11
29	6 Kilo Tele	8	6	3	7
30	Megenagna	8	3	8	7
31	Megazen	8	6	18	8
32	Kela	7	6	16	8
33	Kenean	11	6	13	10
34	Mazoria	6	6	8	6
35	Megenagna	6	3	17	6
36	Kokebe Tsebah	3	9	6	5
37	Kokeb Tsebay School	6	9	5	7
38	Lamberet	16	3	5	12
39	Misrak	8	4	17	8
40	Menelik Hospital	3	7	13	5
41	Shola Gebya	4	4	13	5
42	Shola	8	4	20	8
43	Shola	6	9	17	8
44	Shola Chaf	15	9	14	13
45	Signal	7	4	18	7
46	Waryt Square	4	4	8	4
47	Shola	8	13	5	9
48	Yesetoch Adebabay	11	4	9	9
49	Engilsh Embassy	5	9	7	6
50	Megenagna	8	9	15	9
51	Megenagna	27	14	4	21
52	Megenagna	8	14	8	10
53	Total	8	14	18	11
54	Lamberet	18	13	17	17
55	Ahmed Building	9	5	14	8
56	St .Mecael	8	13	27	11
57	Salite Mihret	6	5	18	7
58	Signal	5	4	3	5
59	Yeka Michael	18	9	18	16

60	Gurd Shola	7	13	11	9
61	Tikur Abay	5	13	3	7
62	Kera Condminium	7	5	10	7
63	Kera Sayiders	7	4	17	7
64	Mazoriya	6	8	12	7
65	Minilik School	13	3	4	10
66	Bono Weha	6	6	7	6
67	Yeha	9	6	10	8
68	Gurara	10	8	11	10
69	Gurara	7	8	11	8
70	Kokebe Tsebah School	6	9	5	7
71	BretDildy(BunoWeha)	11	6	9	10
72	Aware Dildiy	8	4	14	8
73	Aware Square	7	4	11	7
74	Megenagna	11	3	6	8
75	Shola	9	3	20	9
76	Dinberwa Hospital	9	4	20	9
77	Aware	8	4	13	7
78	Kazanchis / Meles Foundation	8	6	8	7
79	Cmc Square	3	13	5	6
80	Megenagna	10	13	8	11
81	Megenagna	19	9	17	16
82	6 Kilo Tele	6	3	11	6
83	6 Kilo	5	3	8	5
84	Eyesus	6	13	11	8
85	Hamle 19	10	3	10	8
86	Feres Bet	5	6	3	5
87	Ayat Square	11	9	7	10
88	Ayat	12	13	6	12
89	Condominium	7	27	7	12
90	Cmc	4	13	7	7
91	St. Micheal Church	6	13	6	8
92	Century Mall	5	13	6	7
93	Balderas	8	4	20	8
94	Radison Blue	9	13	18	11
95	Biherawi	4	7	11	5
96	Legehar	16	14	19	16
97	Tafo Mebrat Hail	3	6	3	3
98	Kazzanchis	12	9	3	10
99	Shola	9	4	19	9
100	Shola Gebeya	8	3	17	8
101	Menaheria	10	9	5	9
102	Condominium	6	5	12	6
103	Megenagna	12	13	6	12
104	Gurd Shola	10	13	6	10
105	Keste Demena	10	6	6	9
106	Tafo Gebrael	7	6	4	6
107	Tafo Condominium 2	4	6	3	4

108	Tafo Condominium 1	8	5	3	7
109	Wesen Michael	11	6	22	11
110	Kara	5	8	15	7
111	Gedera	3	8	4	4
112	Tafo Adebabay	7	13	3	8
113	Abissnia	8	8	18	9
114	Hillside School	11	5	18	10
115	Wosone	8	4	20	8
116	Yabem Hotel	6	5	11	6
117	Kara Chore Sefer	10	5	16	9
118	Medhanialem	7	8	17	8
119	Kara Condominum	7	8	6	7

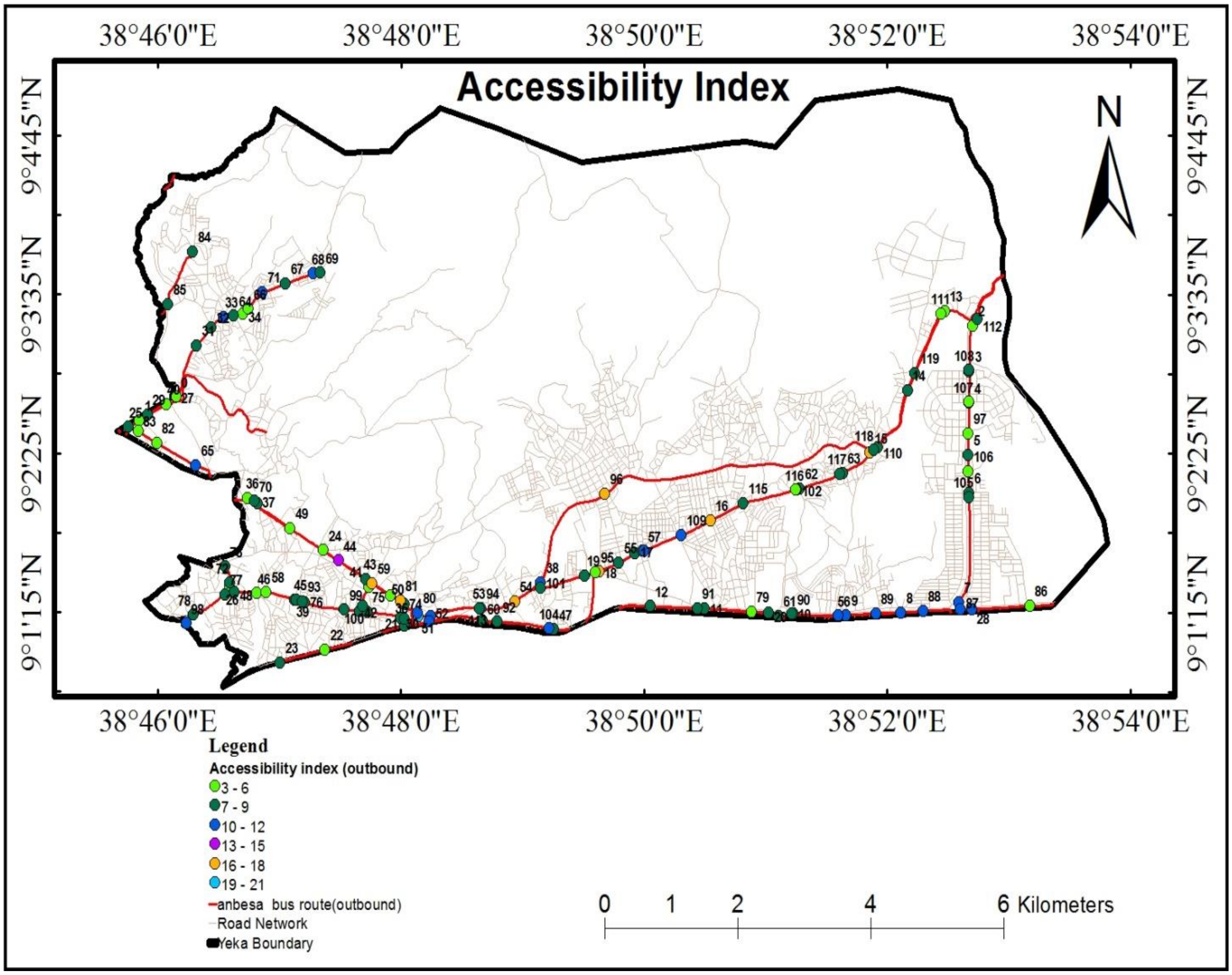


Figure.4. 5: The combined 3 parameters accessibility index of bus stops F-T (Outbound direction)

From the result of outbound bus stops attribute values (Table 4.6), it was found that there were provided only 6.667% (8 out of 120 bus stops) which had high accessibility and categorized as 'Good' (Table 4.8). On the other hand, 19.167% (23out of 120 bus stops) bus stops were have accessibility index of greater than or equal to 10 and less than or equal to 15 which was categorized as moderate (Table 4.9).

Other remained 74.167% (89 out of 120) bus stops were categorized as 'Poor' because of they had very low accessibility less than or equal to 9 (Table 4.10). However, there is no bus stops that satisfied an excellent accessibility index conditions.

Table.4. 7: Categorization of accessibility index for outbound bus stops in percentage

SN	Category	Range of accessibility index	Number of Stops	
		Value	Number	Percentage
1	Excellent	22-27	-	-
2	Good	16-21	8	6.667%
3	Moderate	10-15	23	19.167%
4	Poor	3-9	89	74.167%
Total			120	100%

4.1.2.2. Good Accessibility of Bus Stops

The result of accessibility analysis of existing bus stops shown in (Table 4.8) and the graphical results shown in (Figure.4. 6) that these good accessibility bus stops were located from Megenagna bus terminal to Kara. The bus stop ID 51 had maximum road density but minimum trip generation and its population served within bus stop coverage area was a sub minimum which provided good accessibility. Bus stop ID 15 and 16 were had high road density and population served which approach to grand maximum value but its trip was very low which provided good accessible to the users. Other bus stop ID number of (18, 54, 59, 81 and 96) were had high road density, high trips and more populations served to compared with sub Max and Grand Max values. It has a little difference between each bus stop road density and Grand Maximum values. The grand Maximum road density was found in stop ID 51. All bus stops (except stop ID 51), were had high number of populations greater than the grand average values. These good accessibility bus stops ID number of 15, 16, 18, 54, 59, 81 and 91 (Table 4.9) had high road density that approaches to grand maximum road density and densely population served within stop coverage area that greater than grand average value which were provided high accessibility which means that it gives good access to the users. Generally, the Table 4.8 results were indicated that the maximum road density and high number of populations served within bus stop coverage area were the main factor for all good bus stops, which provided good accessibility. Therefore, the combination of maximum road density, densely population served within service area and high trips were provided good accessibility which means that it gives good access to the users.

Table.4. 8: Bus stops categorized as ‘Good’ for outbound direction

Bus Stop ID	Stop Name	Road Density In (km/km^2)	Trip Generation By Anbesa Bus in (No)	Population Served in(No)	AI
15	Kara1	61.581	66	4214	17
16	Wesen1	59.905	66	5792	17
18	Condominyem1	61.168	208	2240	17
51	Megenagna1	76.662	536	509	21
54	Lamberet1	51.1716	485	3638	17
59	Yeka Michael1	51.110	339	3878	16
81	Megenagna1	53.991	339	3566	16
96	Legehar1	47.967	537	4012	16
Sub Max		76.662	537	5792	21
Sub Min		47.967	66	509	16
Sub Avg.		62.3142	301	3151	19
Grand Max		**76.66188**	**1116**	**6116**	**21**
Grand Mini		**13.3874**	**5**	**46**	**3**
Grand Avg.		**28 338**	**237**	**2040**	**12**

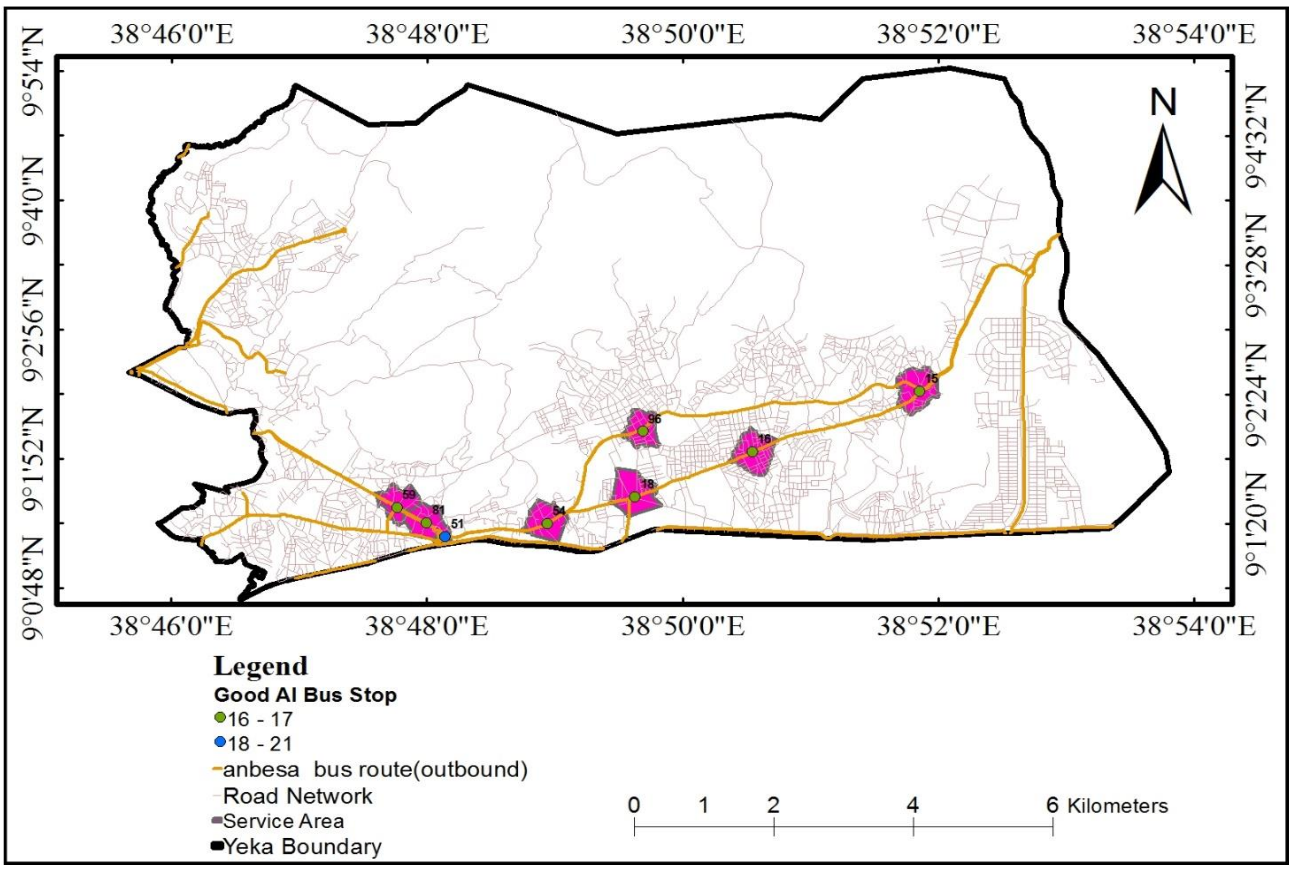


Figure.4. 6: Bus stop categorized as ‘Good’ (Outbound direction)

4.1.2.3. Moderate Accessibility of Bus Stops

The result of accessibility analysis of existing bus stops attribute value shown in (Table 4.9) and the graphical results shown in (Figure.4.7) that the moderate accessibility bus stops were located in most part of study area from Megenagna to Kara. Bus stop ID (7, 38, 65, 71 and 98) were had high road density approach to sub max (47.297) but had lower trips and population served less than grand average values which provided moderate accessibility. Similarly, moderate accessibility bus stops ID number of 33, 44, 68, 109 and 114) (Table 4.9) had high road density that approaches to sub maximum road density and densely population served within stop coverage area that greater than grand average value which were provided high accessibility which means that it gives good access to the users. Stop ID 89 was had minimum road density (i.e. sub min 23.892) and high trips greater than of its grand average values and low population served. Other remained bus stops ID number of (80, 88,103 and 104) were had high road density, trip generation by bus that approaches to its sub maximum values which provided high accessible to the users. Generally, it was evident that, the road density (road network connectivity) was the main factor for these moderate accessibility bus stops to provided high accessibility to the users (Table. 4.9) because of its road density values were approaches to sub maximum values compared with trip and population served data.

Table.4. 9: Bus stops categorized as ‘Moderate’ for outbound direction

Bus Stop ID	Stop-Name	Road Density in (km/km^2)	Trip Generation by Anbesa Bus in (No)	Population Served in (No)	Accessibility Index
7	Ayat Adebabay2	37.909	169	796	10
8	Ayat2	30.097	492	1426	10
9	Meri2	28.583	492	6046	12
28	Ayat Adebabay2	36.219	323	1024	11
33	Kenean2	34.539	156	2590	10
38	Lamberet2	47.297	37	502	12
44	Shola Chaf2	44.107	321	2778	13
52	Megenagna2	26.185	532	1491	10
53	Total2	28.449	532	3786	11
56	St .Mecael2	27.574	492	6116	11
65	Minilik School2	40.179	32	496	10
68	Gurara2	33.393	312	2188	10
71	Bret Dildy	34.848	157	1694	10
80	Megenagna2	31.208	485	1382	11

87	Ayat Square2	35.337	323	1064	10
88	Ayat2	36.665	492	810	12
89	Condominium2	23.892	558	1116	12
94	Radison Blue2	29.673	485	3780	11
98	Kazzanchis2	37.059	286	288	10
103	Megenagna2	38.159	460	923	12
104	Gurd Shola2	31.137	460	998	10
109	Wesen Michael2	33.215	169	4832	11
114	Hillside School2	33.561	104	3706	10
Sub Max.		47.297	532	6116	12
Sub Min.		23.892	32	496	10
Sub Avg.		35.595	282	3306	11
Grand Max		**76.662**	**1116**	**6116**	**21**
Grand Mini		**13.387**	**5**	**46**	**3**
Grand Avg.		**28 338**	**237**	**2040**	**12**

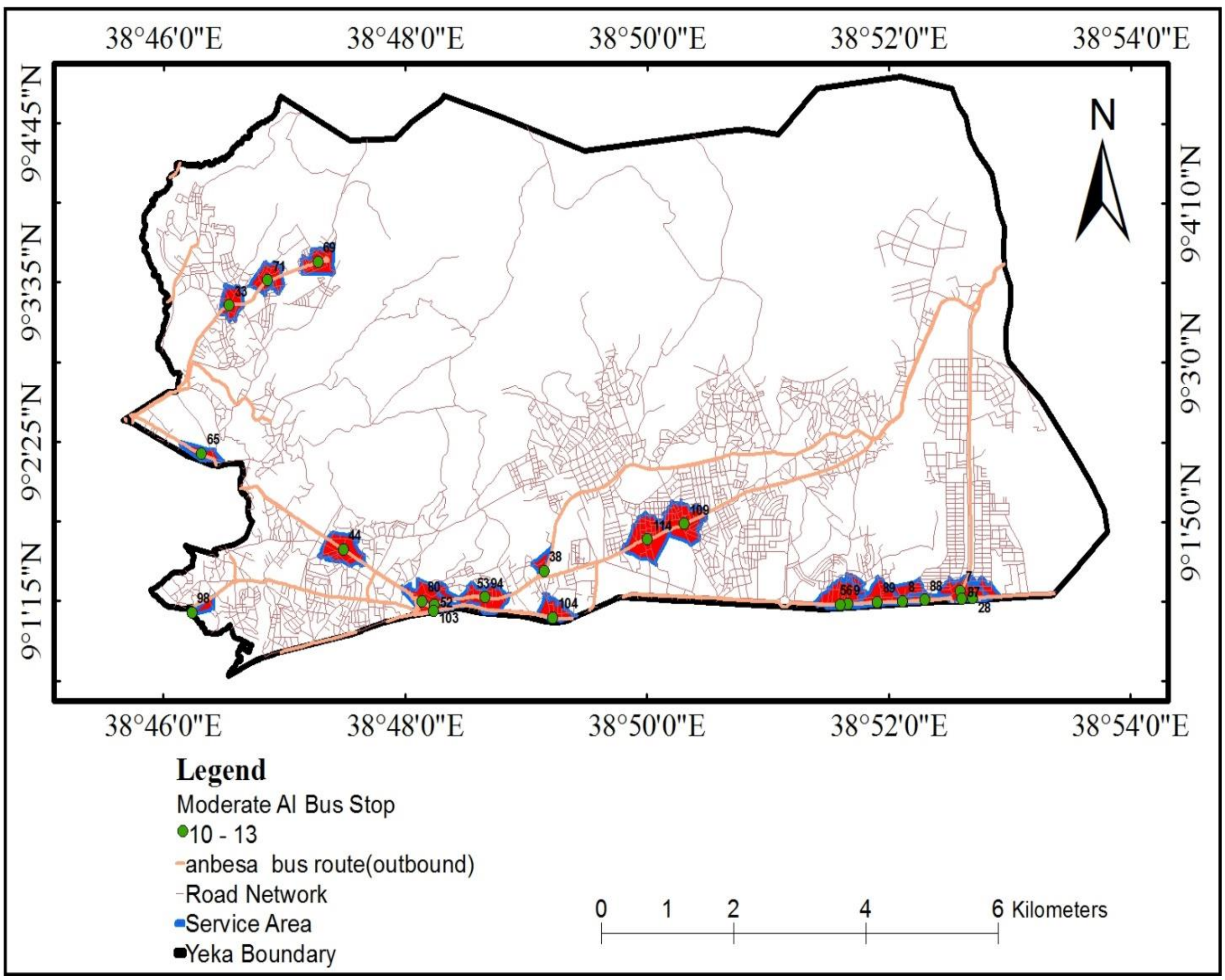


Figure.4. 7: Bus stop categorized as ‘Moderate’ Outbound direction

4.1.2.4. Poor Accessibility of Bus Stops

The result of accessibility analysis of existing bus stops attribute values shown in (Table 4.10) and the graphical results shown in (Figure.4.8) that the poor accessibility bus stops were located all parts of bus route. From 120 existing outbound direction Bus Stops 89 bus stops were categorized as 'Poor'. It was evident that some bus stops ID number of (5, 6, 17, 21, 23, 48, 85, 101,105, and 117) were had road density greater than the grand average value of 28.338, but its trip generation was very low which was less than sub maximum and grand average trip value. Stop ID 97 was had the grand minimum road density and population served which was provided poor accessibility. The bus stop ID 1, 46, 107 and 108 were had very low road density, trip and populations within stop service area that was less than its grand average values which was provided poor accessibility. Other remaining bus stops (for example ID number of 0,22, 24,26, 27, 32, 40, 41 and 59) were had very low trip generation and road density that less than sub and grand average values but had population served greater than grand average values those values were provided poor accessibility. Generally, the Table 4.10 results were indicated that the road density, trip generation by bus and population served within bus stop coverage area were had very low which provided poor accessibility. Therefore the bus stops which had low road density, low trip generation and less densely population served which less than grand average value for example bus stop ID number (1, 2, 3 and 4 etc.) were provided poor accessibility which means that gives poor access to the users (Table 4.10) .

Table.4. 10: Bus stops categorized as 'Poor' for outbound direction

Bus Stop ID	Stop-Name	Road Density in (km/km^2)	Trip Generation by Anbesa Bus in (No)	Population Served in (No)	AI
0	Jalmeda	18.281	163	3728	6
1	6kilo	16.893	72	428	4
2	Tafo	25.308	169	198	6
3	Amistegna Ber	26.371	169	47	7
4	Menafesha	25.747	169	65	6
5	Gebriel	30.149	169	185	8
6	Yeka No1condominum	35.659	169	1038	9
10	Yetebaberut	18.800	492	942	7
11	St Mikale	22.727	492	1548	8
12	Civil Service	23.882	492	116	8
13	Gedera	15.628	295	546	4

14	St Mikale	22.727	492	1548	8
17	Hillside School	30.159	104	3528	9
19	Lamberat	24.536	339	996	7
20	Yetebaberut	18.800	492	942	7
21	Megenaga	32.181	6	714	8
22	Haya Hulet	22.111	5	3328	6
23	Zerihun	32.244	41	1598	8
24	Abebe Suk	23.508	34	2606	6
25	Anbessa Gebi	26.191	156	850	7
26	Aware	21.022	91	3116	6
27	5	18.783	157	3674	6
29	6 Kilo Tele	28.125	157	96	7
30	Megenagna	26.386	33	1364	7
31	Megazen	26.745	156	3788	8
32	Kela	24.459	156	3218	8
34	Mazoria	23.266	157	1502	6
35	Megenagna	26.386	33	1364	7
36	Kokebe Tsebah	15.347	321	910	5
37	Kokeb Tsebay School	22.193	321	690	7
39	Misrak	26.381	52	3536	8
40	Menelik Hospital	15.887	194	2714	5
41	Shola Gebya	18.233	66	2560	5
42	Shola	27.577	52	4418	8
43	Shola	27.577	52	4418	8
45	Signal	24.465	52	3770	7
46	Waryt Square	17.511	52	1376	4
47	Shola	27.577	52	4418	8
48	Yesetoch Adebabay	34.225	52	1544	9
49	Engilsh Embassy	19.622	321	1076	6
50	Megenagna	26.386	33	1364	7
55	Ahmed Building	28.841	104	2952	8
57	Salite Mihret	23.459	104	3822	7
59	Signal	24.465	52	3770	7
60	Gurd Shola	25.218	460	1890	9
61	Tikur Abay	20.828	492	316	7
62	Kera Condminium	25.227	104	1900	7
63	Kera Sayiders	25.634	66	3646	7
64	Mazoriya	21.520	313	2438	7
66	Bono Weha	21.872	157	1124	6
67	Yeha	29.870	157	1792	8
70	Kokebe Tsebah School	21.438	321	692	7
72	Aware Dildiy	27.111	91	2778	8

73	Aware Square	24.436	91	2176	7
74	Megenagna	26.386	33	1364	7
75	Shola	27.577	52	4418	8
76	Dinberwa Hospital	29.091	52	4228	9
77	Aware	21.022	91	3116	6
78	Meles Foundation	28.124	143	1434	7
79	Cmc Square	15.697	492	752	6
82	6 Kilo Tele	28.125	157	96	7
83	6 Kilo	20.757	32	1348	5
84	Eyesus	22.337	492	2178	8
85	Hamle 19	32.384	49	1794	8
86	Feres Bet	18.909	174	188	5
90	Cmc	18.193	492	1072	7
91	St. Micheal Church	22.085	492	908	8
92	Century Mall	20.526	460	986	7
93	Balderas	26.604	52	4234	8
95	Biherawi	18.392	208	2036	5
97	Tafo Mebrat Hail	13.387	143	46	3
99	Shola	27.577	52	4418	8
100	Shola Gebeya	27.314	19	3650	8
101	Menaheria	31.748	339	748	9
102	Condominium	23.892	104	2310	6
105	Keste Demena	33.089	169	960	9
106	Tafo Gebrael	25.567	169	478	6
107	Tafo Condominium	16.843	169	54	4
108	Tafo Condominium	26.465	104	46	7
110	Kara	19.567	295	2992	7
111	Gedera	15.628	295	546	4
112	Tafo Adebabay	23.916	462	266	8
113	Abissnia	26.401	295	3846	9
115	Wosone	28.469	66	4214	8
116	Yabem Hotel	23.453	104	2164	6
117	Kara Chore Sefer	31.704	104	3254	9
118	Medhanialem	24.273	295	3508	8
119	Kara Condominum	24.231	295	996	7
Sub Max		35.659	492	4418	9
Sub Min		13.387	5	46	3
Sub Avg.		24.523	249	2232	6
Grand Max		**76.662**	**1116**	**6116**	**21**
Grand Mini		**13.3874**	**5**	**46**	**3**
GrandAvg.		**28.338**	**237**	**2040**	**12**

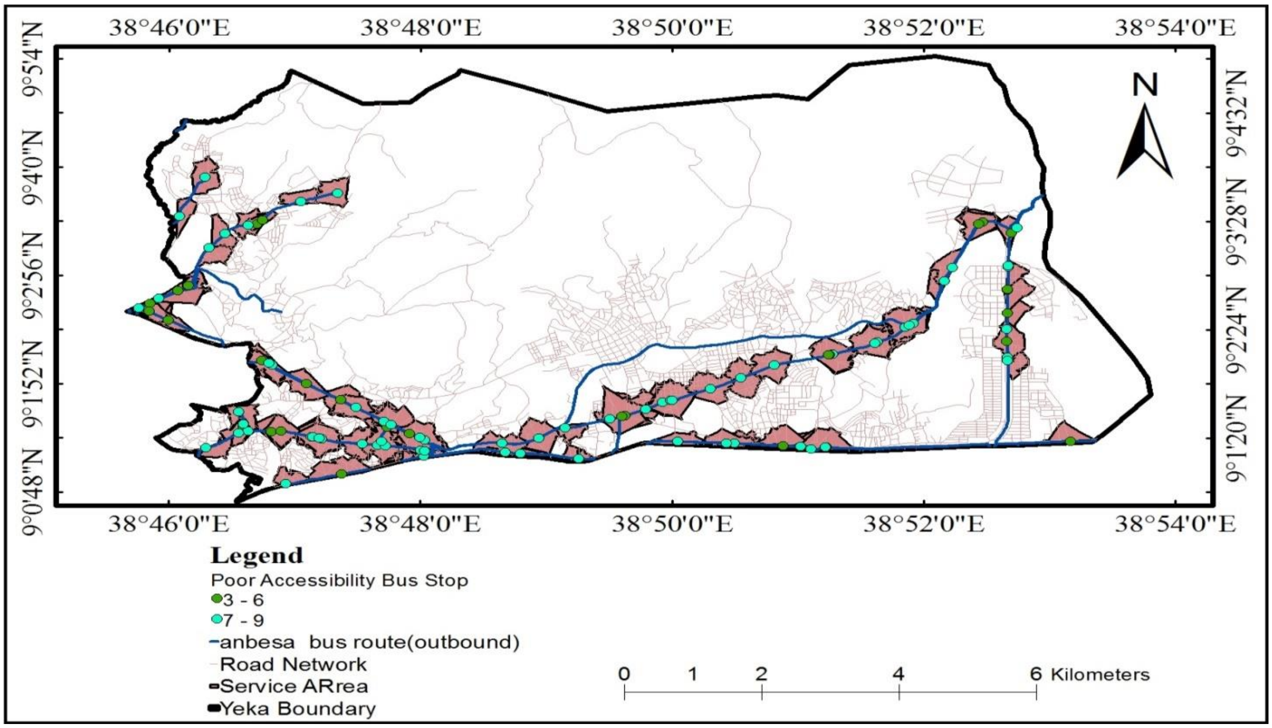


Figure.4. 8: Bus stop categorized as ‘Poor’ Outbound direction.

4.2. Validation

The validation of existing bus stop accessibility result is an important step to check the real bus stop accessibility values on the ground. The validation of existing bus stop accessibility is taken on the days, which had high traffic flows. These selected days, which had high traffic flow, were the working days as among these working days have high population flows from home to work place. Monday and Tuesday were selected for the validation of existing bus stop accessibility because of high population flows. Both inbound and outbound bus stops were validated on both Monday and Tuesday at the same observation time. The validation of existing bus stop accessibility was identified for each selected validated bus stops depending on the observation peak period chosen of morning between 8:00 to 9:30 and after noon from 4:00 to 5:30 for both inbound and outbound direction of bus stop which period had high bus service frequency and high population flows. The data of trip generation by bus and bus number and bus trips were collected for each selected bus stops on selected observation date.

The duration of observed time used for both direction bus stops was 1.5 hrs. From the result of existing bus stop accessibility index, 25 bus stops out of 120 for outbound direction and 26 out of 112 for inbound direction bus stops were taken to validate existing accessibility values.

4.2.1. Validation for Inbound Bus Stops

4.2.1.1. Good Accessibility Bus Stop

From 112 of T-F (inbound direction) five bus stops for good, 10 bus stops for moderate and others remained 11 bus stops for poor were selected. The validated data of inbound road direction of bus stops were shown in (Table 4.11 to 4.13). The validated data of good bus stop inbound road direction can be seen from Table 4.11. The trip generated (TG) by Anbesa bus had a little difference in both observed time and the accessibility values for both morning, afternoon and existing were similar which shows that it provided similar accessibility to users. Out of 15 bus stops, 4 bus stops of (5, 46, 91 and 101) have similar accessibility value to existing accessibility value which indicated that the validation satisfied by more than 50%. The validated result four good bus stop was satisfied by 80% similar values can be seen from Table 4.17. Therefore, these bus stops make good accessibility to users.

Table.4. 11: Bus stops categorized as ‘Good’ for T-F (inbound direction)

		Existing data				Collected observed data for Validation						
						Morning (8:00-9:30 AM)			Afternoon (4:005:30PM)			
Bus Stop ID	Bus Stop Name	Road Density	Trip Generated by Bus	Populatiom Served	Existing AI	Trip generation at Morning	AI	Average AI at Morning	Trip generation at after noon	A I	Average AI at After noon	Average AI for morning and afternoon
5	Zone 8	158.420	309	417	18	238	8	19	302	9	18	18
26	Megenagna	108.257	528	3704	18	626	16	19	578	15	18	19
46	Shola gebaya	108.851	528	4670	18	501	13	18	534	14	18	18
91	Lambere	127.934	346	3636	18	300	9	17	387	11	19	18
101	Keste Demena	169.094	224	413	18	196	9	17	227	11	19	18
S.Av		134.512	387	2568	-	372	-	-	406	-	-	-
G.Ma		169.094	1090	6324	18		-	-				
G.Mi		13.972	13	6	3	-	-	-				
G.Av		33.106	203	1024	1 1							

NB AI- Accessibility Inndex, S.Av- Sub average, G.Ma-Grand maximum, G.Mi- Grand minimum and G.Av- Grand minimum.

4.2.1.2. Moderate Accessibility Bus Stop

For inbound direction moderate bus stop validation, 10 bus stops were taken which used to validate existing bus stop accessibility. From validation data results, bus stop ID 7 had generated a high number of trips which makes high accessible to users with compared to existing trip. The bus stop ID 37 and 72 had very low trip generation with compared to existing trips that less accessibility value. Other bus stops ID number of (3, 31, 41, 70, 73, 84 and 85) were generated a moderate number of trips. All of these 10 bus stops indicated a moderate accessibility to users shown in (Table 4.12). However, out of 10 bus stops, 7 bus stops of (31, 41, 70, 71, 73, 84 and 85) provided similar accessibility value to existing accessibility value which indicated that the validations satisfied by 70% similar values can be seen fromTable 4.17. Therefore, these bus stops make moderate accessibility to users.

Table.4. 12: Validated Bus stops categorized as 'Moderate' for T-F (inbound direction)

		Existing data				Observed data for Validation						
						Morning (8:00-9:30AM)			Afternoon (4:005:30 PM)			
bus stop ID	Stop Name	Road Density	Trip Generated by Bus	Populaion Served	Existing AI	Trip generation at Morning	AI	Average AI at Morning	Trip generation at after noon	AI	Average AI at After noon	Average AI for morning and afternoon
7	Megenagna	92.824	47	192	11	1005	26	17	1146	27	17	17
31	Menelik Hospitial	17.783	1082	2170	10	1013	26	10	1042	26	10	10
37	Shola	22.862	1069	3626	11	797	21	10	915	23	10	10
41	Shola Gebeya	22.572	1069	3668	11	847	25	11	1080	27	11	11
70	British Embassy	17.939	1069	2174	10	978	25	10	1056	25	10	10
71	Minilik School	34.632	1090	664	11	952	24	10	1056	27	11	11
72	6 Kilo Tele	21.782	1090	2020	11	949	24	10	988	25	10	10
73	6 Kilo	20.757	1090	1348	10	1057	27	10	1075	27	10	10
84	Belgium Embassy	20.922	1069	1744	10	935	24	10	969	25	10	10
85	Kokebe Tsebah	21.435	1069	694	10	1017	26	10	1080	27	10	10
S.Av		24.569	186	2226	-	258	-	-	406	-	-	-
G.Ma		169.094	1090	6324	18							
G.Mi		13.972	13	6	3							
G.Av		33.106	203	1024	11							

4.2.1.3. Poor Accessibility Bus Stop

Out of 93 inbound direction poor bus stops, 11 bus stops were randomly taken which used to validate existing poor bus stop accessibility.From validation data results, at afternoon observation time and morning time had rare variations, it generated low trips. Although all of 11 bus stops indicated poor accessible to the users, but 6 bus stops of (21,27,74,81,79,& 80) had similar accessibility value to existing poor accessibility values which estimates the validations that satisfied by more than half of percent (55%) similar values can be seen fromTable 4.17. All of these 11 bus stops were indicated poor accessibility to users (Table 4.13).

Table.4. 13: Bus stops categorized as 'Poor' for T-F (inbound direction)

		Existing data				Observed data for Validation						
						Morning (8:00-9:30AM)			Afternoon (4:005:30 PM)			
bus stop ID	Stop Name	Road Density	Trip Generat by Bus	Population Served	Existing AI	Trip generation at Morning	AI	Average AI at Morning	Trip generation at after noon	AI	Average AI at After noon	Average AI for morning and afternoon
21	Anbessa Gebi	21.315	64	396	4	198	7	4	227	7	4	4
24	MegenagnTerminal	49.995	13	520	6	507	14	6	404	12	9	9
27	Kokeb Tsebay.	19.813	1069	692	9	833	22	8	921	24	9	9
44	Kotebe	29.888	36	3102	5	175	6	6	492	14	8	7
74	Eyesus	22.337	25	2178	4	55	3	4	139	5	4	4
81	Legehar	26.966	37	4012	6	137	5	6	236	8	7	6
10	Kara	24.063	51	4408	5	344	10	7	512	14	8	8
93	Wesen Michael	27.506	36	4594	6	387	11	8	412	12	8	8
79	Civil Service	24.487	74	112	4	182	6	3	337	10	5	4
80	Gurd Shola	18.086	60	430	3	141	5	3	319	10	4	3
28	Lamberet	17.715	67	3790	5	557	15	8	688	18	8	8
S.Av		24.569	186	2226	-	258	-	-	406	-	-	-
G.Ma		169.094	1090	6324	18							
G.Mi		13.972	13	6	3							
G.Av		33.106	203	1024	11							

4.2.2. Validation for Outbound Bus Stops

From 25 bus stops of F-T (outbound direction) five bus stops for good, 10 bus stops for moderate and other remained 10 bus stops for poor were taken and used for both morning and afternoon observed time to validated existing accessibility values. The validated data of outbound direction bus stops was shown in (Table 4.14 to 4.16).

4.2.2.1. Good Accessibility Bus Stops

From attribute values (Table 4.14), the trip generated by Anbesa bus at stop ID 15, 16 18 and 51 were increased and at stop ID 59 was decreased with compared to existing trips. These values indicated that number of high trips was generated. Out of 5 bus stops, 4 bus stops of ID number (15, 16, 51and 59) had similar accessibility value to existing accessibility value which indicated that the validation was satisfied by more than 50%. The validated results for five good bus stops were satisfied by 80% similar values can be seen from Table 4.18. Therefore, the greater than half percentage was indicating the strong similarity that means, the bus stops make good accessibility to users.

Table.4. 14: Bus stops categorized as ‘Good’ for F-T (outbound direction)

		Existing data				Observed data for Validated						
						Morning (8:00-9:30AM)			Afternoon (4:005:30 PM)			
bus stop ID	Stop Name	Road Densiy	Trip Generated by Bus	Population Served	Existing AI	Trip generation at Morning	AI	Average AI at Morning	Trip generation at after noon	AI	Average AI at After noon	Average AI for morning and afternoon
15	Kara1	61.581	66	4212	17	98	15	17	152	17	17	17
16	Wesen	59.905	66	5792	17	109	11	17	125	17	17	17
18	Condominium	61.168	536	509	17	556	15	17	210	18	18	18
51	megenagn	76.662	427	404	21	446	13	21	525	14	21	21
59	Yeka michael	51.110	339	3878	16	301	15	16	345	16	16	16
S.Av.		62.085	287	2959	-	302	-	-	271	-	-	-
G.Ma		76.662	1116	6116	21							
G.Mi		13.387	5	46	3							
G.Av		28.338	237	2040	12							

4.2.2.2. Moderate Accessibility Bus Stops

Out of 21 outbound moderate bus stops, 10 bus stops were randomly taken which used to validate existing moderate bus stop accessibility. From validation results, bus stop 38 and 65 have generated high trips during observation time with compared to existing trip generated. Other bus stops ID number of (7, 9, 52, 53, 68, 71, 96 and 104) generated moderate number of trips. All of these 10 bus stops indicated a moderate accessible to the users (Table 4.15). From these 10 observed data, all of them were under moderate accessibility value. However, out of 10 bus stops, 6 bus stops of 9, 52, 68, 71, 96 and 104 had similar accessibility value to existing accessibility value which indicated that the validation was satisfied by more than 50%. The validated results of six moderate bus stops were satisfied by 60% similar values can be seen from Table 4.18. Therefore, the greater than 50% validation result indicated a strong validation in which the bus stops make good accessibility to users.

Table.4. 15: Bus stops categorized as ‘Moderate’ for F-T (outbound direction)

		Existing data				Observed data for Validation						
						Morning (8:00-9:30AM)			Afternoon (4:005:30PM)			
bus stop ID	Stop Name	Road Densiy	Trip Generated by Bus	Population Served	Existing AI	Trip generation at Morning	AI	Average AI at Morning	Trip generation at after noon	AI	Average AI at After noon	Average AI for morning and afternoon
7	Ayat Adebabay	37.909	169	796	10	321	10	11	401	11	11	11
9	Meri	28.583	492	6046	12	272	9	11	418	12	12	12
38	Lamberet	47.297	37	502	12	213	7	13	359	10	13	13
52	Megenagn	26.185	532	1491	10	575	16	10	730	19	11	10
53	Total	28.449	532	3786	11	405	12	10	588	15	11	10
65	Minilik School	40.179	32	496	10	364	1	12	864	22	14	13
68	Gurara	33.393	312	2188	10	347	10	10	426	12	11	10
71	Bret Dildy	34.848	157	1694	10	279	9	10	294	9	10	10
96	Legehar	26.967	537	4012	11	537	15	11	348	10	10	11
104	GurdShola	31.137	460	998	10	409	12	10	571	15	11	10
S.Av		33.498	326	2201	-	372	-	-	499	-	-	-
G.Ma		76.662	1116	6116	21							
G.Mi		13.387	5	46	3							
G.Av		28.338	237	2040	12							

4.2.2.3. Poor Accessibility Bus Stops

Out of 89 F-T route direction poor bus stops, 10 bus stops were randomly taken which used to validate existing poor bus stop accessibility. From validation data results, at afternoon observation time, more bus stops generated moderate trips rather than morning time. All of these 10 bus stops indicated poor accessibility to the users shown in (Table 4.16). From these 10 observed data, all of them were under poor accessibility value. However, out of 10 bus stops, only five bus stops of 12, 15, 42, 106 and 109 had similar accessibility value which indicated the validation was satisfied by (50%) similar values can be seen fromTable 4.18.

Table.4. 16: Bus stops categorized as 'Poor' for F-T (outbound direction)

		Existing data				Observed data for Validation						
						Morning (8:00-9:30 AM)			Afternoon (4:005:30 PM)			
bus stop ID	Stop Name	Road Density	Trip Generatedby	Population Served	Existing AI	Trip generation at Morning	AI	Average AI at Morning	Trip generation at after noon	AI	Average AI at After noon	Average AI for morning and afternoon
12	Civil Service	23.882	492	116	8	318	10	7	517	14	8	8
15	Kara	23.581	66	4214	8	227	7	8	391	11	9	8
19	Lamberat	24.536	339	996	7	310	9	7	481	13	8	8
25	Anbessa Gebi	26.191	156	850	7	338	10	8	402	11	9	8
30	Megenagn	26.386	33	1364	7	379	11	9	492	13	9	9
41	Shola Gebya	18.233	66	2560	5	268	8	6	625	16	8	7
42	Shola	27.578	52	4418	8	187	7	7	315	9	9	8
64	Mazoria	21.521	313	2438	7	228	7	6	342	10	8	8
106	Tafo Gebrael	25.567	169	478	6	143	6	6	249	8	7	6
109	Wesen Michael	28.215	169	4832	9	186	7	9	247	8	9	9
S.Av		24.569	186	2226	-	258	-	-	406	-	-	-
G.Ma		76.662	1116	6116	21							
G.Mi		13.387	5	46	3							
G.Av		28.338	237	2040	12							

4.2.3. Jaccard similarity index (Jaccard similarity coefficient)

The Jaccard similarity index (Jaccard similarity coefficient) was used to compare members for two sets to see which members are shared and which are distinct. It measures the similarity for the two sets of data, with a range from 0% to 100%. In Jaccard similarity index the higher the percentage the more similar the two sets of data. Although, it is easy to interpret, it is extremely sensitive to small samples size data and may give erroneous results with are disimilar data sets. The Jaccard similarity index was used the following formulas. Jaccard similarity Index = (The number in both sets)/ (The number in either sets) *100. Therefore, in this portion, the Jaccard similarity index was used to identify the similarity percentage between the existing bus stop and validated bus stop accessibility values. The steps to identify the Jaccard similarity index are listed below:

1. Count the number of members which are shared accessibility index between both existing & validated data sets.
2. Count the total number of members in both sets (shared and unshared).
3. Divide the number of shared members by the total number of members.
4. Multiply the number, results gained from step 3 by 100.

Table.4. 17: **Similarity Coefficient Index for Inbound direction**

Bus Stop ID	Category Of Bus Stop	Existing Bus Stop AI	Validated Bus Stop AI	No of Similarity	Jaccard similarity Index In %
	Good				
5	Zone 8	18	18	4	80%
26	Megenagna	18	19		
46	Shila gebaya	18	18		
91	Lamberet	18	18		
101	Keste Demena	18	18		
	Moderate				
7	Megenagia	11	17	7	70%
31	Menelik Hospitial	10	10		
37	Shola	11	10		
41	Shola Gebeya	11	11		
70	British Embassy	10	10		
71	Minilik School	11	11		
72	6 Kilo Tele	11	10		
73	6 Kilo	10	10		
84	Belgium Embassy	10	10		
85	Kokebe Tsebah	10	10		
	Poor				

21	Anbessa Gebi	4	4	6	55%
24	Megenagna Terminal	6	9		
27	Kokeb Tsebay School	9	9		
44	Kotebe	5	7		
74	Eyesus	4	4		
81	Legehar	6	6		
10	Kara	5	8		
93	Wesen Michael	6	8		
79	Civil Service	4	4		
80	Gurd Shola	3	3		
28	Lamberet	5	8		

Table.4. 18: **Similarity Coefficient Index for outbound direction**

Bus Stop ID	Category of bus stop	Existing bus stop AI	Validated bus stop AI	No of similarity	Jaccard similarity Index in %
	Good				
15	Kara1	17	17		
16	Wesen1	17	17		
18	Condominium	17	18		
51	Megenagna	21	21	4	80%
59	Yeka michael	16	16		
	Moderate				
7	Ayat Adebabay	10	11	6	60%
9	Meri	12	12		
38	Lamberet	12	13		
52	Megenagn	10	10		
53	Total	11	10		
65	Minilik School	10	13		
68	Gurara	10	10		
71	Bret Dildy	10	10		
96	Legehar	11	11		
104	Gurd Shola	10	10		
	Poor				
12	Civil Service	8	8	5	50%
15	Kara	8	8		
19	Lamberat	7	8		
25	Anbessa Gebi	7	8		
30	Megenagna	7	9		
41	Shola Gebya	5	7		
42	Shola	8	8		
64	Mazoria	7	8		
106	Tafo Gebrael	6	6		
109	Wesen Michael	9	9		

4.3. Determination of Optimal Bus Stops

4.3.1. Optimal Locations

In the optimal location bus stop, the poor accessible bus stops were relocated and improved to excellent, good and moderate accessibility of bus stop. From the evaluation of existing bus stop accessibility, more bus stops provided poor accessibility in both direction of bus route. The existing bus stop accessibility values evident that, the good and moderate bus stops provided 16.97% and 25.83% of accessibility for inbound and outbound direction respectively. But more stops of 83.04% and 74.17% accessibility of inbound and outbound direction respectively were categorized as poor. This is evident that more existing bus stops provided very low accessibility. Therefore, it is required to identify the optimal locations of bus stops to improve the poor bus stop accessibility.

The Optimal locations for bus stops were proposed and identified based on criterion accessibility index and considering bus stop spacing standard of 800 meters to relocated bus stops (the stop which ensures maximum road density, served maximum population and ensure maximum trip generated by bus). **(**Muhammad et al., 2013). Four possible options such as (As it is of existing bus stops, relocating, creating new bus stops and dissolving of existing bus stops) was considered to mitigate existing poor bus stops and increase optimal accessible bus stop domain. The target of this proposed optimal location of bus stop to improve by increasing good & moderate existing bus stop accessibility domain into 60% and decrease poor bus stop accessibility domains into 40% in both inbound and outbound direction of bus stop. In this section, it was considered four possible options such as (As it is of existing bus stops, relocating, creating new bus stops and dissolving of existing bus stops) to mitigate existing poor bus stops which satisfied an optimal location of proposed bus stops and increase high accessibility bus stop domain. From these four options, the three options of (As it is, relocating and dissolving) were considered after proposed bus stops, which described in section 4.4. For proposed bus stop it was considered that the standard bus stop spacing of 800 meter and 400meter walking distances and the created new bus stops on along bus stop spacing. However, in order to identify optimal locations of bus stop using four possible options, the whole existing bus stops were generated on Anbessa Bus routes. The proposed bus stops within 800 meters standard stop spaced were located. The proposed bus stop kernel service area was determined using network analyst tool (the so-called *service area solver*) of ArcGIS software. For the ease of identifying optimal bus stops, both existing and proposed bus stops on Anbessa Bus route was displayed within the proposed bus stop service areas. Then, four possible options were used to identify optimal locations of bus stops. The bus stops categorized as good and moderate are kept in their location due to their high accessibility to users. There were no existing bus stops on the long portion of bus routes more than 800 meters, the new bus stops were created in that portion of routes. Other option of improving existing bus stop accessibility are done through relocation and dissolving. The existing bus stops provided low accessibility due to their unsuitable stopping spacing place and closeness to another bus stops has such bus stops were relocated and their dissolved.

Therefore, the identified existing bus stops which fall within the service areas that satisfied standard bus stop spacing and proposed bus stops in both inbound and outbound directions were presented in Figure 4.9 and 4.10 respectively. However, other remained accompaniment bus stops that fall in the same service areas within 400m interval which are nearest to the identified stops were removed. Then, the coverage area was generated for each proposed bus stops (Figure 4.19 and 4.20). In the same procedure like existing bus stop, the proposed bus stop accessibility was determined and evaluated and their data was shown in Annex C. The road density and population served were determined within service area of bus stops. The proposed bus stop road density and population served was determined using the same method like existing bus stop described as previous parts in section 3.7.1 and 3.7.3. However, there are two assumptions that were used to determine trip generations by bus. The proposed bus stop was fallen in existing service area, the trip generation of that bus stop was assumed to be an existing bus stop value which was nearest to proposed stop. However, in the new created bus stop, the service area was new. For this case considered the assumption of trip generation value which were an average value of all bus stop trips. Finally, accessibility (in terms of accessibility index) was identified for each bus stop from those three criteria of accessibility index. Based on these four options, the existing bus stop accessibility was improved the high accessibility domain from 16.96% to 60% and 25.83% to 60% and the poor accessibility bus stop domains were decreased from 83.03% to 40% and 74.17% to 40% in both inbound and outbound direction of bus stop respectively.

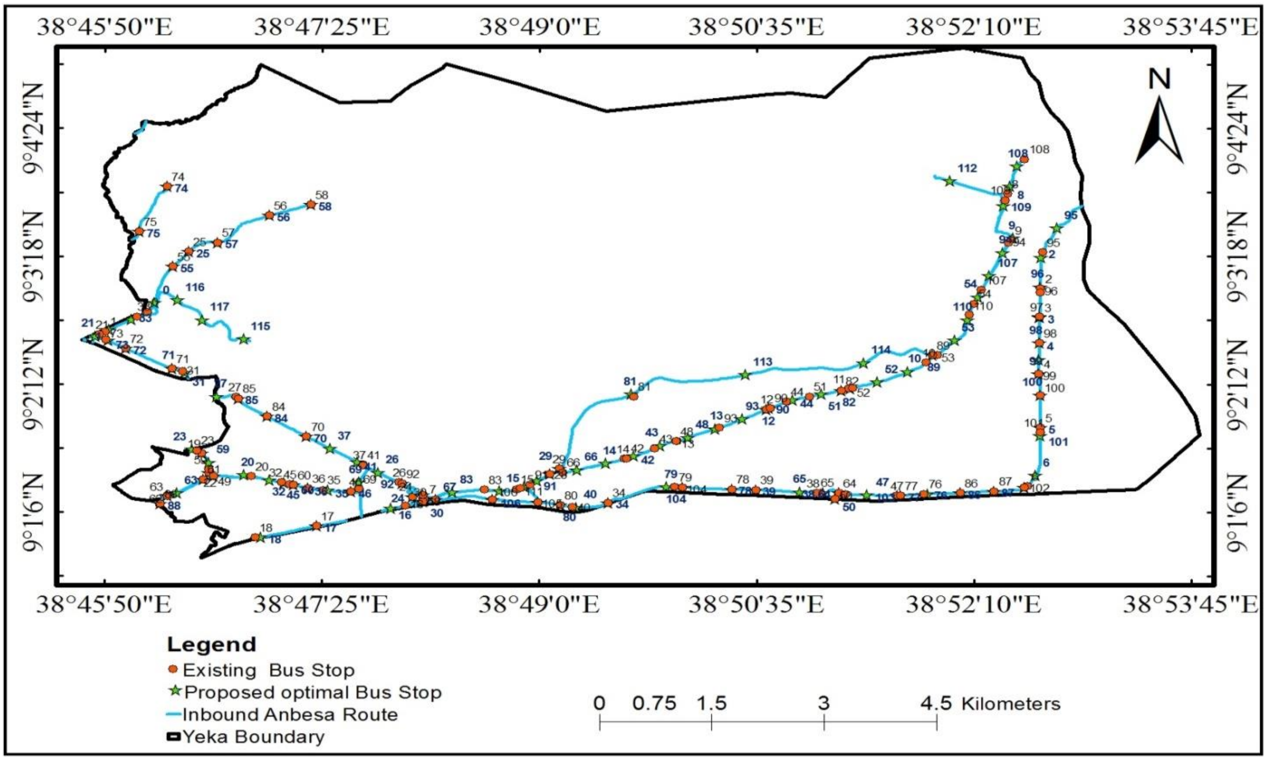


Figure.4. 9: Both existing and proposed Bus Stops T-F (Inbound direction)

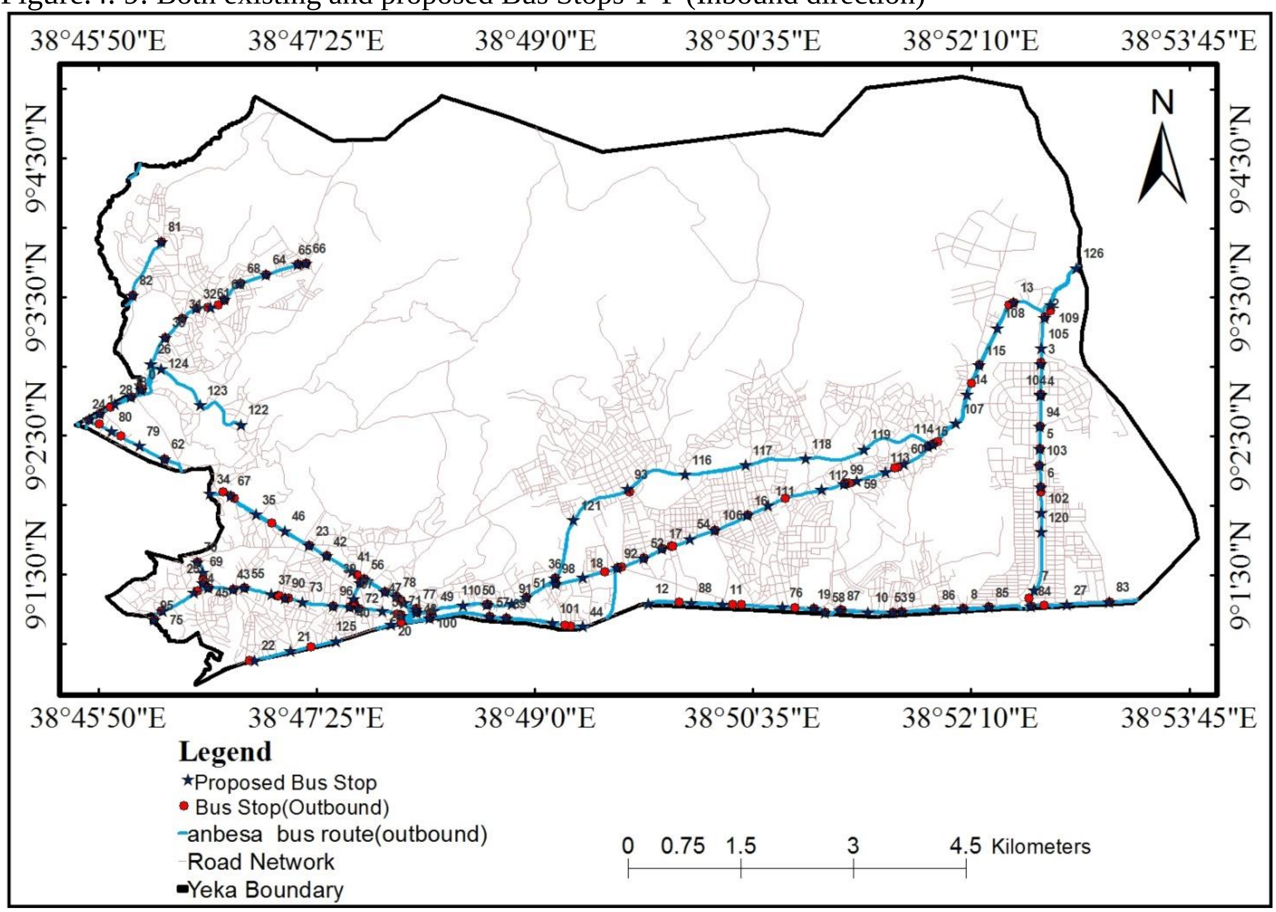


Figure.4. 10: Both existing and proposed Bus Stops F-T (Outbound direction)

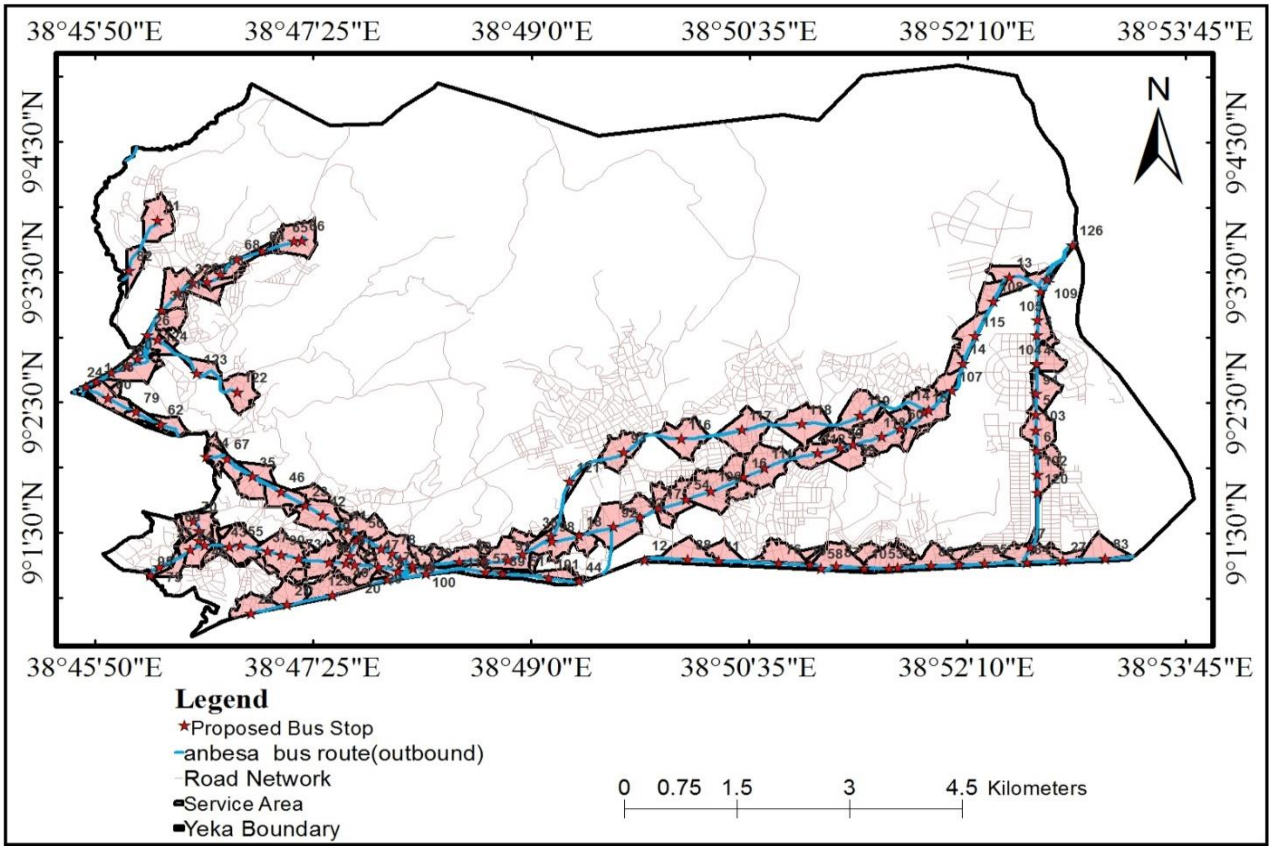


Figure.4. 11: Coverage area of proposed bus stops T-F (Inbound direction)

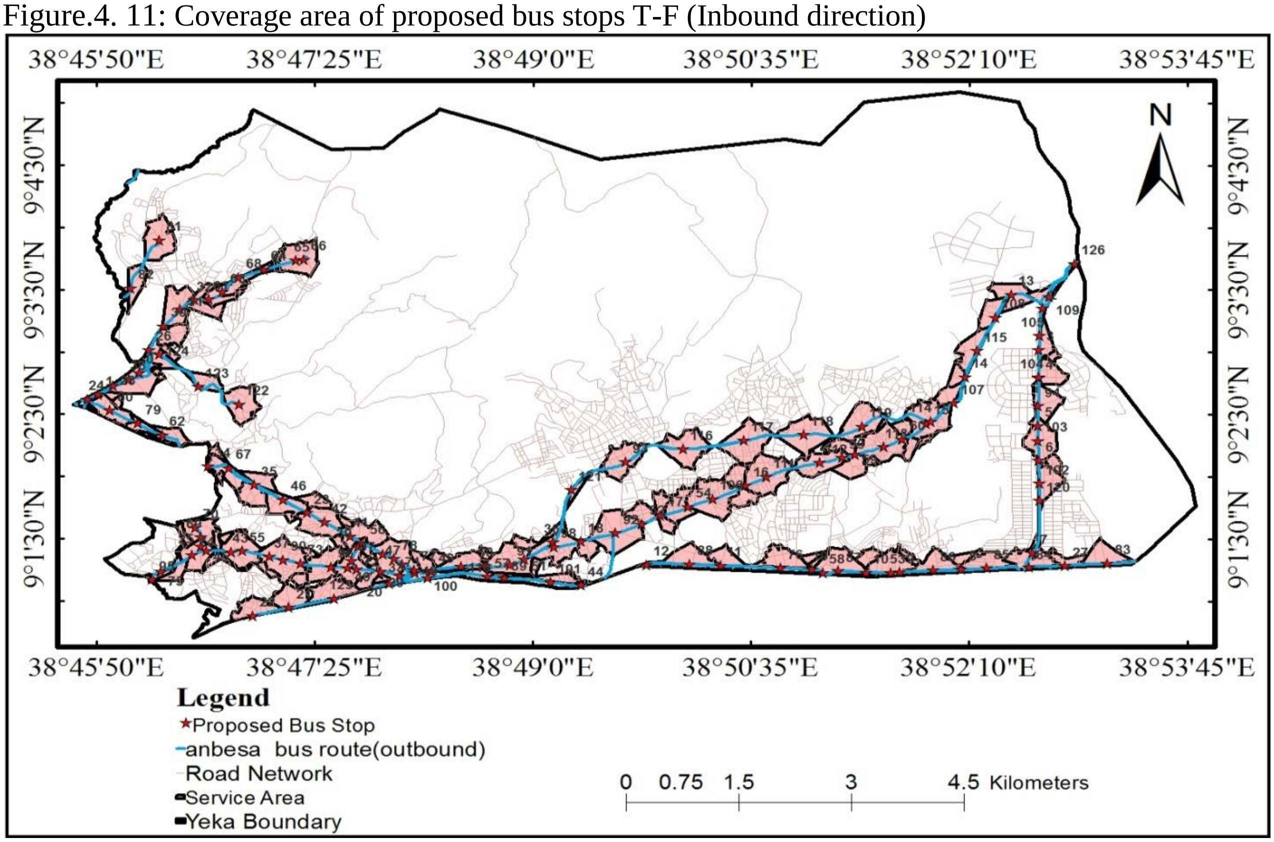


Figure.4. 12: Coverage area of proposed bus stops F-T (Outbound direction)

4.3.2. Evaluation of Inbound Optimal Bus Stops

The evaluation of optimal bus stop was the same procedure to the evaluation of existing bus stops. The accessibility index of each bus stop along with three criteria was shown in Annex C. The accessibility index of existing and proposed bus stop of T-F (inbound direction) was classified into four categories: Excellent, Good, Moderate and Poor attribute values were shown in (Table 4.19) and graphical results shown in (Figure 4.13).

Table.4. 19: Categorization of accessibility index for inbound bus stops

No	Category	Range of accessibility index	Existing Number of Stops		Proposed Number of stops	
		Value	Number	Percentage	Number	Percentage
1	Excellent	22-27	-	-	-	-
2	Good	16-21	9	8.036	10	8.475
3	Moderate	10-15	10	8.929	16	13.559
4	Poor	3-9	93	83.036	92	77.966
Total			112	100%	118	100%

The target of this optimal location was to improve optimal bus stop accessibility by located bus stops on standard stop spacing and created new bus stops along there was no existing bus stops on long stop spacing. For proposed inbound bus stop optimal location, seven new stops were created and the existing bus stop accessibility value was ultimately changed.

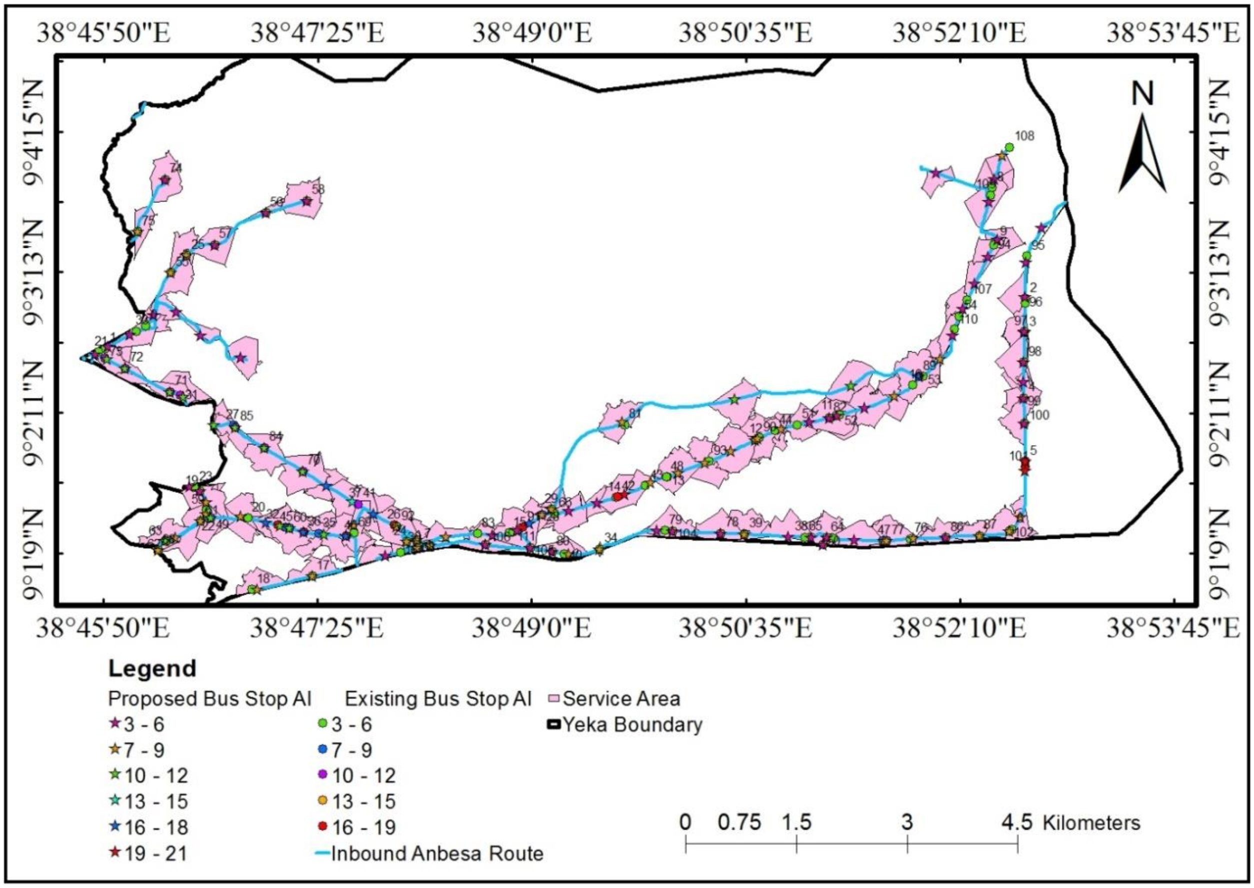


Figure.4. 13: AI classification of both existing and proposed bus stops (inbound direction

4.3.2.1. Good Accessibility Bus Stops

The result of accessibility analysis of proposed optimal bus stops shown in (Table 4.20) and graphically represented in (Figure.4. 14) that the more good accessibility bus stops were located from Megenagna bus terminal to Kara. Most good accessibility bus stops (i.e.70%) were located around Megenagna. After optimal locations, good bus stops were increased in number from nine bus stops to 10 good accessible bus stops which provided good accessibility. The good accessibility bus stop ID 5 and 101 were improved from existing of (18) to 21 and 20 respectively and provided maximum accessibility compared to other existing and proposed good accessibility bus stops values. Bus stop ID 5 and 101 had the same values road density, trip generation by bus and population served data in proposed and existing. Therefore the bus stop 5 and 101 accessibility index was changed by case of dissolved other bus stops which very closed to stop ID 5 and 101 and they kept standard stop spaced and they shift their accessibility value ranges. The grand maximum road density was found in stop ID 101. The existing bus stop ID 37 road density was increased from 22.86 to 69.86. It was changed from the existing moderate accessibility index value to proposed good accessibility index values which provided good accessibility after optimal locations. Other remaining proposed optimal bus stop ID (26, 32, 36, 42, 46, 89 and 91) had similar accessibility index values with existing values. They complement optimal possible options. In generally these optimal and good accessibility bus stops have high road density, maximum trip generation and dense populations to be served as compared to their sub Max and Grand Average values. Therefore after proposed optimal location of bus stops, the good accessibility bus stops were improved by increasing the number of good accessible bus stops from 9 (8.04%) to 10 (8.47%) and the maximum accessibility index values improved from 18 to 21. Therefore, relocated existing bus stops on standard stop spacing and dissolved bus stops which were very close to standard stop were the main factors for improved optimal bus stop accessibility which provided good accessibility to the users.

Table.4. 20: ‘Good’ bus stops in T-F (inbound road direction)

Bus Stop ID	Stop Name	Road Density (Km/Km^2)	Trip Generated in (No)	Population Served In (No)	Existed AI	Propose AI	AI category
5	Zone8	158.420	309	417	18	21	Good
26	Megenagna	108.537	528	3704	18	18	Good
32	Misrak	117.925	455	3184	18	18	Good
36	Signal	114.052	528	4702	18	18	Good
37	Shola	69.863	1069	3626	-	16	Good
42	Cool Hintsa	125.423	455	2370	18	18	Good
46	Shola Gebeya	109.157	528	4670	17	17	Good
89	Kara	139.771	51	4408	18	18	Good
91	Lamberet	126.869	346	3636	18	18	Good
101	Keste Demena	169.094	224	413	18	20	Good
Sub Max.		169.094	1069	4702	18	21	
Sub Min.		69.863	51	417	17	16	
Sub Avg.		117.4553	449	3113	18	17	
GrandMax.		**169.094**	**1090**	**6324**	**18**	21	
GrandMin.		**1.2239**	**13**	**4**	**3**	**3**	
Grand Avg.		**35.0407**	**198**	**1940**	**7**	**8**	

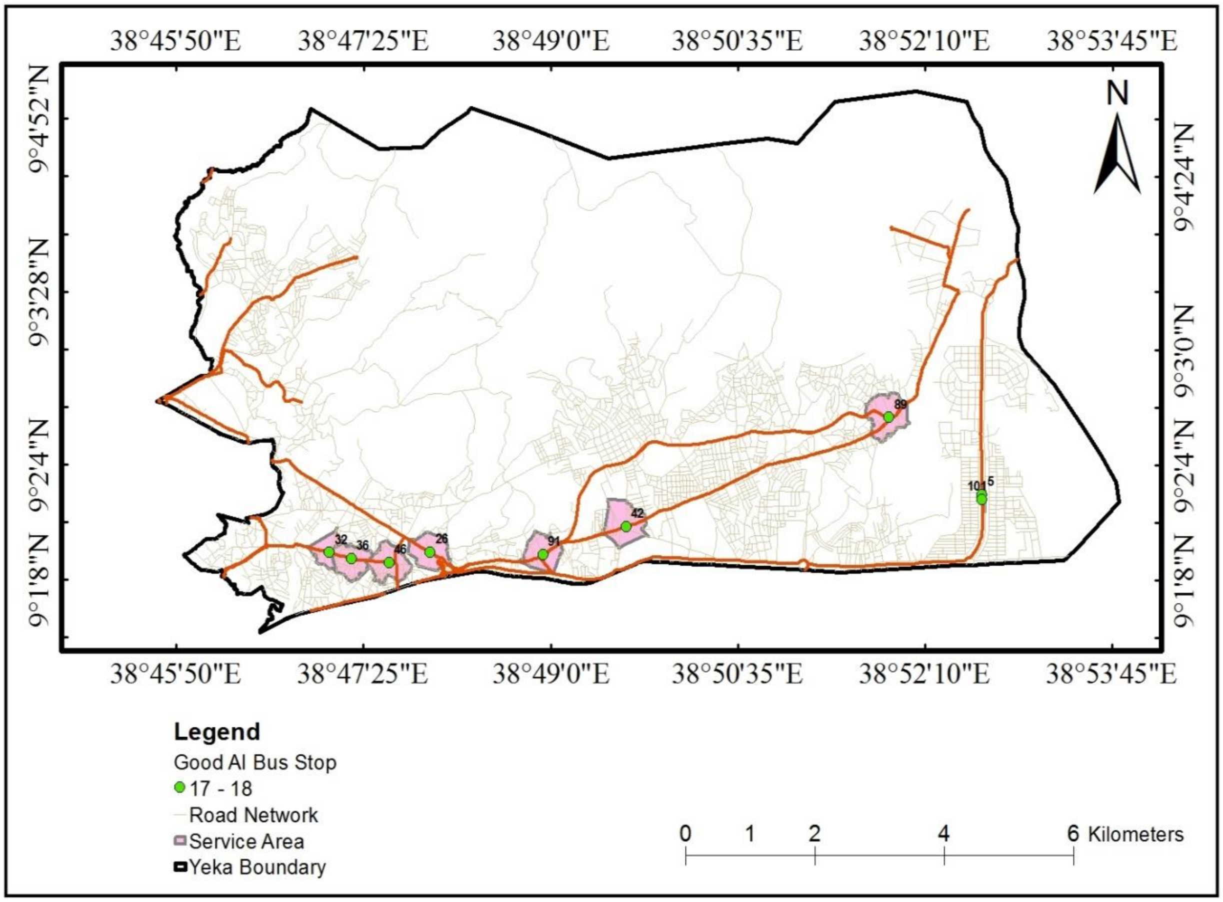


Figure.4. 14: 'Good' bus stops for proposed T-F (inbound road direction)

4.3.2.2. Moderate Accessibility Bus Stop

The result of accessibility analysis of proposed optimal bus stops were shown in (Table 4.21) and graphically shown in (Figure.4. 15) that the more moderate accessibility bus stops (i.e. 87%) were located from Megenagna bus terminal to six killo. After optimal locations, stop ID 27, 35, 45, 49 and 60 bus stops were improved and changed accessibility index values from poor to moderate which provided moderate accessibility (Table 4.21). The bus stop 27 and 35 accessibility was increase by increasing road density and densely population served within bus stop service area (Table 4.21). The bus stop ID 49 were had the same value of road density, trip and population served in both proposed and existing but after proposed optimal bus stop it categorized under moderate accessibility bus stops. Because after dissolved, Relocated and created new bus stops, the bus stops accessibility value was reclassified then bus stop ID 45 and 49-accessibility value was improved and fallen under moderate accessibility ranges. Bus stop ID 70 and 84-accessibility value were enhanced from 10 to 11 where increased population served after proposed optimal locations but road density and trip generation by bus was the same with existing values. In the same case, bus stop ID 41, 71, 72 and 73 accessibility values was increased. The road density of bus stop ID 31 was enhanced which increase accessibility index values. In generally these optimal moderate bus stops have moderate road density, generated maximum trips and served densely populations as compared to their sub Average and Grand Average values and existing moderate accessibility values improved from 8.93% to 13.56% which increased by 5%. Therefore the possible option of optimal locations such as standard stop spacing and dissolved were an important options which enhanced existing bus stops accessibility index value from minimum of 8 (poor) to maximum of 13 (moderate).

Table.4. 21: 'Moderate' bus stops in T-F (inbound road direction)

Bus Stop ID	Road Density (Km/Km^2)	Trip Generated by bus in (No)	Population Served in (No)	Existed AI	Proposed Accessibility Index	AI Category
7	92.824	47	192	11	11	Moderate
27	21.843	1069	788	9	11	Moderate
31	24.783	1082	2170	10	11	Moderate
35	30.732	528	6097	9	10	Moderate
41	22.572	1069	3668	11	13	Moderate
45	30.399	528	4148	9	10	Moderate
49	31.864	528	1636	8	10	Moderate
60	32.974	528	4304	9	10	Moderate
70	17.939	1069	2174	10	11	Moderate
71	34.632	1090	664	11	12	Moderate
72	21.782	1090	2020	11	12	Moderate
73	20.757	1090	1348	10	11	Moderate
84	20.922	1069	1744	10	11	Moderate
85	21.435	1069	694	10	11	Moderate
113	56.054	109	4409	10	10	Moderate
114	56.248	109	3504	10	10	Moderate
Sub Max	92.824	1090	6097	11	13	
Sub Min	17.939	47	192	8	10	
Sub Avg.	33.610	755	2472	10	11	
Grand Max.	**169.094**	**1090**	**6324**	**18**	**21**	
Grand Min.	**1.224**	**13**	**4**	**3**	**3**	**-**
Grand Avg.	**35.041**	**198**	**1940**	**7**	**8**	**-**

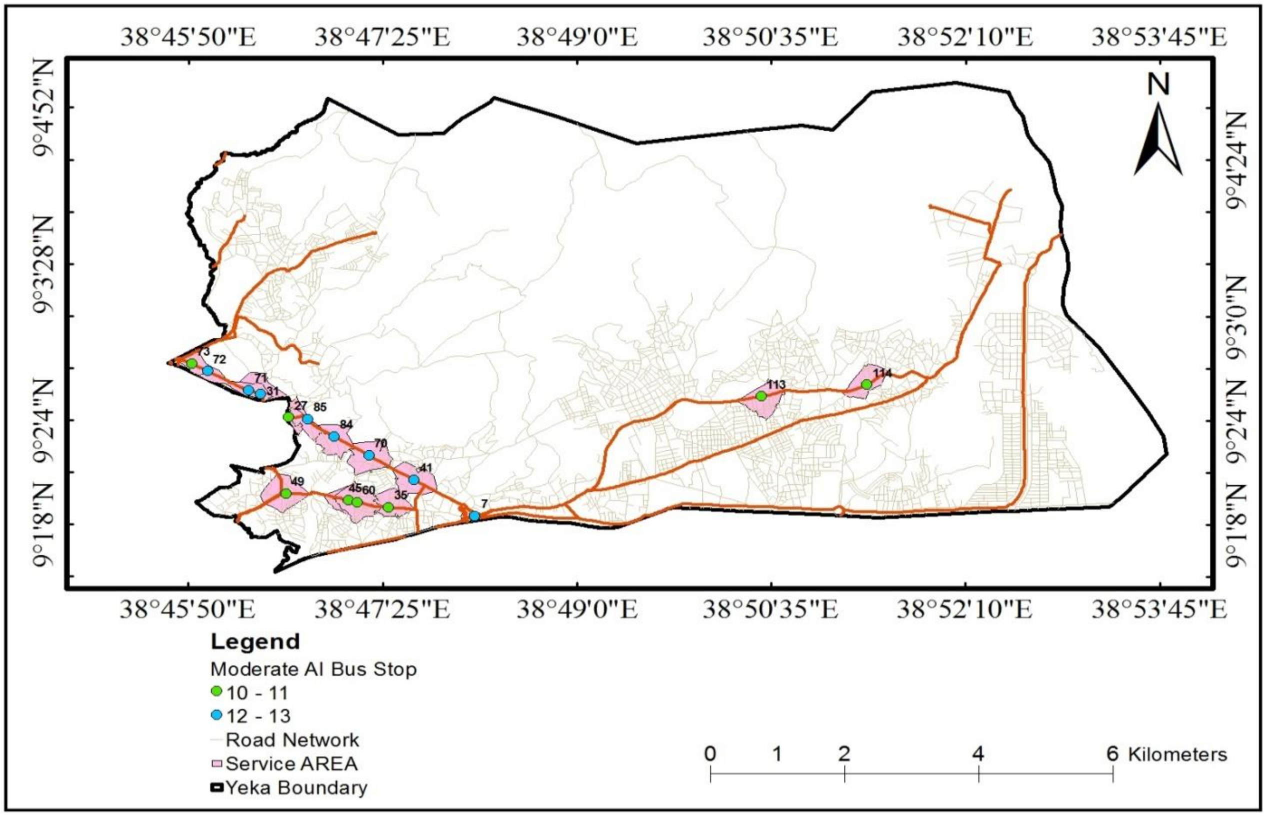


Figure.4. 15: ‘Moderate’ bus stops for proposed T-F (inbound road direction)

4.3.2.3. Poor Accessibility Bus Stops

The result of accessibility analysis of proposed optimal bus stops attributes values shown in (Table 4.22) and the graphical results shown in (Figure.4.16) that the poor bus stops were located all parts of bus route lines. From 118 proposed optimal inbound Bus Stops 92 bus stops were categorized as Poor. It was evident that some bus stops ID number of (6, 24, 25, 29, 30, 67 and 87) had road density greater than sub and grand average value, but its trip generation and population served were very low which less than sub and grand average value that was they provided poor accessibility. Bus stop ID number of (0, 10, 12, 13, 15, 17, 39, 43, 44, 47, 48, 53, 55, 69, 74, 77, 81, 83, 90, 92, 93, 106, 111 and 115) had high populations within bus stop service area but have very low road density and trip generation, which provided poor accessibility. Other remaining bus stops had low road density, population and trips generated by bus less than its sub maximum and grand average values. They provided very low accessible to the users and categorized as poor. The grand minimum road density, trip and population found in this poor category of bus stop. Generally, the attribute Table 4.22 results indicated that the road density, trip generation by bus and population served within bus stop coverage area were very low which provided poor accessible to the users. Therefore, the two parameters of road density and trip generation results less than their grand average values were provided poor accessibility, which means that it gives poor access to the users.

Table.4. 22: ‘Poor’ bus stops in T-F (inbound road direction)

Bus Stop ID	Road Density (Km/Km²)	Trip Generated by bus in (No)	Population Served in (No)	Existed bus stop AI	Proposed bus stop Accessibility Index	AI Category
0	18.834	64	3760	5	6	Poor
1	16.692	64	350	3	5	Poor
2	21.769	64	51	4	5	Poor
3	27.349	47	56	4	5	Poor
4	30.816	47	416	4	6	Poor
6	35.685	47	1274	5	7	Poor
8	14.684	36	14	3	4	Poor
9	15.517	66	400	3	5	Poor
10	22.072	36	4028	5	6	Poor
11	24.151	36	2186	4	6	Poor
12	30.509	36	4264	6	7	Poor
13	25.289	36	3666	5	6	Poor
14	18.536	36	2162	4	5	Poor
15	19.922	67	3552	5	6	Poor
16	32.631	41	708	5	6	Poor
17	22.465	41	3334	5	6	Poor
18	32.244	41	1598	5	6	Poor
19	19.507	58	2474	4	5	Poor
20	19.773	528	684	6	7	Poor
21	21.315	64	396	4	5	Poor
22	21.022	149	3116	6	7	Poor
23	25.267	58	1664	4	6	Poor
24	49.995	13	520	6	8	Poor
25	35.889	15	2552	6	7	Poor
28	28.023	346	1406	7	8	Poor
29	47.297	37	643	6	7	Poor
30	36.638	451	472	8	9	Poor
33	15.887	64	2714	4	6	Poor
34	38.019	74	80	5	6	Poor
38	18.367	74	382	3	5	Poor
39	21.609	74	3082	5	6	Poor
40	28.278	74	852	5	6	Poor
43	28.690	36	3394	6	7	Poor

44	29.888	36	3102	5	7	Poor
47	29.061	47	6190	7	8	Poor
48	24.687	36	3744	5	6	Poor
50	22.512	27	508	4	5	Poor
51	24.715	36	1604	4	6	Poor
52	25.612	36	1896	4	6	Poor
53	23.793	36	3410	5	6	Poor
54	24.494	46	586	4	5	Poor
55	26.537	15	3748	6	6	Poor
56	27.866	15	1776	5	6	Poor
57	23.535	15	2246	5	6	Poor
58	24.698	15	2132	4	6	Poor
59	27.111	149	2778	6	7	Poor
61	28.488	91	2604	6	7	Poor
62	31.087	470	2990	8	9	Poor
63	28.125	91	1434	5	6	Poor
64	17.547	47	938	3	5	Poor
65	18.237	74	296	3	5	Poor
66	25.762	36	892	4	5	Poor
67	37.898	47	688	5	6	Poor
68	32.273	67	1180	5	6	Poor
69	27.408	58	3636	6	7	Poor
74	22.337	25	2178	4	6	Poor
75	32.383	25	1794	5	6	Poor
76	32.585	47	2094	5	6	Poor
77	27.561	47	6324	7	7	Poor
78	13.973	74	882	4	4	Poor
79	17.959	47	78	3	5	Poor
80	21.713	74	910	4	5	Poor
81	26.967	37	4012	6	6	Poor
82	22.837	36	1932	4	6	Poor
83	25.523	67	3526	5	6	Poor
86	27.382	47	1138	5	5	Poor
87	38.512	47	770	5	7	Poor
88	37.059	91	288	5	7	Poor
90	30.784	36	4016	6	7	Poor
92	23.990	77	3506	5	6	Poor
93	27.506	36	4594	6	7	Poor
94	17.771	66	380	3	5	Poor
95	24.175	47	200	4	5	Poor
96	28.023	47	42	4	5	Poor
97	25.816	47	62	4	5	Poor
98	23.381	47	28	4	5	Poor
99	32.256	47	306	4	6	Poor
100	33.974	47	180	5	6	Poor

102	35.049	47	1538	6	7	Poor
103	20.611	47	1026	4	5	Poor
104	24.487	74	112	4	5	Poor
105	18.086	60	430	3	5	Poor
106	26.557	60	2092	5	6	Poor
107	24.131	36	328	4	5	Poor
108	16.632	336	6	5	6	Poor
109	14.578	36	66	3	3	Poor
110	22.466	66	548	4	5	Poor
111	21.715	67	3790	5	6	Poor
112	13.651	109	4	4	4	Poor
115	14.977	109	3022	5	6	Poor
116	15.797	109	1247	4	5	Poor
117	1.224	109	1247	4	3	Poor
Sub Max.	49.995	528	6324	8	8	
Sub Min.	1.224	13	4	3	3	
Sub Avg.	26.418	74	1731	5	6	
Grand Max.	**169.094**	**1090**	**6324**	**18**	**21**	**-**
Grand Min.	**1.224**	**13**	**4**	**3**	**3**	**-**
Grand Avg.	**35.041**	**198**	**1940**	**7**	**8**	

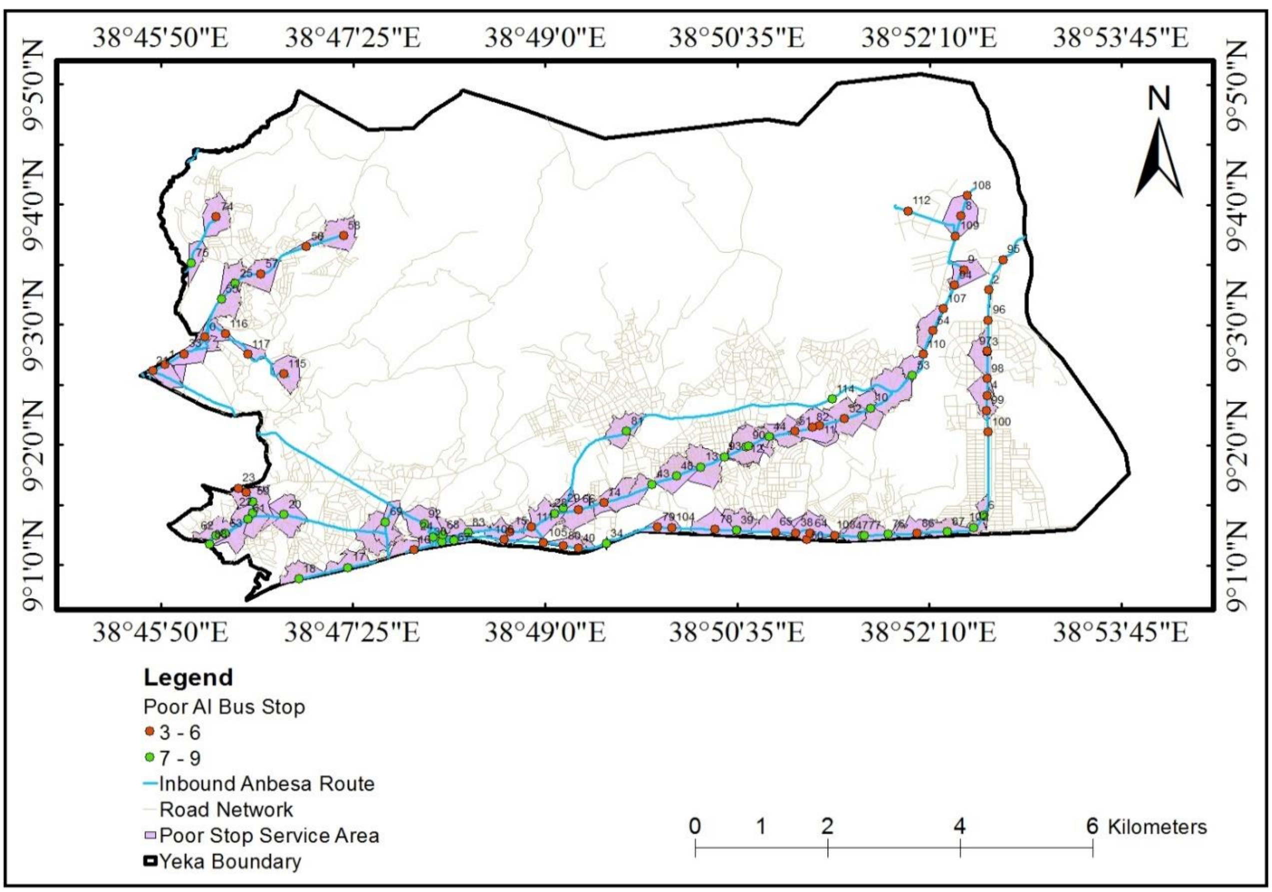


Figure.4. 16: ‘Poor’ bus stops for proposed T-F (inbound road direction)

4.3.3. Evaluation of Optimal Outbound Bus Stops

The outbound route direction had 120 existed bus stop and 127 proposed bus stops. From the outbound stops, it was evident that similar to inbound stop direction, there were no bus stop which categorized as excellent. All both existed and proposed optimal bus stop accessibility was categorized as under good, moderate and poor. However, more bus stops (out of 127 bus stop, 87 bus stops) fall under poor stop category. Therefore, the optimal location of bus stop was required to improve the accessibility values which increase the good and moderate accessibility and diminished the poor accessible values. In proposed optimal location of bus stop, seven new bus stops were created to improve existing bus stops accessibility.

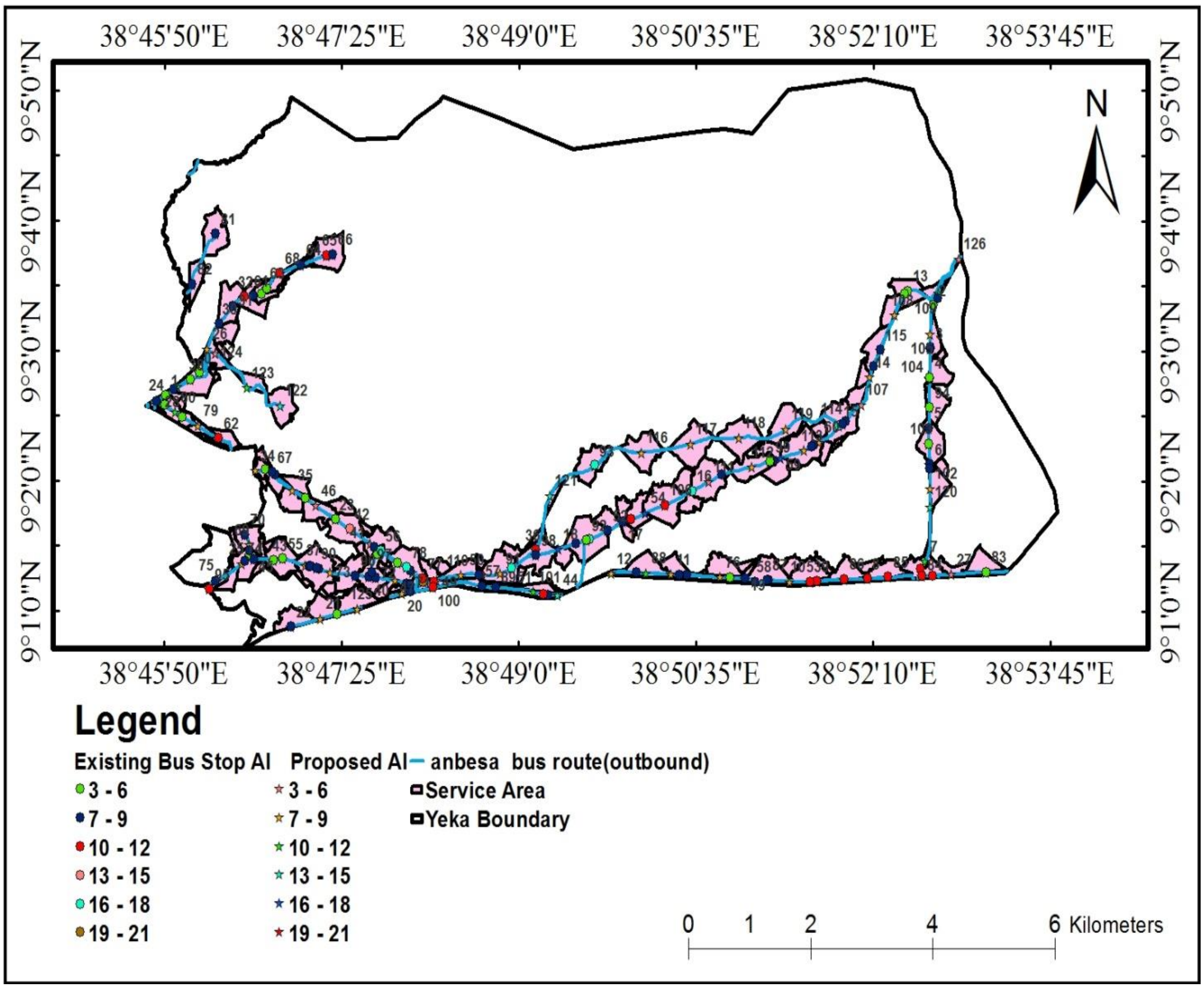


Figure.4. 17: Accessibility index of both existing and proposed bus stops in outbound direction

4.3.3.1 Good Accessibility Bus Stops

The result of accessibility analysis of proposed optimal bus stops attribute values were shown in (Table 4.23) and graphical results (Figure.4. 18) that more of (60%) good accessibility bus stops were located from Megenagna to Kara. After optimal locations of bus stops, numbers of good bus stops were increased by one from 8 good accessibility bus stops to 9 good accessibility bus stops which provided good accessibility. The bus stop ID 96 had the same value of road density, trip and populations in both proposed and existing data but after proposed optimal locations, enhanced and provided maximum accessibility to compare with existing accessibility values. The road density of existing bus stop ID number 63 increased from 25.634 to 52.735. It was changed the accessibility index values from poor accessibility to good accessibility values, which provided good accessibility to the users after optimal locations. Other remaining proposed optimal bus stop ID numbers (15, 16, 18, 51, 54 and 81) had high road density and population served within their service area had similar accessibility value with existing values. They kept the existed good accessibility values. All bus stops had high road density value that greater than their grand average road density value and more approach to grand maximum values, that was the main factors for provided good accessibility. In generally these optimal and good accessibility bus stops have high road density and dense population to be served as compared with their grand average value which provided good accessibility to the users. Therefore after proposed optimal location of bus stops, the good bus stops were improved by enhancing the number of good accessible bus stops from 8 (6.667%) to 9 (7.087%) and the grand average accessibility index value increased from existing of 8 to 9. Therefore, the possible options of newely created bus stops, existing bus stops relocated on standard stop spacing and dissolved bus stops which are very close to standard stops were the main factors for improved optimal bus stop accessibility which provided good accessibility to the users.

Table.4. 23: 'Good' bus stops in T-F (Outbound road direction

Bus Stop ID	Stop Name	Road Density (Km/Km²)	Trip Generated By Bus in (No)	Population Served in (No)	Existed AI	Proposed AI
15	Kara1	61.581	66	4214	17	17
16	Wesen1	59.905	66	5792	17	17
18	Condominyem1	61.168	208	2240	17	17
51	Megenagna1	76.662	536	509	21	21
54	Lamberet1	51.172	485	3638	17	17
59	Yeka Michael1	51.110	339	3878	16	16
63	Kera Sayiders	52.735	66	3646		16
81	Megenagna1	53.991	339	3566	16	16
96	Legehar1	47.967	537	4012	16	17
Sub Max.		76.662	537	5792	21	21
Sub Min.		47.967	66	509	16	16
Sub Avg.		54.354	293	3499	17	17
Grand Max.		**76.662**	**1116**	**6116**	**21**	**21**
Grand Min.		**10.982**	**5**	**45**	**3**	**3**
Grand Avg.		**28.719**	**231**	**2017**	**8**	**9**

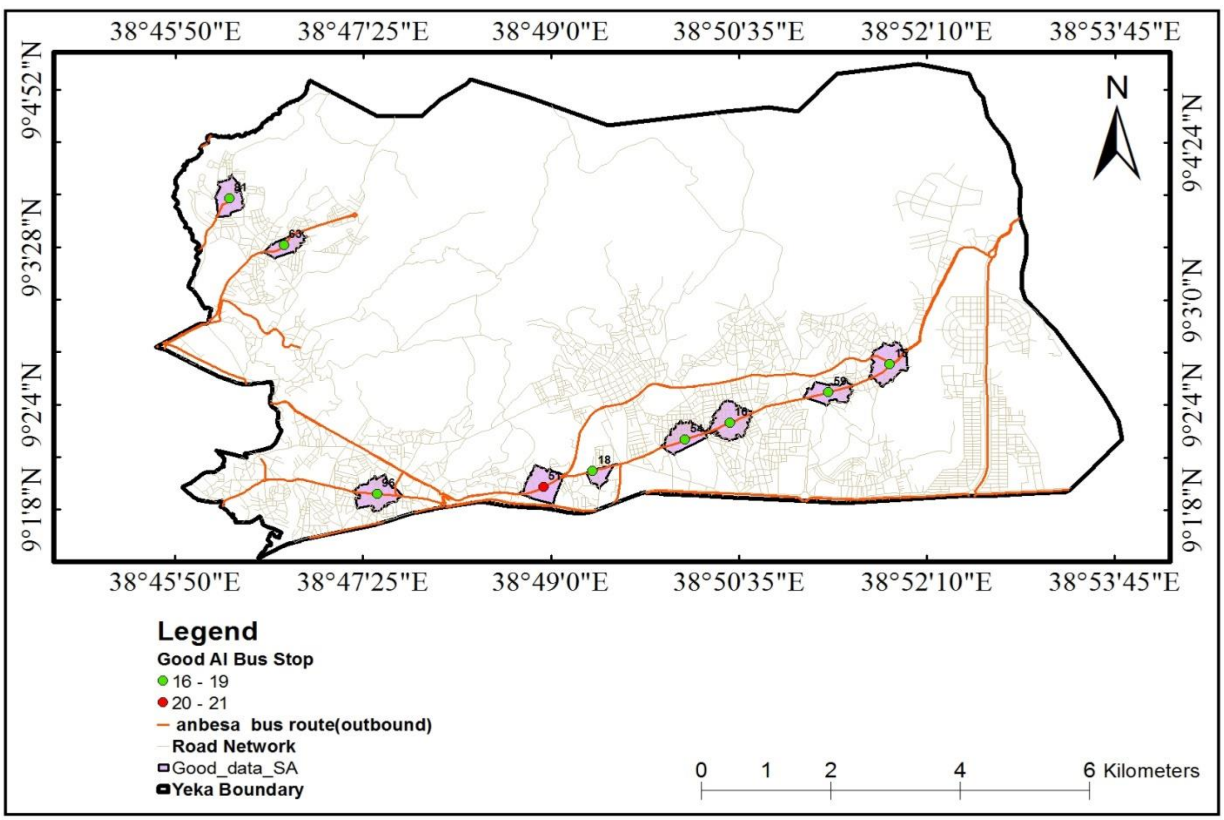


Figure.4. 18: 'Good' bus stops F-T (Outbound road direction)

4.3.3.2. Moderate Accessibility Bus Stops

The result of accessibility analysis of proposed optimal bus stops attribute values were shown in (Table 4.24) and graphical results shown in (Figure.4. 19) that the moderate accessibility bus stops were located on all parts of the study area. The bus stop ID 6, 47, 50 and 101 had the similar value of road density, trip generation and population served in both proposed and existing values but after proposed optimal bus stop, they categorized as under moderate accessibility bus stops. Because after dissolved, Relocated and created new bus stops, the bus stops accessibility value were reclassified then these bus stop accessibility value was fall under moderate accessibility index ranges. Simlarly, created new bus stop ID number of 120, 121, 122 and 123 on long stop spacing where their was no located existing bus stops. From these newely created bus stops, stop ID number 121 provide sub maximum road density and stop ID 120 and 121 provide sub maximum moderate accessibilityindex values. The grand maximum population served also found in moderate accessibility bus stops category. Therefore, the parameter of population served was the main factor for moderate accessibility bus stops. Other remaining proposed optimal moderate accessibility bus stop had similar result of road density, trip generation and population served with existing values and they kept the existing good accessibility values. Therefore the possible option of optimal locations of standard stop spacing, dissolved and created new bus stop are an important options that change existing bus stop accessibility values from minimum of 8 (poor accessibility) to maximum of 14 (moderate accessibility) and enhancing number of existing moderate accessibility bus stops from 23 (19.167%) to 31 (24.409%) which increase by 5%. In generally for outbound direction of bus stop, more stops were satisfied moderate accessibility than of inbound direction bus stops.

Table.4. 24: 'Moderate' bus stops in T-F (Outbound road direction)

Bus Stop ID	Road Density in (Km/Km²)	Trip Generated By Bus	Population Served within service area	Existed AI	proposed AI
6	35.659466	169	1038	-	10
7	37.909594	169	796	10	10
8	30.097009	492	1426	10	11
9	28.582954	492	6046	12	12
28	36.219211	323	1024	11	11
33	34.538917	156	2590	10	10

38	47.297552	37	502	12	12
44	44.106705	321	2778	13	14
47	28.445404	460	666	-	10
50	27.789662	339	3037	-	10
52	26.184681	532	1491	10	10
53	28.449554	532	3786	11	11
56	27.574391	492	6116	11	12
65	40.179417	32	496	10	10
68	33.392792	312	2188	10	10
71	34.848549	157	1694	10	10
80	31.207954	485	1382	11	11
87	35.336629	323	1064	10	11
88	36.665531	492	810	12	12
89	23.89171	1116	1116	12	12
94	29.672712	485	3780	11	12
98	37.059942	286	288	10	10
101	31.747962	339	748	-	10
103	38.159934	460	923	12	12
104	31.137192	460	998	10	10
109	33.214929	169	4832	11	11
114	33.560928	104	3706	10	10
120	53.346448	112	122	-	14
121	57.512326	112	95	-	14
122	46.665705	112	3157	-	13
123	35.460242	112	1792	-	10
Sub Max.	57.512326	1116	6116	13	14
Sub Min.	23.89171	32	95	10	10
Sub Avg.	35.035213	328	1951	11	11
Grand Max.	**76.662**	**1116**	**6116**	**21**	**21**
Grand Min.	**10.982**	**5**	**45**	**3**	**3**
Grand Avg.	**28.719**	**231**	**2017**	**8**	**9**

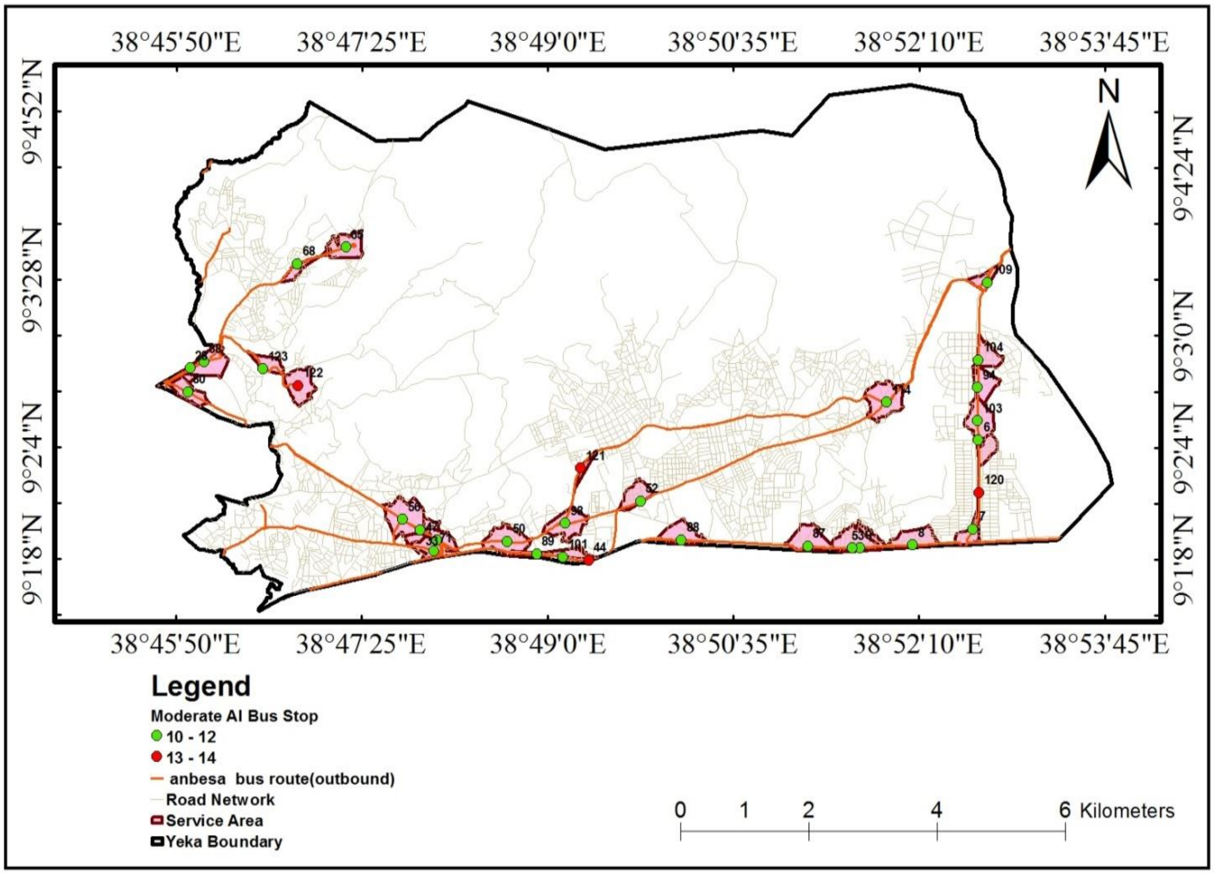


Figure.4. 19: 'Moderate' bus stops F-T (Outbound road direction)

4.3.3.3. Poor Accessibility Bus Stops

The result of accessibility analysis of proposed optimal bus stops attributes values were shown in (Table 4.25) and graphical results (Figure.4.20) the poor bus stops were located all parts of bus route lines. From 127 proposed optimal outbound Bus Stops 87 bus stops were categorized as Poor. It was evident that some bus stops such as (5, 17, 21, 23, 85, 105 and 117) had road density greater than sub and grand average value, but generated very low trips less than sub and grand average value and served low population that they provided poor accessibility. Other remaining proposed bus stops (for example. 10, 12, 13, 61, 92, 112 etc.) had very low road density and served minimum population less than its proposed grand average value which provided poor accessibility. The grand minimum road density, trip generation and population served were found to be in poor category of bus stop. Therefore, the two parameters of road density and trip generation results less than of their grand average value were the cases to provide poor accessibility, which means that it gives poor access to the users. Generally the attribute results shown in (Table 4.25) indicated that the road density, trip generation by bus and population served within bus stop coverage area had very low which provided poor accessibility to the users. However, 74.167% of existing stops out of 120 and 68.504% proposed optimal stops out of 127 were provided poor accessibility to the users which indicated that 5% of poor accessibility bus stops were minimized and improved existing bus stop accessibility.

Table.4. 25: 'Poor' bus stops in T-F (Outbound road direction)

Bus Stop ID	Road Density (Km/Km^2)	TripGenerated by bus in (No)	Population Served in (No)	Existed stop AI	Proposed AI
0	18.280903	163	3728	6	6
1	16.893418	72	428	4	5
2	25.308156	169	198	6	5
3	26.370812	169	47	7	5
4	25.747049	169	65	6	6
5	30.148798	169	185	8	7
10	18.800423	492	942	7	4
11	22.726988	492	1548	8	5
12	23.881831	492	116	8	6
13	15.628123	295	546	4	6
14	24.967588	295	596	7	7
17	30.159644	104	3528	9	6
19	24.536458	339	996	7	5
20	20.606013	492	296	7	6
21	32.180605	6	714	8	6
22	22.110698	5	3328	6	6
23	32.244301	41	1598	8	6
24	23.508416	34	2606	6	5
25	26.191082	156	850	7	7
26	21.022058	91	3116	6	5
27	18.782676	157	3674	6	7
29	28.124791	157	96	7	6
30	26.386359	33	1364	7	8
31	26.744667	156	3788	8	7
32	24.459561	156	3218	8	8
34	23.265885	157	1502	6	7
35	23.497031	32	3618	6	9
36	15.347303	321	910	5	6
37	22.193521	321	690	7	6
39	26.380696	52	3536	8	5
40	15.88735	194	2714	5	6
41	18.233101	66	2560	5	6
42	27.577693	52	4418	8	7

43	22.580035	321	3672	8	7
45	24.464958	52	3770	7	8
46	17.511265	52	1376	4	6
48	34.224839	52	1544	9	5
49	19.622202	321	1076	6	6
55	28.841353	104	2952	8	6
57	23.459367	104	3822	7	6
58	18.852652	52	764	5	5
60	25.21857	460	1890	9	6
61	20.827993	492	316	7	6
62	25.227135	104	1900	7	6
64	21.52058	313	2438	7	6
66	21.872003	157	1124	6	7
67	29.870368	157	1792	8	7
69	24.698419	312	2132	8	9
70	21.438392	321	692	7	6
72	27.110996	91	2778	8	5
73	24.436212	91	2176	7	5
74	34.294054	33	948	8	5
75	28.906284	33	4268	9	6
76	29.091308	52	4228	9	6
77	28.488975	91	2604	7	7
78	28.124572	143	1434	7	6
79	15.697089	492	752	6	6
82	21.502086	32	2080	6	6
83	20.756872	32	1348	5	7
84	22.337306	492	2178	8	4
85	32.383596	49	1794	8	5
86	18.909849	174	188	5	5
90	18.192872	492	1072	7	6
91	22.085095	492	908	8	6
92	20.526282	460	986	7	6
93	26.60389	52	4234	8	5
95	18.392397	208	2036	5	7
97	13.387412	143	46	3	7
99	29.694552	52	4104	9	7
100	27.314118	19	3650	8	6
102	22.609586	104	2310	6	7
105	33.088952	169	960	9	5
106	25.566697	169	478	6	5
107	16.842734	169	54	4	5
108	26.465466	104	46	7	5
110	19.567415	295	2992	7	5
111	15.200188	295	422	4	6
112	23.91572	462	266	8	6

113	26.401179	295	3846	9	7
115	28.469054	66	4214	8	5
116	23.453212	104	2164	6	5
117	31.704164	104	3254	9	5
118	24.272768	295	3508	8	6
119	24.231345	295	996	7	5
124	15.66759	112	2387		6
125	27.170031	112	3700		3
126	10.982062	112	45		5
Sub Max.	34.294054	492	4418	9	9
Sub Min.	10.982062	5	45	3	3
Sub Avg.	23.7042	189	1887	7	6
Grand Max.	**76.662**	**1116**	**6116**	**21**	**21**
Grand Min.	**10.982**	**5**	**45**	**3**	**3**
Grand Avg.	**28.719**	**231**	**2017**	**8**	**9**

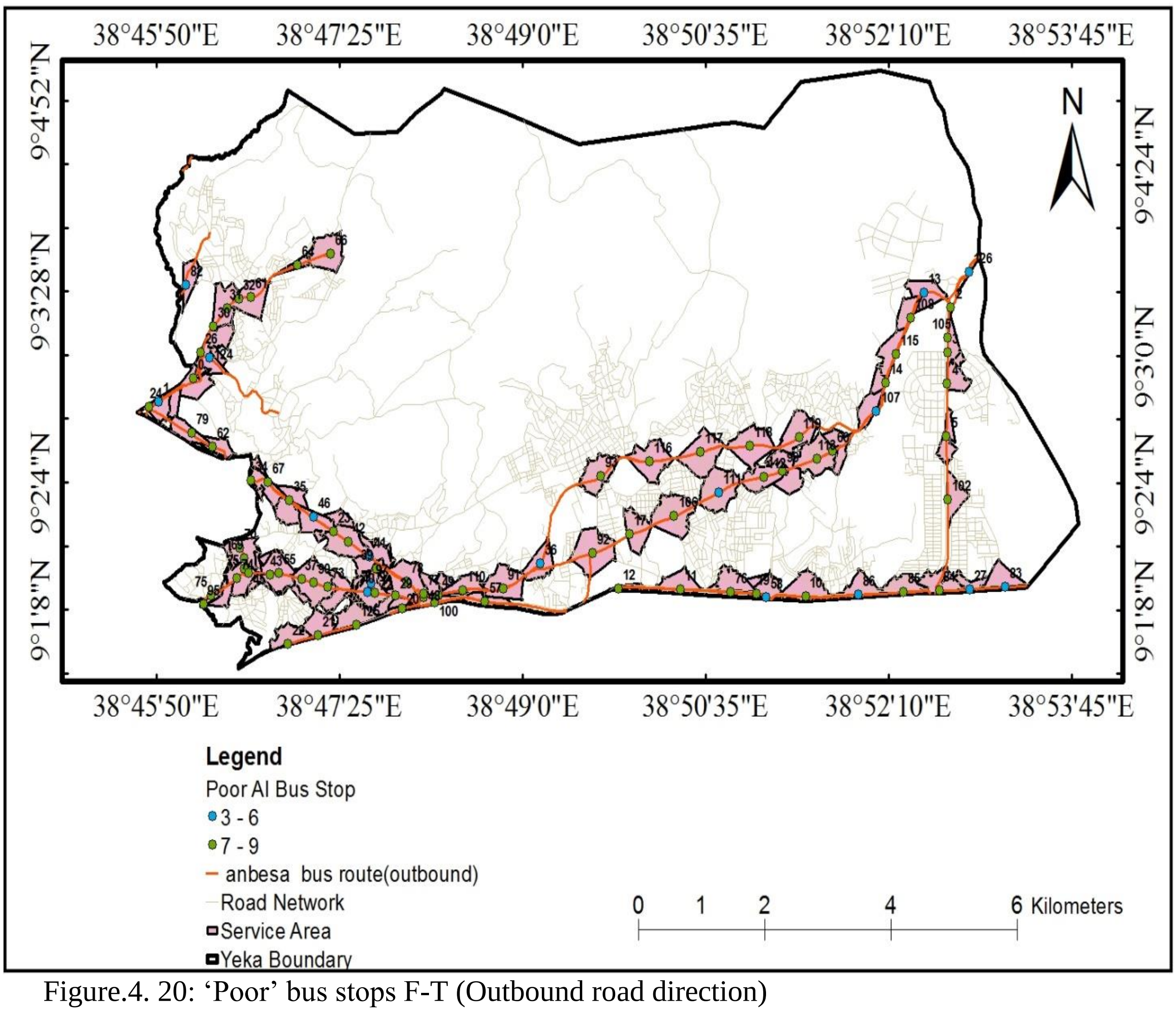


Figure.4. 20: ‘Poor’ bus stops F-T (Outbound road direction)

4.4. Identifying of Mitigation Measures for Optimal Bus Stop Locations

The optimal locations were determined in a comparative basis. For a given length of road and from a series of bus stops, the stop which shows the maximum accessibility was denoted as optimal location. Closer stop spacing were provide denser bus stops which would be facilitate short walking distance and hence increase accessibility. However, it could increase travel time considerably. In general where longer trips are made, long travel time for public bus which make the service less effective. However, this section of research was presented to identify optimal locations from a series of generated bus stops based on accessibility index and considering a standard for bus stop spacing. In this study, optimal locations for bus stops are denoted those locations where passengers can get highest accessibility compared to other adjacent locations. Different transport authorities of different city have different criteria about how they will provide services to the passengers. For example, there are two concepts to specify optimal location of bus stop. The first factor to identify optimal location of bus stop was accessibility index. If two or more stops fall under the same range of accessibility index, then bus stop having the highest accessibility index could be considered as optimal location. Moreover, if two or more stops have same accessibility index, then parameters of the accessibility index could be considered in the following order of priority weightage: Road Density, Trip Generation and Population Served.

The second important factor that is considered for identifying optimal locations for the whole bus routes was bus stop spacing which has a major impact on transit vehicle by bus and system performance. Stop spacing also affects overall travel time, and therefore, demand for transit, (TCRP, 1996). Although, the standard for bus stop spacing varies from country to country-different transport authority used different standard according to the demand based on development types. Moreover, the standard of spacing however differs in urban areas and rural areas. The country offers service to the largest number of people with the notion of increasing access to services rather than increasing accessibility, which led to an increase in the number of stops along the existing routes. However, the increase in the number of stops has a direct effect on the type and quality of service provided. Van Nes and Bovy (2000) compared estimates of optimum stop spacing based on costs to average stop spacing in two cities (Europe and Netherlands), in the Netherlands, which range between 9,144 to 13,716 feet (300 to 450 meters) and recommended an increase in spacing from 15,240 to 24,384 feet (500 to 800 meters). In

Yeka Sub City, there was no common standard for bus stop spacing because of variation of development type. Long spacing would provide longer walking distance but more infrequent stops which will facilitate higher travel speeds and therefore shorter bus trips. But long spacing might be unfeasible where generally shorter trips are made, and where providing accessibility was more important for passengers. Therefore, it is important to understand the requirement or demand of the passengers in order to specify the bus stops, and transport authority of that area is to determine the suitable parameter. In Yeka Sub City, the bus stop spacing was generated from 400m to 1000m. However, some bus stops were generated within less than of 400m spacing intervals. These stops would provide less confortable transport facilities because of in variation of urban growth and its population. It assumed that passengers would prefer public bus for travelling of short trips having distance more than 400 meter. All these reviewed many research paper and criterias could suggest that considered an average a reasonable and comfortable walking distance of 800 meter Since, 400 meter was a comfortable walking distance; any passenger located within the spacing distance of 800 meter could be easily reached at any of the two bus stops. In this research, the bus stops would be located in an average distance of 800 meter was considered for bus stop spacing in densely populated areas of Yeka Sub City. Therefore, optimal locations for bus stops were identified by considering accessibility index and bus stop spacing standard (800 meter) with in 400m walking distance coverage area. Figure 4.21 shown inbound directions of existing bus stops along with proposed bus stops with accessibility index along their routes. Similarly, the graphical results (Figure 4.22) shows outbound direction of existing bus stops along with proposed bus stops with accessibility index along their routes. Bus stop ID has been changed for both existing and generated bus stops for easy understanding. Existing bus stops having high accessibility index is tried to keep at the same location where they were located, because of providing high accessibility to the passengers. On the other hand, existing bus stops which had comparatively lower accessibility indexes are relocated to the suitable generated stops where better accessibility can be assured. Bus stop spacing standard of 800 meter is also considered in order to relocate bus stops. Unnecessary closely located bus stops are eliminated. Besides, new bus stop was created to identify better accessible location of bus stops where existing bus stop was not present. However, graphical results (Figure 7.23 and 7.24) were identified for the final optimal locations of bus stops for both inbound and outbound direction respectively.

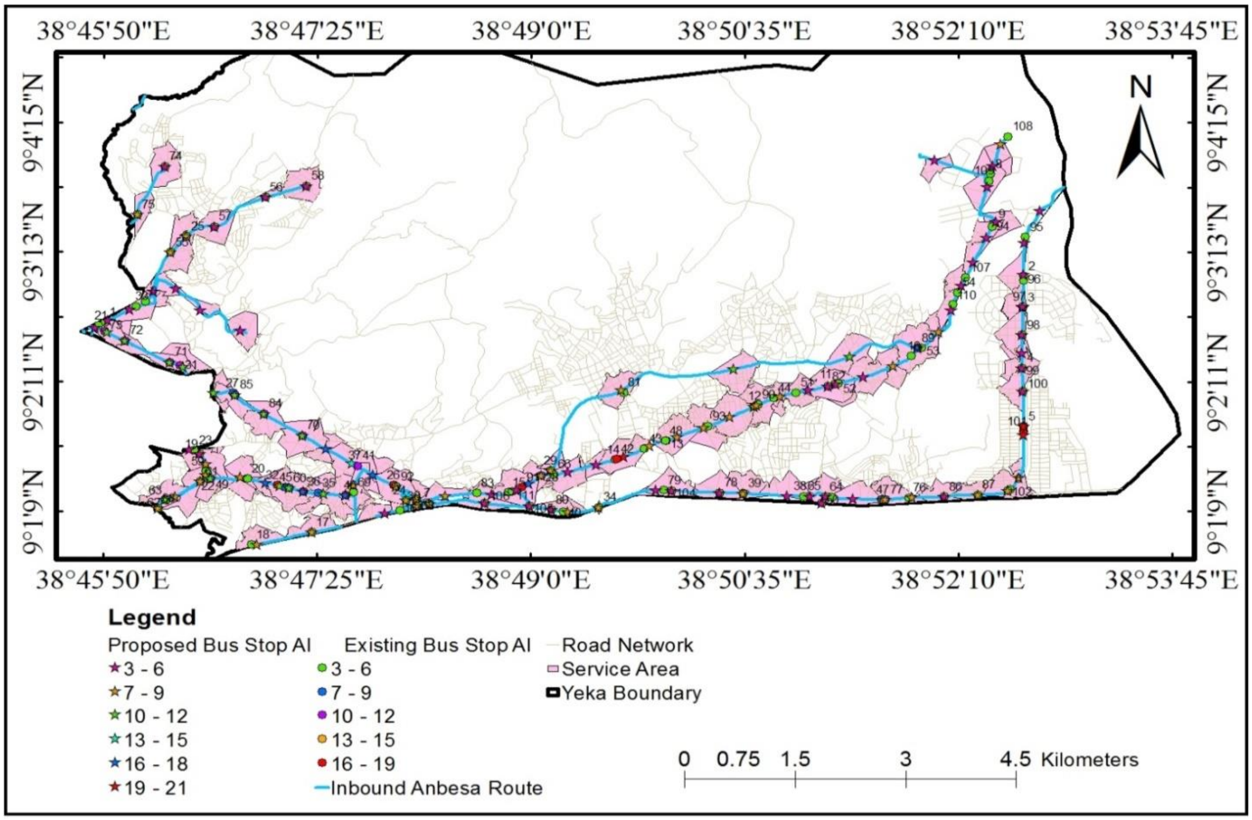


Figure.4. 21: Map showing AI for existing and proposed T-F (Inbound direction) bus stops

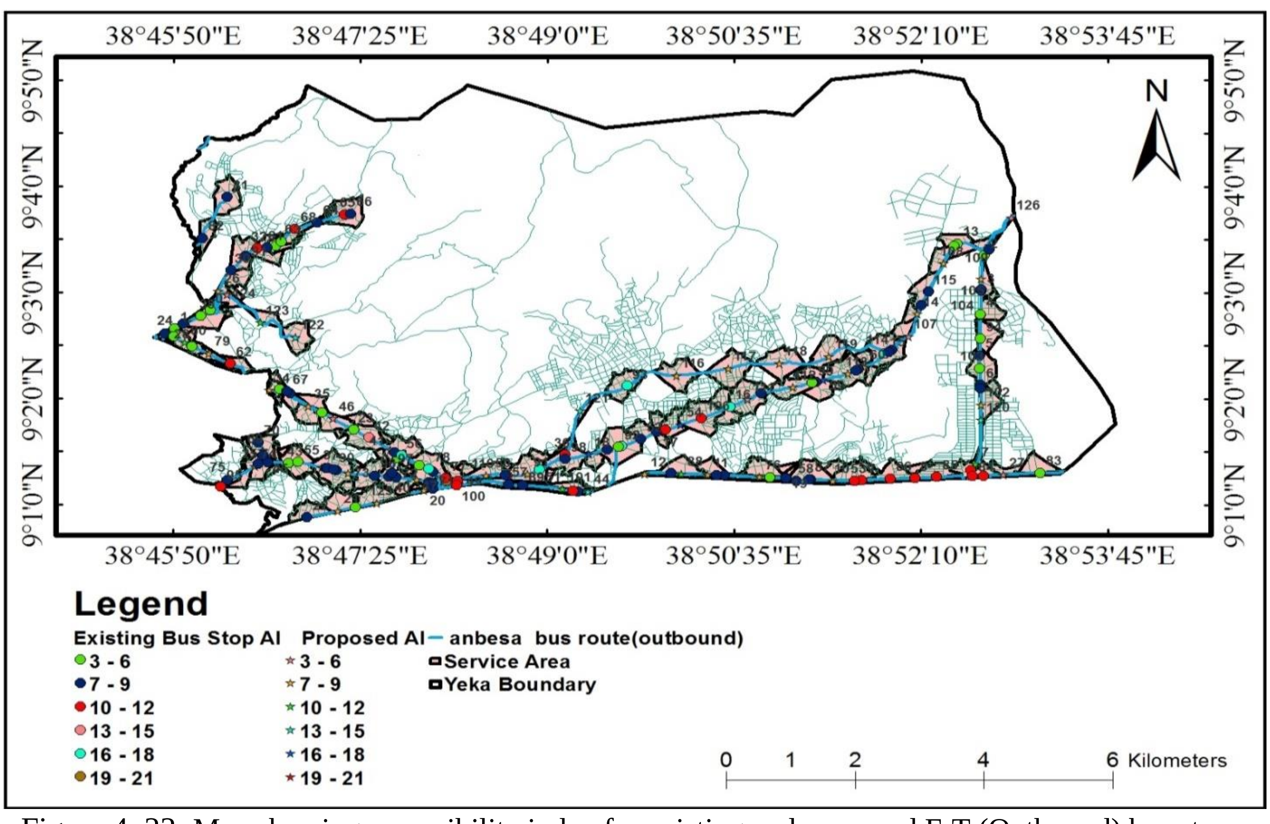


Figure.4. 22: Map showing accessibility index for existing and proposed F-T (Outbound) bus stops

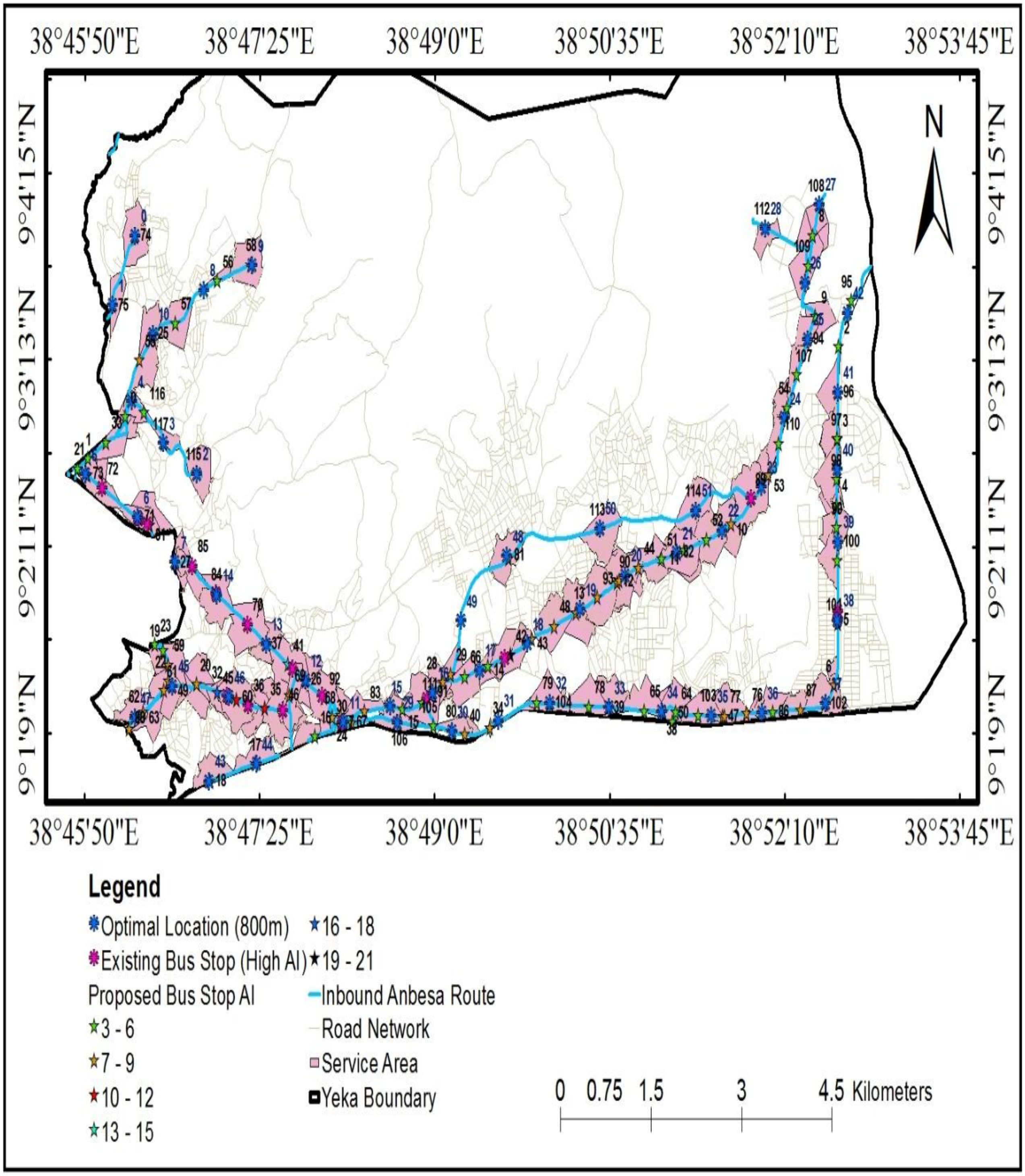


Figure.4. 23: Final Optimal Location for Proposed Inbound bus stop

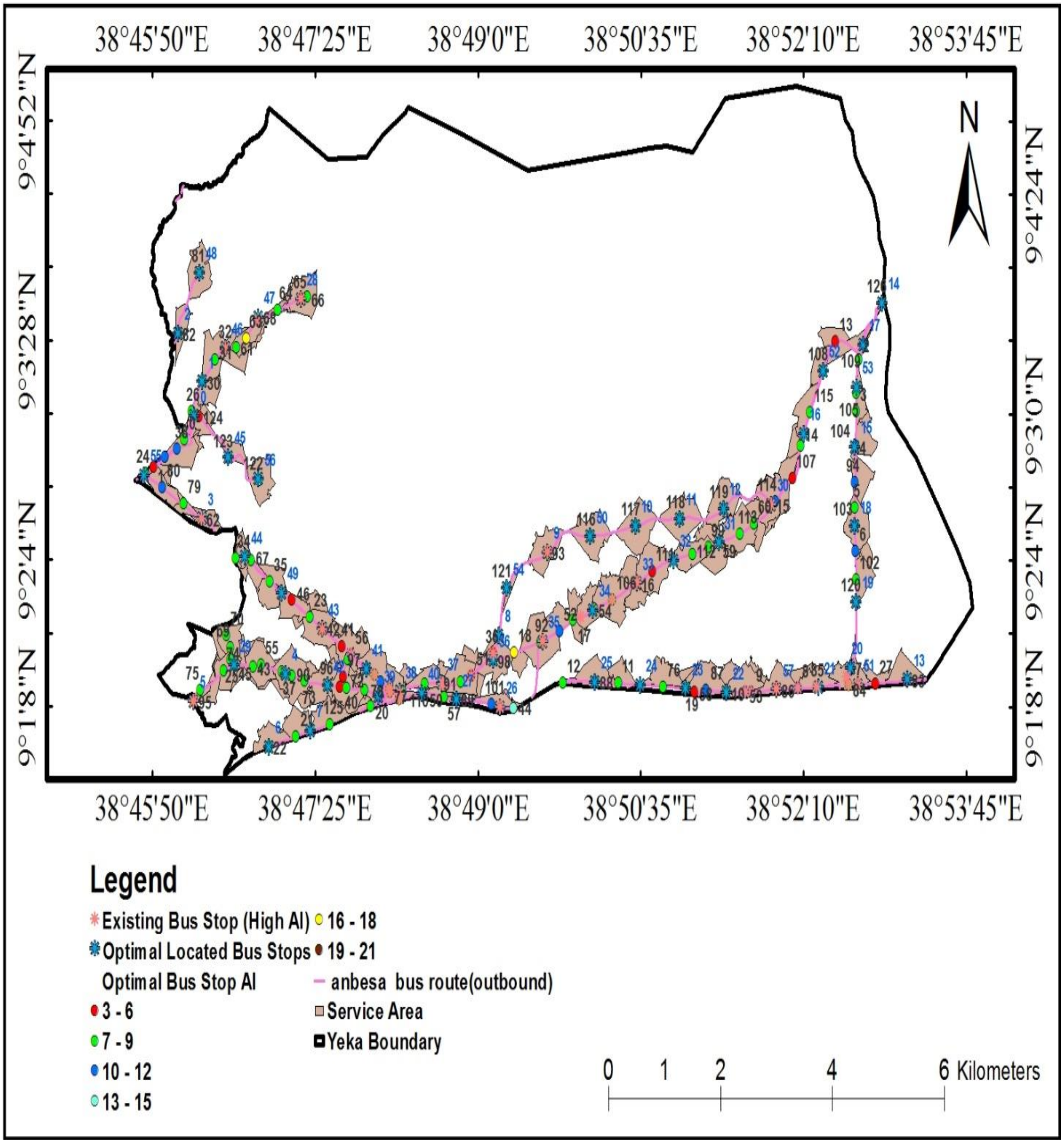


Figure.4. 24: Final Optimal Location for proposed outbound bus stops

4.4.1. Inbound Direction Bus Stop

Existing bus stop ID numbers of 7, 32, 45, and 91are kept as in their original locations because they are located at the same locations with the optimal location of bus stop providing high accessibility to the passengers and they fulfilled the stop spacing standards of 800meter. Although they were providing low accessibility, existing bus stop ID numbers of 2, 17, 18, 23, 25, 37, 39, 38, 43, 49, 54, 58, 74, 75, 80, 81, 84, 98, 102, 104 and 106 are also kept at the same locations of optimal stops keeping the stop spacing standard of 800m. Besides stop 37, 49 and 84 provide high accessibility to the users. Existing bus stop 11 is kept the same location nearest to the generated optimal stop 16; and provides high accessibility compared to other nearest stops. However, existing stop 15 & 111 were eliminated as they are situated very close to bus stop 11.

Existing bus stop ID 85 was kept at the same location as it provides high accessibility. In the same case, existing bus stop 71 was kept at its location which was located at the same location to the generated stop 6 because of providing high accessibility to the passengers and to keep standard of stop spacing of 800 meter.

However, stop ID number 31 and 27 were eliminated as they are situate much closer to the bus stop 71 and 85 respectively.

Existing bus stop 73 is kept at the same location near to the generated stop 5 which provide high accessibility and kept the standard of stop spacing of 800 meters. But stop 1 & 21 are eliminated as they were situated very close to bus stop 73 and existing bus stop of 22, 59 and 61 were dissolved as they were situated very close to stop 49. Existing bus stop 19 was eliminated as it was situated very close to stop 23. Existing bus stop ID number of 47, 50, 64, 65, 80,102and 103 are eliminated as they were situated very close to bus stop 6, 38, 40 and 77.

Existing bus stop ID number of 5 & 101 were relocated into the generated bus stop 38. Existing bus stop ID number 77, 86, 90, 95,100 and 108 were relocated to the nearest generated standared bus stop 35, 36,20, 42,39 and 27 respectively to keep the standard stop spacing of 800 meters .

However, the situated of existing bus stop 4. 12, 44, 52, 96 and 99 were dissolved as they are situated much closer to the bus stop 100; stop 96, 2, 82 and 90 and bus stop ID number28, 29 and 66 were dissolved as they are situated in closed stop spacing to each other.

Other remaining existing bus stops ID number 14, 20, 33, 36, 41, 46, 51, 57, 70, 76 and 87 are kept as in their original locations they fulfilled the half of standard stop spacing of 400 meter. Beside stop ID number 14, 36, 41, 46 and 70 provides high accessibility.

From inbound bus stop10 bus stops ID number 7, 11, 32,37, 49,71,73,85 and 89 are kept as in their original locations they are located at the same locations with the optimal location of bus stop for providing high accessibility to the users and they fulfilled the stop spacing standard of

800meters and bus stop ID numbers 2, 17, 18, 23, 25, 39, 38, 43, 54, 58, 74, 75, 80, 81, 98, 102, 104 and 106 are kept as in their original location they are locatedat the same location with the optimal location of bus stop for they fullfilled the standard stop spacing of 800meters.

Similarly, 11 bus stops arekept as in their original locations because they fulfilled the half-length of standard stop spacing of 800 meters.

Proposed new bus stops ID 115, 116, and 117 were created on there was no located existing bus stops on that portion of routes along stop spacing distance of about 1900 meter. New bus stop ID 49 and 112 were created on they were no located existing bus stops along bus stop spacing of 1300 and 1800 meters long respectively. Two new bus stops 113 and 114 were created on there were no located existing bus stops between existing stops of 81 and 89 along stop spacing of 4000 meters.

The existing 29 bus stops were dissolved as they are situated very close to other bus stops. Therefore, from the three option of locating optimal bus stop locations concluded that, inbound good and moderate accessibility bus stop were increased from existing of 16.96% to proposed of 22.03% after creating new bus stops, 38 bus stops (34%) in both condition (existing and after proposed) are kept as in their location they are located at the same location for providing high accessibility and they fulfilled the standard stop spacing of 800 meters and 6.25% bus stops are relocated. However, 25.79% of bus stops were dissolved as they are situated much close to other stops (unnecessary stop locations) and they provided very low accessibility. Other remaining 11.99% of bus stops are the same as it is and they have very low accessibility. In general, from the determined optimal location of bus stops the inbound bus stops were satisfied by (62.21%) due to three options of created new stops, kept stops as it is and relocated that satisfy by more than the target of (60%) in outbound directions.

Table.4. 26: Bus stops that satisfied optimal locations for inbound direction

Bus Stop ID	Bus Stop-Name	Road Density	Trip Generation By Bus	Population Served In Service Area	AI
7	Megenagia	92.824251	47	192	11
32	Misrak	26.282956	455	3184	18
37	Shola	22.862504	1069	3626	11
49	Women Square	31.864131	528	1636	10
71	Minilik School	34.631517	1090	664	11
73	6 Kilo	20.756872	1090	1348	10

85	Kokebe Tsebah	21.435126	1069	694	10
89	Kara	139.063008	51	4408	18
2	Amistegna Ber	21.7698	64	51	4
11	Kera Condominyam	24.150881	36	2186	4
17	Haya Hulet	22.465664	41	3334	5
18	Zerihun	32.244301	41	1598	5
23	Aware	25.26796	58	1664	4
25	Kela	35.88915	15	2552	6
38	Yetebaberut Chaf	18.367666	74	382	3
39	St Michale	21.609526	74	3082	5
54	Mikael	24.494347	46	586	4
58	Gurara	24.698419	15	2132	4
Stop ID	Having Half Stop Space				AI
14	Condomineym	18.536544	36	2162	4
20	Aware Square	19.772863	528	684	6
33	Menelik Hospital	15.88735	64	2714	10
36	Signal	114.500186	528	4702	18
41	Shola Gebeya	22.571838	1069	3668	11
46	Shola Gebeya	108.85134	528	4670	17
51	Wesen	24.714908	36	1604	4
57	Mazoriya	23.535639	15	2246	5
70	British Embassy	17.93938	1069	2174	10
76	Condominium	32.585025	47	2094	5
87	Ayat Train Station	38.512166	47	770	5
Stop ID	New Created Bus Stop				AI
112	Prop_109	13.651302	67	4	4
113	Prop_10	56.054306	109	4409	10
114	Prop_11	56.248867	109	3504	10
115	Prop_12	14.977475	109	3022	6
116	Prop_13	15.797478	109	1247	5
117	Prop_14	1.22392	109	1247	4
Stop ID	Relocated Bus Stop				AI
77	Meri	27.560734	47	6324	7
86	Ayat Zone 2	27.382003	47	1138	5
90	Wesen	30.78387	36	4016	6
95	Tafo Square	24.175033	47	200	4
100	Maryam	33.974508	47	180	5
101	Keste Demena	169.09441	224	413	19
108	Yeka Abado Condominum	16.632385	336	6	5

4.4.2. Outbound Direction Bus Stop

Almost some of optimal locations of outbound bus stops were identify as optimal locations for inbound bus stops, but some locations of outbound stops were identify as the following: Existing bus stops ID number 16, 18, 28, 33. 44, 52, 65, 88, 89, 96, 98 and 104 are kept as in theier original locations they were located at the same location with the optimal locations of bus stop for providing high accessibility to the passengers and they fulfilled the stop spacing standard of 800meters.

Existing bus stops ID 4, 15,35, 68, 71, 74, 84, 94,99, 101, 106 and 112 are kept as in their original locations they are located at the same locations with the proposed optimal location of bus stops for providing high accessibility to the passengers and they fulfilled the stop spacing standard of 800meter. Existing bus stop ID 14, 20, 22, 23, 25, 31, 36, 39,48, 49, 85 and 86 are kept as in their original locations they are located because of they fulfilled the stop spacing standard of 800meters.. However, bus stop ID 45, 76 and 93 were eliminated as they are situated very close to the bus stop 39 and bus stop ID 110 and 118 were eliminated as they are situated very close to the bus stop 15.

Existing bus stops ID number of (30, 34, 47, 60 & 64) were dissolved as they are situated very close to bus stop ID (74, 66, 104, 92 and 33) respectively. Existing bus top 50 & 81 were situated very close to stop 35 and 25, 42 &100 were situated close to bus stop 99 as they are eliminated. The existing bus stop ID numbers of (41 & 43) awere close to bus stop 59; stop 37 & 70 were close to stop 36; 1 & 83 were close to stop 25; stop 19 & 95 were close to stop 18; stop 17, 57 were close to bus stop 114 and 26, 72 & 77 are close to stop 48 as their situated they are dissolved to fulfilled bus stop spacing standard of 800 meters.

Existing bus stop ID number 62, 102 and 116 were relocated to proposed bus stop 31 as it providing good accessibility.

Existing bus stop ID number 12 was relocated to the generated stop 25 as they are providing comparatively high accessibility and they fulfilled standared stop spacing of 800meters.

Existing bus stop ID number 7, 11 and 56 were relocated to the generated stop 20, 24 and 22 respectively to keep the standard bus stop spacing of 800 meters. Besides, the stop 20 provided high accessibility to users. However, existing bus stop 61 & 90 and 91 were dissolved as they are situated very close to proposed stop 23 and 11 respectively.

Existing bus stop ID number 111 was relocated to the proposed bus stop 52, and stop 3 was relocated to proposed stop ID 53 to keep standard the bus stop spacing of 800 meter. However, bus stops ID number 2, 13. 87, 105, 107, and 108 were dissolved as they are situated very close to bus stop 112, 111, 28, 6, 4 and 3 respectively.

New bus stop ID 122, 123 and 124 were created on there was no located existing bus stops along bus stop spacing of 1900 meter. New bus stop ID 14 was created on there is no located existing bus stops along bus stop spacing of 900 meter. As a result, one stop was created on the generated stops which provide comparatively high accessibility. New proposed bus stops ID number of 116, 117, 118, and 119 were created along stop spacing of 4000meters that there is no located existing stops on that portion of bus routes.

New bus stop ID number 8 and 54 were created along 1700meters on there is located existing bus stops in order to keep the bus stop spacing standard of 800 meters and to keep the distance within comfortable walking distance. Besides, bus stop 54 provided high accessibility to users. New bus stop 120 was created to keep the stop spacing standard of 800m and providing comparatively high accessibility to others.

Other remaining existing bus stops ID number 6, 8, 9, 10, 40, 51, 55, 59, 66, 80, 81, 97 and 103 are kept as in their locations they are located because of kept half standard stop spacing of 400 meter and they provided high accessibility to the users.

Generally, in outbound direction of bus stops, 26 existing bus stops ID number of 14, 15, 16, 18, 120, 22, 23, 25, 28, 31, 33, 36, 39, 44, 48, 49, 52, 65, 85, 86, 88, 89, 94, 96, 98 and 104 are kept as in their original locations they are located at the same locations with the optimal locations of bus stops for providing high accessibility to the users and they fulfilled the standard stop spacing of 800meters. Other 10 bus stops ID number of 4, 35, 68, 71, 74, 84, 99,101, 106 and 112 are kept as in their original locations they are located at the same locations with for providing high accessibility to the users were satisfied after proposed optimal bus stops and they fulfilled the stop spacing standard of 800meter.

Then 13 bus stops ID number of 6, 8, 9, 10, 40, 51, 55, 59, 66, 80, 81, 97 and 103 are kept as in the originallocations they are located at the same locations with the optimal locations of bus stops for providing high accessibility to the users and they fulfilled half of the standard stop spacing of 400 meter. Because, most of public transport studies assumed that walking as an access mode occurred up to 400 to 800 meters of walking distance or 10 to 15 minutes of walking time as Vas Nes and Bovy (200) reported. Seven existing bus stops were relocated which to satisfied comparatively high accessibility and to keep standard stop spacing. Seven new bus stops were created to improved bus stop accessibility.

Therefore, from the three option of locating optimal bus stop locations concluded that, outbound good and moderate accessibility bus stop were increased from existing of 25.83% to proposed of 31.49% after creating new bus stops, 49 bus stops (38.58%) in both condition (existing and after proposed) are kept as in their location they are located at the same location for providing high accessibility and they fulfilled the standard stop spacing of 800 meters and 5.51% bus stops were relocated. In general, from the determined optimal location of outbound bus stops were satisfied by (75.59%) due to three options of created new stops, kept stops as it is and relocated that satisfy by more than the target of (60%) in outbound directions. Other 24.41% bus stops were dissolved as they are situated much close to other stops (unnecessary stop locations) and they provided very low accessibility.

Table.4. 27: Bus stops that satisfied optimal locations for outbound direction

Bus Stop ID	Bus Stop-Name	Road Density	Trip Generation By Bus	Population Served In Service Area	AI
4	Menafesha	31.137192	460	998	10
14	St Mikale	24.967588	295	596	7
15	Kara	61.581307	66	4214	17
16	Wesen	59.905268	66	5792	17
18	Condominyem	61.167927	208	2240	17
22	Haya Hulet	22.110698	5	3328	6
23	Zerihun	32.244301	41	1598	8
25	Anbessa Gebi	26.191082	156	850	7
28	Ayat Adebabay2	36.219211	323	1024	11
31	Megazen	26.744667	156	3788	8
33	Kenean2	34.538917	156	2590	10
35	Megenagna	34.538917	156	2590	10
36	Kokebe Tsebah	15.347303	321	910	5
39	Misrak	26.380696	52	3536	8
44	Shola Chaf2	44.106705	321	2778	13
48	Yesetoch Adebabay	34.224839	52	1544	9
49	Engilsh Embassy	19.622202	321	1076	6
52	Megenagna2	26.184681	532	1491	10
65	Minilik School2	40.179417	32	496	10
68	Gurara2	33.392792	312	2188	10
71	Bret Dildy (Buno Weha)2	34.848549	157	1694	10

74	Megenagna	34.848549	157	1094	10
85	Hamle 19	32.383596	49	1794	8
86	Feres Bet	18.909849	174	188	5
88	Ayat3	36.665531	492	810	12
89	Condominium2	23.89171	1116	1116	12
94	Radison Blue2	29.672712	485	3780	11
96	Legehar1	47.966642	537	4012	16
98	Kazzanchis2	37.059942	286	288	10
99	Shola	29.694552	52	4104	9
101	Menaheria2	37.059942	286	288	10
104	Gurd Shola3	31.137192	460	998	10
106	Tafo Gebrael	25.566697	169	478	6
112	Tafo Adebabay	33.214929	169	4832	11
Stop ID	Having Half stop Space				AI
6	Yeka No 1condominume2	38.159934	460	923	12
8	Ayat2	30.097009	492	1426	10
9	Meri2	28.582954	492	6046	12
10	Yetebaberut	35.336629	323	1064	11
40	Menelik Hospital	47.297552	37	502	12
51	Megenagna1	76.661886	536	509	21
55	Ahmed Building	28.841353	532	1492	10
59	Yeka Michael1	51.110121	339	3878	16
66	Bono Weha	21.872003	157	1124	6
80	Megenagna4	31.207954	485	1382	11
81	Megenagna1	53.990554	339	3566	16
84	Eyesus	53.990554	339	3566	16
97	Tafo Mebrat Hail	29.672712	485	3780	12
103	Megenagna5	38.159934	460	923	12
112	Tafo Adebabay	33.214929	169	4832	11
Stop ID	Relocated Bus stop				AI
3	Amistegna Ber	26.370812	169	47	7
7	Ayat Adebabay22	37.909594	169	796	10
11	St Mikale	22.726988	492	1548	8
12	Civil Service	23.881831	492	116	8
56	St .Mecael2	27.574391	492	6116	11
62	Kera Condminium	25.227135	104	1900	7
111	Gedera	15.200188	295	422	4
Stop ID	Created Stop				AI
8	AYAT2	30.097009	492	1426	11
116	Prop-50	23.453212	104	2164	8
117	Prop-10	31.704164	104	3254	9
118	Prop-11	24.272768	295	3508	9
119	Prop-12	24.231345	295	996	8
120	Prop_9	53.346448	112	122	14

121	Prop_10	57.512326	112	95	14
122	Prop_11	46.665705	112	3157	13
123	Prop_12	35.460242	112	1792	10
124	Prop_13	15.66759	112	2387	5
125	Prop_14	27.170031	112	3700	9
126	Prop_16	10.982062	112	45	4

4.5. Discussion

4.5.1. Evaluation of existing bus stop

In this current study, the existing bus stop accessibility were evaluated based on three parameters (road density, trip generation by bus and population served within bus stop coverage area) which are the basic considerations to evaluate the bus stop accessibility and to identify optimal location of bus stops. From the evaluation of existing bus stops, good and moderate optimal accessibility bus stops satisfies about 22.03% of accessibility for inbound direction. For inbound direction bus stops, the high road density that approaches to grand maximum road density, high trip generation and dense populations served within stop coverage area were the parameter that to provided good accessibility to the users. For moderate accessibility bus stops, the high trip generation and population served are the main parameters to provide moderate accessibility bus stops. The bus stops had road density greater than the grand average value of 33.106, but its trip generation was very low which is less than the sub maximum and grand average (1069) trip values that the lower trip generation value was influence the poor accessibility.

From the evaluation of existing bus stops, good and moderate optimal accessibility bus stops were satisfied about 25.83%of accessibility for outbound direction. The maximum road density and high number of populations served within bus stop coverage area were the main factor for outbound direction good accessibility bus stops which provided good accessible to the users. Population density was used as an indicator of the spatial distribution of the population in calculating the index (Saghapour et al., 2016). The bus stops located in a densely populated area that high number of population are participated its nearest bus stop that bus stops provided high accessibility to the users. The maximum road density the factor for outbound direction moderate accessibility bus stops that gives high accessibility index values which provided moderate accessibility. The bus stops had low road density, low trip generation and less density of population served which have less than the grand average value provided poor accessibility index values. Therefore the combination of high road density, dense population served with in bus stop coverage area and trip generation by a certain number of bus provided good and moderate accessibility to the users. The reason of poor accessibility bus stop was one of the following: the stops were located in a place where there are fewer roads, therefore less connectivity; the stops serve comparatively fewer number of people or the stops generates fewer number of bus trips; or combination of two or more reasons. Other case was some stops were located close to other stops and others were located at greater distance to other which are uncomfortable to the users to use the bus services. Berhan. (2013) evaluated the ACBSE operating performance for ninteen months using passenger volumes, vehicle-Killo meters and passenger load factors(PLF). He reported that, the ACBSE had significantly low operational performance as compared to the standard. According to these authors the Average number of passenger per operating bus per day (PPVPD) was one of the parameters that measure the operational performance of a bus transport. Therefore, he evaluated the ACBSE operational performance for ninteen months interms of PPVPD and found to be 786.63 with standard deviation of 151.59 and maximum of 955.41. From his finding results, he concluded that as compared to the standard of 1000 to 1200 with mean of 1100, the performance of ACBSE was significantly low that means, the maximum of ACBSE PPVPD of 955.41 could not attain the standard minimum of 1000. He also studied the passengers load factor (PLF) of ACBSE using the ratio of passengers-killometer to carrying capacity of buses and found an average value of 65.33. From the finding result of passenger load factor of ACBSE , he reported that, the ACBSE had very low performance as compared to the standard of 80% to 90%. Generally Berhan. (2013) concluded that the operational performance of ACBSE as compared to the standard was low in most performance measuring parameters. Therefore as Berhan. (2013) reporeted, the anbesa bus service served low number of passengers(i.e. trip generations by bus). However, the current study evaluated the anbesa bus service accessibility for each bus stops using three parameters such as road density, trip generation by bus and population served within bus stop coverage area. Similarly, the evaluated results of Anbesa Bus Service accessibility on bus stop in the current study was very low in which more than 70% bus stops were indicating poor accessibility index values (Table 4.7 and 4.12). From the evaluation of existing bus stops attribute results, the good and moderate optimal accessibility bus stops satisfied about 22.03% of accessibility from 112 inbound direction bus stops and 25.83% accessibility from 120 outbound direction of bus stops. The maximum number of bus stops (i.e.77.97% inbound and 74.17% outbound) direction bus stops were coverd by poor accessibility bus stop which provide poor accessibility to the passengers. In generally, the evaluated results of ACBSE operating performance reported by Berhan. (2013) and the evaluated Anbesa bus stop accessibility in the current study depicted the lower values which provide low service for the passengers. Therefore, the parameters of road density, trip generation by bus and population served within bus stop service area ensure for proper evaluating bus stops accessibility.

4.5.2. Optimal Location of Bus Stops

In this cuurent study, the optimal locations for bus stops were identified based on only one criterion (accessibility index) which was measure based on three criteria: Road Density, Population Served and Trip Generation and considering bus stop spacing standard of 800 meters in order to relocated bus stops Muhammad et al. (2013). For instance, considering ideal bus stop when bus stops has maximum accessibility index values (i.e. the stop which ensures maximum road density, served maximum population within threshold area and ensure maximum trip generation by bus). Therefore, excellent, good and moderate stops would marked as optimal accessibility, these stops keep as optimal location and poor stops were those which provided the least accessibility, they required relocated. The operational effect of bus-stop spacing has been a critical issue (Li et al. 2011), Close spaced bus stops provide short distances for passenger access Wirasinghe. (1981) but increase trip times Van Nes and Bovy. (2000) Large bus stop spacing minimized passengers in-vehicle time but reduces the accessibility of the system. In the current study, four mitigation measures (as it in their original locations, creating new bus stops, relocated and dissolving) were used and were considered standared bus stop spacing of 800 meters to identify optimal location of bus stops to increase high accessibility bus stop domain. Seven new bus stops for inbound and nine new bus stops for outbound direction were created a long very larg stop spacing using standard stop spacing of 800meter.

After applying four mitigation measures and standard stop spacing, the results of proposed inbound bus stop optimal location were shown in Annex B1and annexB2 respectively that, good and moderate accessibility bus stop was increased from 16.96% to 22.03% after creating new bus stops, 38 bus stops were kept as in their original locations they were located at the same location with optimal location of bus stop because providing high accessibility and they fulfilled standard stop spacing which covered 34% and other bus stops 6.25% were relocated. But 25.79% of bus stops were dissolved as they are situated much close to other stops

The outbound proposed bus stop accessibility (Annex B2) was increase from 25.83% to 31.49% after creating new bus stops, 49 bus stops were kept as in their original locations they are located for providing high accessibility and they fulfilled standard stop spacing of 800meters which were covered 38.58% and other bus stops of 5.51% were relocated. However, 24.4% of bus stops were dissolved as they are situated much close to other stops. From the evaluation of existing bus stops, the total population of 215486were used bus service in existing inbound bus stop. However, after the created seven new bus stops and proposed optimal location of bus stop, the total population of 229,015 was counted within proposed bus stop service areas which increased by 13,552 populations who are not accessed by bus service within existing bus stop service areaa.

Similarly, the total population of 244,917 was used bus service in existing outbound bus stop. However, after created nine new bus stops and proposed optimal location of bus stop, the total population of 256,215 was served within proposed bus stop service area which increased by 11,298 populations who are not access by bus service within existing bus stops service area. Generally, after proposed optimal location of inbound and outbound bus stops, good and moderate bus stop accessibility were improved to (62.21% and 75.59%) respectively due to three options such as (created new stops, kept stops as in their original locations and relocated) and additional populations of 13,552 for proposed inbound and 11, 298 for proposed outbound direction bus stop are included and they access by bus. However, other remaining of 37.78% and 24.4% of inbound and outbound bus stops respectively were unsatisfied and dissolved they are providing low accessibility and they situated a very close to other stops. Therefore, the optimal locations of bus stops were identified based on accessibility index and considering bus stop spacing standard of 800 meters in order to relocated bus stops, improved optimal accessibility which satisfied more than the target of (60%) in both directions of bus stop.

CHAPTER FIVE
Conclusion and Recommendation

5.1. Conclusion

No systematic study or techniques has been applied to Yeka Sub City to identify spatial informations for optimal locations of bus stops to achieve optimal accessibility and provide optimal locations that served maximum number of peoples in the way that people can reach adjacent (nearest) bus stops easily by walking.

- The current study confirmed that the existing Anbessa Bus Service Accessibility in Yeka Sub City was generally poor in status. The evaluation of existing bus stops accessibility results showed that most of the bus stops more than 70% in both inbound and outbound direction are categorized as poor & provide comparatively less accessibility. This is becuase the stops are located in a place where there are few road network connectivity, therefore less road density; the stops serve small coverage areas, then served comparatively fewer number of people or the stops generates fewer number of trips by bus. Road density is the main reason for high accessibility index. The other reason may be as some stops are closely located to each other which are uncomfortable to the users to use the bus services.
- The current study confirmed that the identified optimal location of bus stops accessibility are better than the existing once by applying four mitigation measures of creating new bus stops, keeping in their original location, relocating and dissolving unnecessary bus stops. Therefore, after using these four mitigation measures, the accessibility of optimal location of bus stop is increased by more than 60% in both directions of bus stops. Besides the poor accessibility of bus stop is diminished to less than of 30% in both directions of bus stops. Therefore, the accessibility of the optimal location of bus stop could be increase by these four possible mitigation measures and improved bus stop accessibility by an average of 40.18% of inbound and 49.76% of outbound bus stops.
- GIS based service area analysis was found to be important for accessibility analyses both the existing and optimal Bus Stop in Yeka Sub City. The GIS based service area analysis is critical to evaluate the bus stop location by estimating the bus stop covered area (Actual pedestrian road length, Actual pedestrian road network and Actual bus stop access coverage area) and population lying within a suitable access distance from the bus stops were considered for the analysis.

5.2. Recommendation

Based on this study, the following recommendations were forwarded.

- ✓ Anbessa City Bus Service Enterprise (ACBSE) should use the findings related to the accessible optimal bus stop in Yeka Sub-City for future use in their planning activities. Moreover, the evaluated status of the existing bus stop in Yeka Sub-City could be one of the future intervention points for the improvement of the bus transport services in the Sub-city.
- ✓ Anbessa City Bus Service Enterprise (ACBSE) should devise a data collection scheme related to Trip Generation and population served for each bus stops in Yeka Sub City.
- ✓ In addition to road density, trip generation by bus and population served within bus stop coverage area, the researchers should be addressed the parameters of traffic jams, the number of buses deployed in the city, the work ethics of bus derivers, the bus repair and maintenance time and efficiency and commitment of the management to evaluating Anbessa City Bus Service Accessibility.
- ✓ Anbessa City Bus Service Enterprise should use GIS based service area analysis than buffering which is found to be important for accessibility analyses both for the existing and optimal Bus Stops in Yeka Sub City. Because the GIS based service area analysis is done using actual pedestrian road length, actual pedestrian road network and actual bus stop access coverage areas surrounding bus stops which to identify actual geography of pedestrian road network and realistic bus stop service areas.

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APPENDIX-A

THE PREPARED DATA OF THREE PARAMETERE

Annex.A1: Road density of bus stops T-F (inbound direction)

Bus Stop ID	Bus Stop-Name	Sum of Road Length Inside Coverage Area(L) In Km	Coverage Area (A) In Km²	Road Density (L/A) In Km/Km²
0	Jalmeda	3.693932	0.196128	18.834295
1	6kilo	2.08959	0.125189	16.691535
2	Amistegna Ber	3.275568	0.150464	21.7698
3	Menafesha	4.228327	0.154601	27.349905
4	Yeka 03	5.837482	0.189432	30.815784
5	Zone 8	24.64176	0.15555	158.420231
6	Hill Bottom	6.332624	0.177461	35.684619
7	Megenagia	11.54849	0.12441	92.824251
8	Meskelaga	3.298623	0.224646	14.683636
9	Gedera	2.97594	0.19178	15.517498
10	Kara	6.1195	0.277249	22.072181
11	Kera Condominyam	6.047411	0.250401	24.150881
12	Wesen	7.778345	0.254949	30.509472
13	Hillside School	7.050985	0.278807	25.289868
14	Condomineym	5.95157	0.321072	18.536544
15	Lamberat	4.434829	0.222608	19.922185
16	Megenaga	3.025984	0.092733	32.630983
17	Haya Hulet	4.703367	0.209358	22.465664
18	Zerihun	3.152969	0.097784	32.244301
19	Aware	3.47403	0.178089	19.507291
20	Aware Square	3.438762	0.173913	19.772863
21	Anbessa Gebi	2.08959	0.098033	21.315208
22	Aware	3.768651	0.179271	21.022058
23	Aware	3.258731	0.128967	25.26796
24	Megenagna Terminal	2.980153	0.05961	49.994601
25	Kela	3.279837	0.091388	35.88915
26	Megenagna	28.933151	0.255474	113.25700
27	Kokeb Tsebay School	2.887832	0.145754	19.813035
28	Lamberet	3.125229	0.111523	28.02325
29	Lamberet	2.099502	0.044389	47.297552
30	Megenagna	2.538851	0.069294	36.638678
31	Menelik Hospitial	2.788008	0.156777	17.783309
32	Misrak	27.022774	0.229151	117.282956
33	Menelik Hospital	3.000992	0.188892	15.88735
34	Salite Mehret	1.435557	0.037758	38.019568
35	Signal	6.719026	0.233853	28.73183
36	Signal	28.990099	0.254184	114.500186
37	Shola	5.75986	0.251935	22.862504
38	Yetebaberut Chaf	3.250059	0.176945	18.367666
39	St Michale	4.517647	0.209058	21.609526
40	Shola	3.002948	0.106191	28.278651
41	Shola Gebeya	5.75986	0.255179	22.571838
42	Cool Hintsa	41.353656	0.329713	127.270288

43	Noc Chaf	6.628341	0.231032	28.690102
44	Kotebe	7.030434	0.235225	29.888079
45	Balderas	7.419564	0.244067	30.399686
46	Shola Gebeya	28.827009	0.264087	108.85134
47	Mere	5.719483	0.196808	29.06122
48	Ethio China Mebrat Hayil	7.116762	0.288277	24.687217
49	Women Square	2.959141	0.092867	31.864131
50	Yetebaberut	2.678353	0.118974	22.512067
51	Wesen	5.901903	0.238799	24.714908
52	Condominium	5.277898	0.206073	25.611831
53	Kera	6.388797	0.268519	23.792723
54	Mikael	3.938208	0.16078	24.494347
55	Mezan	3.936626	0.148343	26.537278
56	Tena Tabea	3.700512	0.132798	27.865686
57	Mazoriya	3.322631	0.141174	23.535639
58	Gurara	4.380962	0.177378	24.698419
59	Aware Dildiy	4.712563	0.173825	27.110996
60	Dinberwa Hospital	6.846042	0.236286	28.97353
61	Aware	4.018162	0.141043	28.488975
62	Kazanchis / Meles Foundation	3.636811	0.116988	31.086957
63	Kazanchis / Meles Foundation	2.679593	0.095276	28.124572
64	Cmc Square	3.534587	0.201436	17.546951
65	Cmc Square	2.99915	0.164452	18.237219
66	Lamberet	2.788996	0.10826	25.761952
67	Megenagna	2.634341	0.06951	37.898489
68	Megenagna	3.826796	0.118575	32.273251
69	Shola	6.046295	0.220598	27.408643
70	British Embassy	4.311629	0.240344	17.93938
71	Minilik School	3.165688	0.091411	34.631517
72	6 Kilo Tele	2.826485	0.12976	21.782395
73	6 Kilo	2.130699	0.10265	20.756872
74	Eyesus	4.420872	0.197914	22.337306
75	Hamle 19	3.67059	0.113347	32.383596
76	Condominium	3.235072	0.099281	32.585025
77	Meri	5.646357	0.20487	27.560734
78	St. Micheal Church	2.593192	0.185592	13.972567
79	Civil Service	1.592779	0.088688	17.959356
80	Gurd Shola	1.74124	0.080195	21.712645
81	Legehar	5.64307	0.209261	26.966642
82	Yabem Hotel	4.951275	0.216804	22.837549
83	Abisinia Cafe	4.980873	0.195155	25.522693
84	Belgium Embassy	5.103376	0.243925	20.921885
85	Kokebe Tsebah	3.040383	0.141841	21.435126
86	Ayat Zone 2	4.181936	0.152726	27.382003
87	Ayat Train Station	1.729595	0.04491	38.512166
88	Kazzanchis	1.233609	0.033287	37.059942
89	Kara	45.902592	0.328412	139.063008
90	Wesen	7.896714	0.256521	30.78387
91	Lamberet	32.643824	0.257303	127.93456
92	Megenagna	5.7982	0.241689	23.990332
93	Wesen Michael	7.003953	0.25463	27.506352
94	Yeka Abado Megenteya	3.066694	0.17257	17.770725

95	Tafo Square	2.192586	0.090696	24.175033
96	Tafo Condominium 1	3.982272	0.142107	28.023052
97	Tafo Condominium 2	4.014358	0.155499	25.81592
98	Mebrat Hail	3.812849	0.163072	23.381414
99	Tafo Gebrael	5.927512	0.183765	32.255942
100	Maryam	3.230776	0.095094	33.974508
101	Keste Demena	21.05417	0.124573	169.09441
102	Ayat Square	6.900549	0.196884	35.048748
103	Yetebaberut	3.951755	0.191733	20.610726
104	Civil Service	3.078199	0.125706	24.487197
105	Gurd Shola	1.746484	0.096566	18.085936
106	Gurd Shola	3.238545	0.121945	26.55744
107	Kara Condominum	3.129663	0.129692	24.131424
108	Yeka Abado Condominum	1.752438	0.105363	16.632385
109	Meskelegna Ababdo	3.538734	0.242749	14.577774
110	Kara Condominum	2.877265	0.128073	22.465907
111	Lamberet	4.620365	0.260812	17.715327

Annex.A2: *Road density of bus stops F-T (Outbound direction)*

Bus Stop ID	Stop Name	Sum Of Road Length InsideCoverage Area (L) In Km	Coverage Area (A) In Km²	Road Density (L/A) In Km/Km²
0	Jalmeda	3.441047	0.188232	18.280903
1	6kilo	2.282161	0.135092	16.893418
2	Tafo	2.192586	0.086636	25.308156
3	Amistegna Ber	1.996472	0.075708	26.370812
4	Menafesha	3.882307	0.150786	25.747049
5	Gebriel	3.454924	0.114596	30.148798
6	Yeka No 1condominume	5.409929	0.151711	35.659466
7	Ayat Adebabay	4.849734	0.127929	37.909594
8	Ayat	4.889848	0.16247	30.097009
9	Meri	6.001469	0.209967	28.582954
10	Yetebaberut	3.095521	0.164652	18.800423
11	St Mikale	3.664517	0.161241	22.726988
12	Civil Service	3.078199	0.128893	23.881831
13	Gedera	3.487319	0.223144	15.628123
14	St Mikale	3.938208	0.157733	24.967588
15	Kara	18.124354	0.302119	61.581307
16	Wesen	17.932155	0.289017	59.905268
17	Hillside School	7.476638	0.247902	30.159644
18	Condominyem	20.035629	0.332213	61.167927
19	Lamberat	4.57623	0.186507	24.536458
20	Yetebaberut	3.393913	0.164705	20.606013
21	Megenaga	3.025984	0.094031	32.180605
22	Haya Hulet	4.630642	0.20943	22.110698
23	Zerihun	3.152969	0.097784	32.244301
24	Abebe Suk	5.012103	0.213205	23.508416
25	Anbessa Gebi	2.282161	0.087135	26.191082
26	Aware	3.768651	0.179271	21.022058
27	5	3.441047	0.183203	18.782676
28	Ayat Adebabay	5.387446	0.148746	36.219211
29	6 Kilo Tele	2.916565	0.103701	28.124791

30	Megenagna	3.604016	0.136586	26.386359
31	Megazen	3.993538	0.149321	26.744667
32	Kela	3.485678	0.142508	24.459561
33	Kenean	4.166806	0.120641	34.538917
34	Mazoria	2.435075	0.104663	23.265885
35	Megenagna	5.363646	0.228269	23.497031
36	Kokebe Tsebah	2.654078	0.172934	15.347303
37	Kokeb Tsebay School	3.040383	0.136994	22.193521
38	Lamberet	2.099502	0.044389	47.297552
39	Misrak	6.220093	0.235782	26.380696
40	Menelik Hospital	3.000992	0.188892	15.88735
41	Shola Gebya	3.558708	0.195178	18.233101
42	Shola	7.108972	0.25778	27.577693
43	Shola	5.75986	0.255086	22.580035
44	Shola Chaf	8.285189	0.202446	44.106705
45	Signal	5.945993	0.243041	24.464958
46	Waryt Square	3.447871	0.196894	17.511265
47	Shola	2.019861	0.071008	28.445404
48	Yesetoch Adebabay	2.959141	0.086462	34.224839
49	Engilsh Embassy	3.980203	0.202842	19.622202
50	Megenagna	5.43004	0.195398	27.789662
51	Megenagna	17.67998	0.23062	76.661886
52	Megenagna	2.679399	0.102327	26.184681
53	Total	5.442271	0.191295	28.449554
54	Lamberet	13.699286	0.258606	51.171606
55	Ahmed Building	6.148813	0.213194	28.841353
56	St .Mecael	5.390722	0.195497	27.574391
57	Salite Mihret	6.821574	0.290783	23.459367
58	Signal	3.438762	0.182402	18.852652
59	Yeka Michael	13.817743	0.263126	51.110121
60	Gurd Shola	2.881112	0.114246	25.21857
61	Tikur Abay	2.678353	0.128594	20.827993
62	Kera Condminium	5.277898	0.209215	25.227135
63	Kera Sayiders	6.963727	0.271655	25.634415
64	Mazoriya	3.156102	0.146655	21.52058
65	Minilik School	3.165688	0.078789	40.179417
66	Bono Weha	1.593397	0.072851	21.872003
67	Yeha	3.990882	0.133607	29.870368
68	Gurara	5.172282	0.154892	33.392792
69	Gurara	4.380962	0.177378	24.698419
70	Kokebe Tsebah School	3.040383	0.14182	21.438392
71	Bret Dildy (Buno Weha)	4.996194	0.143369	34.848549
72	Aware Dildiy	4.712563	0.173825	27.110996
73	Aware Square	3.956178	0.161898	24.436212
74	Megenagna	3.943776	0.114999	34.294054
75	Shola	6.899064	0.23867	28.906284
76	Dinberwa Hospital	6.686334	0.22984	29.091308
77	Aware	4.018162	0.141043	28.488975
78	Kazanchis / Meles Foundation	2.679593	0.095276	28.124572
79	Cmc Square	2.463546	0.156943	15.697089
80	Megenagna	4.085895	0.130925	31.207954
81	Megenagna	13.423732	0.246639	53.990554
82	6 Kilo Tele	2.826485	0.131452	21.502086

83	6 Kilo	2.130699	0.10265	20.756872
84	Eyesus	4.420872	0.197914	22.337306
85	Hamle 19	3.67059	0.113347	32.383596
86	Feres Bet	2.381903	0.125961	18.909849
87	Ayat Square	5.447204	0.154152	35.336629
88	Ayat	1.823251	0.049727	36.665531
89	Condominium	3.248205	0.135955	23.89171
90	Cmc	3.679673	0.202259	18.192872
91	St. Micheal Church	3.153131	0.142772	22.085095
92	Century Mall	1.445775	0.070435	20.526282
93	Balderas	6.427965	0.241617	26.60389
94	Radison Blue	5.655627	0.1906	29.672712
95	Biherawi	6.029136	0.327806	18.392397
96	Legehar	10.64307	0.209261	47.966642
97	Tafo Mebrat Hail	1.770913	0.132282	13.387412
98	Kazzanchis	1.233609	0.033287	37.059942
99	Shola	7.173812	0.241587	29.694552
100	Shola Gebeya	6.046295	0.221362	27.314118
101	Menaheria	2.989344	0.094159	31.747962
102	Condominium	5.812923	0.2571	22.609586
103	Megenagna	2.388533	0.062593	38.159934
104	Gurd Shola	3.385441	0.108727	31.137192
105	Keste Demena	4.37277	0.132152	33.088952
106	Tafo Gebrael	5.018273	0.196282	25.566697
107	Tafo Condominium 2	2.772578	0.164616	16.842734
108	Tafo Condominium 1	1.996472	0.075437	26.465466
109	Wesen Michael	8.486511	0.265339	33.214929
110	Kara	4.857184	0.248228	19.567415
111	Gedera	2.97594	0.195783	15.200188
112	Tafo Adebabay	2.411444	0.100831	23.91572
113	Abissnia	5.179477	0.196184	26.401179
114	Hillside School	8.050985	0.287081	33.560928
115	Wosone	6.792694	0.238599	28.469054
116	Yabem Hotel	5.812923	0.247852	23.453212
117	Kara Chore Sefer	7.962964	0.251165	31.704164
118	Medhanialem	6.606513	0.272178	24.272768
119	Kara Condominum	3.129663	0.129158	24.231345

Annex.A3: Trip Generation by public bus for bus stops T-F (Inbound direction)

Bus Stop ID	Bus Stop-Name	Trip Generation By Anbesa Bus
0	Jalmeda	64
1	6kilo	64
2	Amistegna Ber	64
3	Menafesha	47
4	Yeka 03	47
5	Zone 8	309
6	Hill Bottom	47
7	Megenagia	47
8	Meskelaga	36
9	Gedera	66
10	Kara	36
11	Kera Condominyam	36
12	Wesen	36

13	Hillside School	36
14	Condomineym	36
15	Lamberat	67
16	Megenaga	41
17	Haya Hulet	41
18	Zerihun	41
19	Aware	58
20	Aware Square	528
21	Anbessa Gebi	64
22	Aware	149
23	Aware	58
24	Megenagna Terminal	13
25	Kela	15
26	Megenagna	528
27	Kokeb Tsebay School	1069
28	Lamberet	346
29	Lamberet	37
30	Megenagna	451
31	Menelik Hospitial	1082
32	Misrak	455
33	Menelik Hospital	64
34	Salite Mehret	74
35	Signal	528
36	Signal	528
37	Shola	1069
38	Yetebaberut Chaf	74
39	St Michale	74
40	Shola	74
41	Shola Gebeya	1069
42	Cool Hintsa	455
43	Noc Chaf	36
44	Kotebe	36
45	Balderas	528
46	Shola Gebeya	528
47	Mere	47
48	Ethio China Mebrat Hayil	36
49	Women Square	528
50	Yetebaberut	27
51	Wesen	36
52	Condominium	36
53	Kera	36
54	Mikael	46
55	Mezan	15
56	Tena Tabea	15
57	Mazoriya	15
58	Gurara	15
59	Aware Dildiy	149
60	Dinberwa Hospital	528
61	Aware	91
62	Kazanchis / Meles Foundation	470
63	Kazanchis / Meles Foundation	91
64	Cmc Square	47
65	Cmc Square	74

66	Lamberet	36
67	Megenagna	47
68	Megenagna	67
69	Shola	58
70	British Embassy	1069
71	Minilik School	1090
72	6 Kilo Tele	1090
73	6 Kilo	1090
74	Eyesus	25
75	Hamle 19	25
76	Condominium	47
77	Meri	47
78	St. Micheal Church	74
79	Civil Service	47
80	Gurd Shola	74
81	Legehar	37
82	Yabem Hotel	36
83	Abisinia Cafe	67
84	Belgium Embassy	1069
85	Kokebe Tsebah	1069
86	Ayat Zone 2	47
87	Ayat Train Station	47
88	Kazzanchis	91
89	Kara	51
90	Wesen	36
91	Lamberet	346
92	Megenagna	77
93	Wesen Michael	36
94	Yeka Abado Megenteya	66
95	Tafo Square	47
96	Tafo Condominium 1	47
97	Tafo Condominium 2	47
98	Mebrat Hail	47
99	Tafo Gebrael	47
100	Maryam	47
101	Keste Demena	224
102	Ayat Square	47
103	Yetebaberut	47
104	Civil Service	74
105	Gurd Shola	60
106	Gurd Shola	60
107	Kara Condominum	36
108	Yeka AbadoCondominum	336
109	Meskelegna Ababdo	36
110	Kara Condominum	66
111	Lamberet	67

Annex.A4: Trip Generation by public bus for bus stops F-T (outbound direction)

Bus Stop ID	Bus Stop-Name	Trip Generation By Anbesa Bus
0	Jalmeda	163
1	6kilo	72
2	Tafo	169
3	Amistegna Ber	169
4	Menafesha	169
5	Gebriel	169
6	Yeka No 1condominume	169
7	Ayat Adebabay	169
8	Ayat	492
9	Meri	492
10	Yetebaberut	492
11	St Mikale	492
12	Civil Service	492
13	Gedera	295
14	St Mikale	295
15	Kara	66
16	Wesen	66
17	Hillside School	104
18	Condominyem	208
19	Lamberat	339
20	Yetebaberut	492
21	Megenaga	6
22	Haya Hulet	5
23	Zerihun	41
24	Abebe Suk	34
25	Anbessa Gebi	156
26	Aware	91
27	5	157
28	Ayat Adebabay	323
29	6 Kilo Tele	157
30	Megenagna	33
31	Megazen	156
32	Kela	156
33	Kenean	156
34	Mazoria	157
35	Megenagna	32
36	Kokebe Tsebah	321
37	Kokeb Tsebay School	321
38	Lamberet	37
39	Misrak	52
40	Menelik Hospital	194
41	Shola Gebya	66
42	Shola	52
43	Shola	321
44	Shola Chaf	321
45	Signal	52
46	Waryt Square	52
47	Shola	460
48	Yesetoch Adebabay	52
49	Engilsh Embassy	321

50	Megenagna	339
51	Megenagna	536
52	Megenagna	532
53	Total	532
54	Lamberet	485
55	Ahmed Building	104
56	St .Mecael	492
57	Salite Mihret	104
58	Signal	52
59	Yeka Michael	339
60	Gurd Shola	460
61	Tikur Abay	492
62	Kera Condminium	104
63	Kera Sayiders	66
64	Mazoriya	313
65	Minilik School	32
66	Bono Weha	157
67	Yeha	157
68	Gurara	312
69	Gurara	312
70	Kokebe Tsebah School	321
71	Bret Dildy (Buno Weha)	157
72	Aware Dildiy	91
73	Aware Square	91
74	Megenagna	33
75	Shola	33
76	Dinberwa Hospital	52
77	Aware	91
78	Kazanchis / Meles Foundation	143
79	Cmc Square	492
80	Megenagna	485
81	Megenagna	339
82	6 Kilo Tele	32
83	6 Kilo	32
84	Eyesus	492
85	Hamle 19	49
86	Feres Bet	174
87	Ayat Square	323
88	Ayat	492
89	Condominium	1116
90	Cmc	492
91	St. Micheal Church	492
92	Century Mall	460
93	Balderas	52
94	Radison Blue	485
95	Biherawi	208
96	Legehar	537
97	Tafo Mebrat Hail	143
98	Kazzanchis	286
99	Shola	52
100	Shola Gebeya	19
101	Menaheria	339
102	Condominium	104

103	Megenagna	460
104	Gurd Shola	460
105	Keste Demena	169
106	Tafo Gebrael	169
107	Tafo Condominium 2	169
108	Tafo Condominium 1	104
109	Wesen Michael	169
110	Kara	295
111	Gedera	295
112	Tafo Adebabay	462
113	Abissnia	295
114	Hillside School	104
115	Wosone	66
116	Yabem Hotel	104
117	Kara Chore Sefer	104
118	Medhanialem	295
119	Kara Condominum	295

Annex.A1*: Population served by bus stops T-F (Inbound direction)*

Bus Stop ID	Bus Stop-Name	Coverage Area (A) In Km²	No Of Parcel Inside Coverage (A) In Km²	Population Inside Coverage Area
0	Jalmeda	0.196128	1880	3760
1	6kilo	0.125189	175	350
2	Amistegna Ber	0.150464	24	51
3	Menafesha	0.154601	28	56
4	Yeka 03	0.189432	166	416
5	Zone 8	0.015555	27	417
6	Hill Bottom	0.177461	637	1274
7	Megenagia	0.012441	96	192
8	Meskelaga	0.224646	7	14
9	Gedera	0.19178	200	400
10	Kara	0.277249	2014	4028
11	Kera Condominyam	0.250401	1093	2186
12	Wesen	0.254949	2132	4264
13	Hillside School	0.278807	1833	3666
14	Condomineym	0.321072	1081	2162
15	Lamberat	0.222608	1776	3552
16	Megenaga	0.092733	354	708
17	Haya Hulet	0.209358	1667	3334
18	Zerihun	0.097784	799	1598
19	Aware	0.178089	1237	2474
20	Aware Square	0.173913	342	684
21	Anbessa Gebi	0.098033	198	396
22	Aware	0.179271	1558	3116
23	Aware	0.128967	832	1664
24	Megenagna Terminal	0.05961	260	520
25	Kela	0.091388	1276	2552
26	Megenagna	0.266574	1852	3704
27	Kokeb Tsebay School	0.145754	346	692
28	Lamberet	0.111523	703	1406
29	Lamberet	0.044389	251	643

30	Megenagna	0.069294	236	472
31	Menelik Hospitial	0.156777	1085	2170
32	Misrak	0.229151	1592	3184
33	Menelik Hospital	0.188892	1357	2714
34	Salite Mehret	0.037758	40	80
35	Signal	0.233853	2549	5098
36	Signal	0.254184	2351	4702
37	Shola	0.251935	1813	3626
38	Yetebaberut Chaf	0.176945	191	382
39	St Michale	0.209058	1541	3082
40	Shola	0.106191	426	852
41	Shola Gebeya	0.255179	1834	3668
42	Cool Hintsa	0.329713	1185	2370
43	Noc Chaf	0.231032	1697	3394
44	Kotebe	0.235225	1551	3102
45	Balderas	0.244067	2074	4148
46	Shola Gebeya	0.264087	2335	4670
47	Mere	0.196808	3095	6190
48	Ethio China Mebrat Hayil	0.288277	1872	3744
49	Women Square	0.092867	818	1636
50	Yetebaberut	0.118974	254	508
51	Wesen	0.238799	802	1604
52	Condominium	0.206073	948	1896
53	Kera	0.268519	1705	3410
54	Mikael	0.16078	293	586
55	Mezan	0.148343	1874	3748
56	Tena Tabea	0.132798	888	1776
57	Mazoriya	0.141174	1123	2246
58	Gurara	0.177378	1066	2132
59	Aware Dildiy	0.173825	1389	2778
60	Dinberwa Hospital	0.236286	2152	4304
61	Aware	0.141043	1302	2604
62	Kazanchis / Meles Foundation	0.116988	1495	2990
63	Kazanchis / Meles Foundation	0.095276	717	1434
64	Cmc Square	0.201436	469	938
65	Cmc Square	0.164452	148	296
66	Lamberet	0.10826	446	892
67	Megenagna	0.06951	344	688
68	Megenagna	0.118575	590	1180
69	Shola	0.220598	1818	3636
70	British Embassy	0.240344	1087	2174
71	Minilik School	0.091411	332	664
72	6 Kilo Tele	0.12976	1010	2020
73	6 Kilo	0.10265	674	1348
74	Eyesus	0.197914	1089	2178
75	Hamle 19	0.113347	897	1794
76	Condominium	0.099281	1047	2094
77	Meri	0.20487	3162	6324
78	St. Micheal Church	0.185592	441	882
79	Civil Service	0.088688	39	78
80	Gurd Shola	0.080195	455	910
81	Legehar	0.209261	2006	4012

82	Yabem Hotel	0.216804	966	1932
83	Abisinia Cafe	0.195155	1763	3526
84	Belgium Embassy	0.243925	872	1744
85	Kokebe Tsebah	0.141841	347	694
86	Ayat Zone 2	0.152726	569	1138
87	Ayat Train Station	0.04491	385	770
88	Kazzanchis	0.033287	144	288
89	Kara	0.328412	2204	4408
90	Wesen	0.256521	2008	4016
91	Lamberet	0.257303	1818	3636
92	Megenagna	0.241689	1753	3506
93	Wesen Michael	0.25463	2297	4594
94	Yeka Abado Megenteya	0.17257	190	380
95	Tafo Square	0.090696	100	200
96	Tafo Condominium 1	0.142107	21	42
97	Tafo Condominium 2	0.155499	31	62
98	Mebrat Hail	0.163072	14	28
99	Tafo Gebrael	0.183765	153	306
100	Maryam	0.095094	90	180
101	Keste Demena	0.014573	29	413
102	Ayat Square	0.196884	769	1538
103	Yetebaberut	0.191733	513	1026
104	Civil Service	0.125706	56	112
105	Gurd Shola	0.096566	215	430
106	Gurd Shola	0.121945	1046	2092
107	Kara Condominum	0.129692	164	328
108	Yeka AbadoCondominum	0.105363	3	6
109	Meskelegna Ababdo	0.242749	33	66
110	Kara Condominum	0.128073	274	548
111	Lamberet	0.260812	1895	3790

Annex.A6: Population served by bus stops coverage area in F-T (Outbound direction)

BusStop ID	Bus Stop-Name	Coverage Area (A) In Km²	Number Of Parcels Inside Coverage Area(A) In Km²	Population Inside Coverage Area
0	Jalmeda	0.188232	1864	3728
1	6kilo	0.135092	214	428
2	Tafo	0.086636	99	198
3	Amistegna Ber	0.075708	19	47
4	Menafesha	0.150786	28	65
5	Gebriel	0.114596	76	185
6	Yeka No 1condominume	0.151711	519	1038
7	Ayat Adebabay	0.127929	398	796
8	Ayat	0.16247	713	1426
9	Meri	0.209967	3023	6046
10	Yetebaberut	0.164652	471	942
11	St Mikale	0.161241	758	1548
12	Civil Service	0.128893	58	116
13	Gedera	0.223144	273	546
14	St Mikale	0.157733	298	596
15	Kara	0.302119	2107	4214
16	Wesen	0.289017	2896	5792

17	Hillside School	0.247902	1764	3528
18	Condominyem	0.332213	1120	2240
19	Lamberat	0.186507	498	996
20	Yetebaberut	0.164705	148	296
21	Megenaga	0.094031	357	714
22	Haya Hulet	0.20943	1664	3328
23	Zerihun	0.097784	799	1598
24	Abebe Suk	0.213205	1303	2606
25	Anbessa Gebi	0.087135	425	850
26	Aware	0.179271	1558	3116
27	5	0.183203	1837	3674
28	Ayat Adebabay	0.148746	512	1024
29	6 Kilo Tele	0.103701	48	96
30	Megenagna	0.136586	682	1364
31	Megazen	0.149321	1894	3788
32	Kela	0.142508	1609	3218
33	Kenean	0.120641	1295	2590
34	Mazoria	0.104663	751	1502
35	Megenagna	0.228269	1809	3618
36	Kokebe Tsebah	0.172934	455	910
37	Kokeb Tsebay School	0.136994	345	690
38	Lamberet	0.044389	251	502
39	Misrak	0.235782	1768	3536
40	Menelik Hospital	0.188892	1357	2714
41	Shola Gebya	0.195178	1280	2560
42	Shola	0.25778	2209	4418
43	Shola	0.255086	1836	3672
44	Shola Chaf	0.202446	1389	2778
45	Signal	0.243041	1885	3770
46	Waryt Square	0.196894	688	1376
47	Shola	0.071008	333	666
48	Yesetoch Adebabay	0.086462	772	1544
49	Engilsh Embassy	0.202842	538	1076
50	Megenagna	0.195398	1335	3037
51	Megenagna	0.023062	138	509
52	Megenagna	0.102327	576	1491
53	Total	0.191295	1893	3786
54	Lamberet	0.258606	1819	3638
55	Ahmed Building	0.213194	1476	2952
56	St .Mecael	0.195497	3058	6116
57	Salite Mihret	0.290783	1911	3822
58	Signal	0.182402	382	764
59	Yeka Michael	0.263126	1939	3878
60	Gurd Shola	0.114246	945	1890
61	Tikur Abay	0.128594	158	316
62	Kera Condminium	0.209215	950	1900
63	Kera Sayiders	0.271655	1823	3646
64	Mazoriya	0.146655	1219	2438
65	Minilik School	0.078789	248	496
66	Bono Weha	0.072851	562	1124
67	Yeha	0.133607	896	1792
68	Gurara	0.154892	1094	2188
69	Gurara	0.177378	1066	2132

70	Kokebe Tsebah School	0.14182	346	692
71	Bret Dildy	0.143369	847	1694
72	Aware Dildiy	0.173825	1389	2778
73	Aware Square	0.161898	1088	2176
74	Megenagna	0.114999	474	948
75	Shola	0.23867	2134	4268
76	Dinberwa Hospital	0.22984	2114	4228
77	Aware	0.141043	1302	2604
78	Kazanchis / Meles Foundation	0.095276	717	1434
79	Cmc Square	0.156943	376	752
80	Megenagna	0.130925	691	1382
81	Megenagna	0.246639	1783	3566
82	6 Kilo Tele	0.131452	1040	2080
83	6 Kilo	0.10265	674	1348
84	Eyesus	0.197914	1089	2178
85	Hamle 19	0.113347	897	1794
86	Feres Bet	0.125961	94	188
87	Ayat Square	0.154152	532	1064
88	Ayat	0.049727	405	810
89	Condominium	0.135955	558	1116
90	Cmc	0.202259	536	1072
91	St. Micheal Church	0.142772	454	908
92	Century Mall	0.070435	493	986
93	Balderas	0.241617	2117	4234
94	Radison Blue	0.1906	1890	3780
95	Biherawi	0.327806	1018	2036
96	Legehar	0.209261	2006	4012
97	Tafo Mebrat Hail	0.132282	23	46
98	Kazzanchis	0.033287	144	288
99	Shola	0.241587	2052	4104
100	Shola Gebeya	0.221362	1825	3650
101	Menaheria	0.094159	374	748
102	Condominium	0.2571	1155	2310
103	Megenagna	0.062593	289	923
104	Gurd Shola	0.108727	499	998
105	Keste Demena	0.132152	480	960
106	Tafo Gebrael	0.196282	239	478
107	Tafo Condominium 2	0.164616	27	54
108	Tafo Condominium 1	0.075437	23	46
109	Wesen Michael	0.265339	2416	4832
110	Kara	0.248228	1496	2992
111	Gedera	0.195783	211	422
112	Tafo Adebabay	0.100831	133	266
113	Abissnia	0.196184	1923	3846
114	Hillside School	0.287081	1853	3706
115	Wosone	0.238599	1505	4214
116	Yabem Hotel	0.247852	1082	2164
117	Kara Chore Sefer	0.251165	1627	3254
118	Medhanialem	0.272178	1754	3508
119	Kara Condominum	0.129158	165	996

APPENDIX-B

Three Parameter Accessibility Index for Inbound Direction Existing Bus Stop

Annex.B1: Road density of bus stops T-F (Inbound direction)

Bus Stop ID	Bus Stop-Name	Sum of Road Length (L)Inside Coverage Area In Km	Coverage Area (A) In Km²	Road Density (L/A) In Km/Km²	Road Density AI
0	Jalmeda	3.693932	0.196128	18.834295	3
1	6kilo	2.08959	0.125189	16.691535	3
2	Amistegna Ber	3.275568	0.150464	21.7698	4
3	Menafesha	4.228327	0.154601	27.349905	5
4	Yeka 03	5.837482	0.189432	30.815784	5
5	Zone 8	2.464176	0.015555	158.420231	26
6	Hill Bottom	6.332624	0.177461	35.684619	6
7	Megenagia	1.154849	0.012441	92.824251	15
8	Meskelaga	3.298623	0.224646	14.683636	3
9	Gedera	2.97594	0.19178	15.517498	3
10	Kara	6.1195	0.277249	22.072181	4
11	Kera Condominyam	6.047411	0.250401	24.150881	4
12	Wesen	7.778345	0.254949	30.509472	5
13	Hillside School	7.050985	0.278807	25.289868	4
14	Condomineym	5.95157	0.321072	18.536544	3
15	Lamberat	4.434829	0.222608	19.922185	3
16	Megenaga	3.025984	0.092733	32.630983	6
17	Haya Hulet	4.703367	0.209358	22.465664	4
18	Zerihun	3.152969	0.097784	32.244301	5
19	Aware	3.47403	0.178089	19.507291	3
20	Aware Square	3.438762	0.173913	19.772863	3
21	Anbessa Gebi	2.08959	0.098033	21.315208	4
22	Aware	3.768651	0.179271	21.022058	4
23	Aware	3.258731	0.128967	25.26796	4
24	Megenagna Terminal	2.980153	0.05961	49.994601	8
25	Kela	3.279837	0.091388	35.88915	6
26	Megenagna	28.933151	0.266574	108.257058	19
27	Kokeb Tsebay School	2.887832	0.145754	19.813035	3
28	Lamberet	3.125229	0.111523	28.02325	5
29	Lamberet	2.099502	0.044389	47.297552	8
30	Megenagna	2.538851	0.069294	36.638678	6
31	Menelik Hospitial	2.788008	0.156777	17.783309	3
32	Misrak	27.022774	0.229151	117.282956	20
33	Menelik Hospital	3.000992	0.188892	15.88735	3
34	Salite Mehret	1.435557	0.037758	38.019568	6
35	Signal	6.719026	0.233853	28.73183	5
36	Signal	28.990099	0.254184	117.500186	18

37	Shola	5.75986	0.251935	22.862504	4
38	Yetebaberut Chaf	3.250059	0.176945	18.367666	3
39	St Michale	4.517647	0.209058	21.609526	4
40	Shola	3.002948	0.106191	28.278651	5
41	Shola Gebeya	5.75986	0.255179	22.571838	4
42	Cool Hintsa	41.353656	0.329713	127.270288	18
43	Noc Chaf	6.628341	0.231032	28.690102	5
44	Kotebe	7.030434	0.235225	29.888079	5
45	Balderas	7.419564	0.244067	30.399686	5
46	Shola Gebeya	28.827009	0.264087	108.85134	17
47	Mere	5.719483	0.196808	29.06122	5
48	Ethio China Mebrat Hayil	7.116762	0.288277	24.687217	4
49	Women Square	2.959141	0.092867	31.864131	5
50	Yetebaberut	2.678353	0.118974	22.512067	4
51	Wesen	5.901903	0.238799	24.714908	4
52	Condominium	5.277898	0.206073	25.611831	4
53	Kera	6.388797	0.268519	23.792723	4
54	Mikael	3.938208	0.16078	24.494347	4
55	Mezan	3.936626	0.148343	26.537278	5
56	Tena Tabea	3.700512	0.132798	27.865686	5
57	Mazoriya	3.322631	0.141174	23.535639	4
58	Gurara	4.380962	0.177378	24.698419	4
59	Aware Dildiy	4.712563	0.173825	27.110996	5
60	Dinberwa Hospital	6.846042	0.236286	28.97353	5
61	Aware	4.018162	0.141043	28.488975	5
62	Kazanchis / Meles Foundation	3.636811	0.116988	31.086957	5
63	Kazanchis / Meles Foundation	2.679593	0.095276	28.124572	5
64	Cmc Square	3.534587	0.201436	17.546951	3
65	Cmc Square	2.99915	0.164452	18.237219	3
66	Lamberet	2.788996	0.10826	25.761952	4
67	Megenagna	2.634341	0.06951	37.898489	6
68	Megenagna	3.826796	0.118575	32.273251	5
69	Shola	6.046295	0.220598	27.408643	5
70	British Embassy	4.311629	0.240344	17.93938	3
71	Minilik School	3.165688	0.091411	34.631517	5
72	6 Kilo Tele	2.826485	0.12976	21.782395	4
73	6 Kilo	2.130699	0.10265	20.756872	4
74	Eyesus	4.420872	0.197914	22.337306	4
75	Hamle 19	3.67059	0.113347	32.383596	5
76	Condominium	3.235072	0.099281	32.585025	5
77	Meri	5.646357	0.20487	27.560734	5
78	St. Micheal Church	2.593192	0.185592	13.972567	3
79	Civil Service	1.592779	0.088688	17.959356	3
80	Gurd Shola	1.74124	0.080195	21.712645	4
81	Legehar	5.64307	0.209261	26.966642	5
82	Yabem Hotel	4.951275	0.216804	22.837549	4

83	Abisinia Cafe	4.980873	0.195155	25.522693	4
84	Belgium Embassy	5.103376	0.243925	20.921885	4
85	Kokebe Tsebah	3.040383	0.141841	21.435126	4
86	Ayat Zone 2	4.181936	0.152726	27.382003	5
87	Ayat Train Station	1.729595	0.04491	38.512166	6
88	Kazzanchis	1.233609	0.033287	37.059942	6
89	Kara	45.902592	0.328412	139.063008	18
90	Wesen	7.896714	0.256521	30.78387	5
91	Lamberet	32.643824	0.257303	127.93456	18
92	Megenagna	5.7982	0.241689	23.990332	4
93	Wesen Michael	7.003953	0.25463	27.506352	5
94	Yeka Abado Megenteya	3.066694	0.17257	17.770725	3
95	Tafo Square	2.192586	0.090696	24.175033	4
96	Tafo Condominium	3.982272	0.142107	28.023052	5
97	Tafo Condominium	4.014358	0.155499	25.81592	4
98	Mebrat Hail	3.812849	0.163072	23.381414	4
99	Tafo Gebrael	5.927512	0.183765	32.255942	5
100	Maryam	3.230776	0.095094	33.974508	6
101	Keste Demena	2.464176	0.014573	169.09441	27
102	Ayat Square	6.900549	0.196884	35.048748	6
103	Yetebaberut	3.951755	0.191733	20.610726	4
104	Civil Service	3.078199	0.125706	24.487197	4
105	Gurd Shola	1.746484	0.096566	18.085936	3
106	Gurd Shola	3.238545	0.121945	26.55744	5
107	Kara Condominum	3.129663	0.129692	24.131424	4
108	Yeka Abado Condominum	1.752438	0.105363	16.632385	3
109	Meskelegna Ababdo	3.538734	0.242749	14.577774	3
110	Kara Condominum	2.877265	0.128073	22.465907	4
111	Lamberet	4.620365	0.260812	17.715327	3

Annex. B2: Trip Generation by public bus for bus stops T-F (Inbound direction)

Bus Stop ID	Bus Stop-Name	Trip Generation By Anbesa Bus	Trip Generation AI
0	Jalmeda	64	4
1	6kilo	64	4
2	Amistegna Ber	64	4
3	Menafesha	47	3
4	Yeka 03	47	3
5	Zone 8	309	9
6	Hill Bottom	47	3
7	Megenagia	47	3
8	Meskelaga	36	3
9	Gedera	66	4
10	Kara	36	3
11	Kera Condominyam	36	3
12	Wesen	36	3
13	Hillside School	36	3

14	Condomineym	36	3
15	Lamberat	67	4
16	Megenaga	41	3
17	Haya Hulet	41	3
18	Zerihun	41	3
19	Aware	58	4
20	Aware Square	528	14
21	Anbessa Gebi	64	4
22	Aware	149	6
23	Aware	58	4
24	Megenagna Terminal	13	3
25	Kela	15	3
26	Megenagna	528	14
27	Kokeb Tsebay School	1069	27
28	Lamberet	346	10
29	Lamberet	37	3
30	Megenagna	451	13
31	Menelik Hospitial	1082	27
32	Misrak	455	13
33	Menelik Hospital	64	4
34	Salite Mehret	74	4
35	Signal	528	14
36	Signal	528	14
37	Shola	1069	27
38	Yetebaberut Chaf	74	4
39	St Michale	74	4
40	Shola	74	4
41	Shola Gebeya	1069	27
42	Cool Hintsa	455	13
43	Noc Chaf	36	3
44	Kotebe	36	3
45	Balderas	528	14
46	Shola Gebeya	528	14
47	Mere	47	3
48	Ethio China Mebrat Hayil	36	3
49	Women Square	528	14
50	Yetebaberut	27	3
51	Wesen	36	3
52	Condominium	36	3
53	Kera	36	3
54	Mikael	46	3
55	Mezan	15	3
56	Tena Tabea	15	3
57	Mazoriya	15	3
58	Gurara	15	3
59	Aware Dildiy	149	6
60	Dinberwa Hospital	528	14
61	Aware	91	4
62	Kazanchis / Meles .F	470	13

63	Kazanchis / Meles. F	91	4
64	Cmc Square	47	3
65	Cmc Square	74	4
66	Lamberet	36	3
67	Megenagna	47	3
68	Megenagna	67	4
69	Shola	58	4
70	British Embassy	1069	27
71	Minilik School	1090	27
72	6 Kilo Tele	1090	27
73	6 Kilo	1090	27
74	Eyesus	25	3
75	Hamle 19	25	3
76	Condominium	47	3
77	Meri	47	3
78	St. Micheal Church	74	4
79	Civil Service	47	4
80	Gurd Shola	74	4
81	Legehar	37	3
82	Yabem Hotel	36	3
83	Abisinia Cafe	67	4
84	Belgium Embassy	1069	27
85	Kokebe Tsebah	1069	27
86	Ayat Zone 2	47	3
87	Ayat Train Station	47	3
88	Kazzanchis	91	4
89	Kara	51	3
90	Wesen	36	3
91	Lamberet	346	10
92	Megenagna	77	4
93	Wesen Michael	36	3
94	Yeka Abado Megentey	66	4
95	Tafo Square	47	3
96	Tafo Condominium 1	47	3
97	Tafo Condominium 2	47	3
98	Mebrat Hail	47	3
99	Tafo Gebrael	47	3
100	Maryam	47	3
101	Keste Demena	224	7
102	Ayat Square	47	3
103	Yetebaberut	47	3
104	Civil Service	74	4
105	Gurd Shola	60	4
106	Gurd Shola	60	4
107	Kara Condominum	36	3
108	Yeka Abado Condominum	336	10
109	Meskelegna Ababdo	36	3
110	Kara Condominum	66	4
111	Lamberet	67	4

Annex.B3: Population served by bus stops T-F (Inbound direction)

Bus Stop ID	Bus Stop-Name	Coverage Area (A) In Km²	No of Parcel Inside Coverage (A) In Km²	Population Inside Coverage Area	Population Served AI
0	Jalmeda	0.196128	1880	3760	17
1	6kilo	0.125189	175	350	4
2	Amistegna Ber	0.150464	24	51	3
3	Menafesha	0.154601	28	56	3
4	Yeka 03	0.189432	166	416	3
5	Zone 8	0.015555	123	417	4
6	Hill Bottom	0.177461	637	1274	8
7	Megenagia	0.012441	96	192	3
8	Meskelaga	0.224646	7	14	3
9	Gedera	0.19178	200	400	4
10	Kara	0.277249	2014	4028	18
11	Kera Condominyam	0.250401	1093	2186	11
12	Wesen	0.254949	2132	4264	19
13	Hillside School	0.278807	1833	3666	17
14	Condomineym	0.321072	1081	2162	11
15	Lamberat	0.222608	1776	3552	17
16	Megenaga	0.092733	354	708	5
17	Haya Hulet	0.209358	1667	3334	16
18	Zerihun	0.097784	799	1598	9
19	Aware	0.178089	1237	2474	12
20	Aware Square	0.173913	342	684	5
21	Anbessa Gebi	0.098033	198	396	4
22	Aware	0.179271	1558	3116	15
23	Aware	0.128967	832	1664	9
24	Megenagna Terminal	0.05961	260	520	5
25	Kela	0.091388	1276	2552	13
26	Megenagna	0.266574	1852	3704	17
27	Kokeb Tsebay School	0.145754	346	692	5
28	Lamberet	0.111523	703	1406	8
29	Lamberet	0.044389	251	643	5
30	Megenagna	0.069294	236	472	4
31	Menelik Hospital	0.156777	1085	2170	11
32	Misrak	0.229151	1592	3184	15
33	Menelik Hospital	0.188892	1357	2714	13
34	Salite Mehret	0.037758	40	80	3
35	Signal	0.233853	2549	5098	23
36	Signal	0.254184	2351	4702	21
37	Shola	0.251935	1813	3626	17
38	Yetebaberut Chaf	0.176945	191	382	4
39	St Michale	0.209058	1541	3082	15
40	Shola	0.106191	426	852	6
41	Shola Gebeya	0.255179	1834	3668	17
42	Cool Hintsa	0.329713	1185	2370	12
43	Noc Chaf	0.231032	1697	3394	16
44	Kotebe	0.235225	1551	3102	15

45	Balderas	0.244067	2074	4148	19
46	Shola Gebeya	0.264087	2335	4670	21
47	Mere	0.196808	3095	6190	27
48	Ethio China Mebrat Hayil	0.288277	1872	3744	17
49	Women Square	0.092867	818	1636	9
50	Yetebaberut	0.118974	254	508	4
51	Wesen	0.238799	802	1604	9
52	Condominium	0.206073	948	1896	10
53	Kera	0.268519	1705	3410	16
54	Mikael	0.16078	293	586	5
55	Mezan	0.148343	1874	3748	17
56	Tena Tabea	0.132798	888	1776	10
57	Mazoriya	0.141174	1123	2246	12
58	Gurara	0.177378	1066	2132	11
59	Aware Dildiy	0.173825	1389	2778	13
60	Dinberwa Hospital	0.236286	2152	4304	20
61	Aware	0.141043	1302	2604	13
62	Kazanchis / Meles .F	0.116988	1495	2990	14
63	Kazanchis / Meles. F	0.095276	717	1434	8
64	Cmc Square	0.201436	469	938	6
65	Cmc Square	0.164452	148	296	4
66	Lamberet	0.10826	446	892	6
67	Megenagna	0.06951	344	688	5
68	Megenagna	0.118575	590	1180	7
69	Shola	0.220598	1818	3636	17
70	British Embassy	0.240344	1087	2174	11
71	Minilik School	0.091411	332	664	5
72	6 Kilo Tele	0.12976	1010	2020	10
73	6 Kilo	0.10265	674	1348	8
74	Eyesus	0.197914	1089	2178	11
75	Hamle 19	0.113347	897	1794	9
76	Condominium	0.099281	1047	2094	11
77	Meri	0.20487	3162	6324	27
78	St. Micheal Church	0.185592	441	882	6
79	Civil Service	0.088688	39	78	3
80	Gurd Shola	0.080195	455	910	6
81	Legehar	0.209261	2006	4012	18
82	Yabem Hotel	0.216804	966	1932	10
83	Abisinia Cafe	0.195155	1763	3526	16
84	Belgium Embassy	0.243925	872	1744	9
85	Kokebe Tsebah	0.141841	347	694	5
86	Ayat Zone 2	0.152726	569	1138	7
87	Ayat Train Station	0.04491	385	770	6
88	Kazzanchis	0.033287	144	288	4
89	Kara	0.328412	2204	4408	20
90	Wesen	0.256521	2008	4016	18
91	Lamberet	0.257303	1818	3636	17
92	Megenagna	0.241689	1753	3506	16

93	Wesen Michael	0.25463	2297	4594	21
94	Yeka Abado Megentey	0.17257	190	380	4
95	Tafo Square	0.090696	100	200	3
96	Tafo Condominium 1	0.142107	21	42	3
97	Tafo Condominium 2	0.155499	31	62	3
98	Mebrat Hail	0.163072	14	28	3
99	Tafo Gebrael	0.183765	153	306	4
100	Maryam	0.095094	90	180	3
101	Keste Demena	0.014573	123	413	4
102	Ayat Square	0.196884	769	1538	9
103	Yetebaberut	0.191733	513	1026	7
104	Civil Service	0.125706	56	112	3
105	Gurd Shola	0.096566	215	430	4
106	Gurd Shola	0.121945	1046	2092	11
107	Kara Condominum	0.129692	164	328	4
108	Yeka Abado Condominum	0.105363	3	6	3
109	Meskelegna Ababdo	0.242749	33	66	3
110	Kara Condominum	0.128073	274	548	5
111	Lamberet	0.260812	1895	3790	17

Three Parameter Accessibility Index for Outbound Direction Existing Bus Stop

Annex.B4: Road density of bus stops F-T (Outbound direction)

Bus stop ID	Stop_Name	Sum Of Road Length Inside Coverage Area(L) In Km	Coverage Area (A) In Km²	Road Density (L/A) In Km/Km²	Road density AI
0	Jalmeda	3.441047	0.188232	18.280903	4
1	6kilo	2.282161	0.135092	16.893418	4
2	Tafo	2.192586	0.086636	25.308156	7
3	Amistegna Ber	1.996472	0.075708	26.370812	8
4	Menafesha	3.882307	0.150786	25.747049	7
5	Gebriel	3.454924	0.114596	30.148798	9
6	Yeka No 1condominume	5.409929	0.151711	35.659466	11
7	Ayat Adebabay	4.849734	0.127929	37.909594	12
8	Ayat	4.889848	0.16247	30.097009	9
9	Meri	6.001469	0.209967	28.582954	9
10	Yetebaberut	3.095521	0.164652	18.800423	5
11	St Mikale	3.664517	0.161241	22.726988	6
12	Civil Service	3.078199	0.128893	23.881831	7
13	Gedera	3.487319	0.223144	15.628123	3
14	St Mikale	3.938208	0.157733	24.967588	7
15	Kara	18.124354	0.302119	61.581307	22
16	Wesen	17.932155	0.289017	59.905268	21
17	Hillside School	7.476638	0.247902	30.159644	9
18	Condominyem	20.035629	0.332213	61.167927	22
19	Lamberat	4.57623	0.186507	24.536458	7
20	Yetebaberut	3.393913	0.164705	20.606013	5

21	Megenaga	3.025984	0.094031	32.180605	10
22	Haya Hulet	4.630642	0.20943	22.110698	6
23	Zerihun	3.152969	0.097784	32.244301	10
24	Abebe Suk	5.012103	0.213205	23.508416	6
25	Anbessa Gebi	2.282161	0.087135	26.191082	8
26	Aware	3.768651	0.179271	21.022058	6
27	5	3.441047	0.183203	18.782676	5
28	Ayat Adebabay	5.387446	0.148746	36.219211	12
29	6 Kilo Tele	2.916565	0.103701	28.124791	8
30	Megenagna	3.604016	0.136586	26.386359	8
31	Megazen	3.993538	0.149321	26.744667	8
32	Kela	3.485678	0.142508	24.459561	7
33	Kenean	4.166806	0.120641	34.538917	11
34	Mazoria	2.435075	0.104663	23.265885	6
35	Megenagna	5.363646	0.228269	23.497031	6
36	Kokebe Tsebah	2.654078	0.172934	15.347303	3
37	Kokeb Tsebay School	3.040383	0.136994	22.193521	6
38	Lamberet	2.099502	0.044389	47.297552	16
39	Misrak	6.220093	0.235782	26.380696	8
40	Menelik Hospital	3.000992	0.188892	15.88735	3
41	Shola Gebya	3.558708	0.195178	18.233101	4
42	Shola	7.108972	0.25778	27.577693	8
43	Shola	5.75986	0.255086	22.580035	6
44	Shola Chaf	8.285189	0.202446	44.106705	15
45	Signal	5.945993	0.243041	24.464958	7
46	Waryt Square	3.447871	0.196894	17.511265	4
47	Shola	2.019861	0.071008	28.445404	8
48	Yesetoch Adebabay	2.959141	0.086462	34.224839	11
49	Engilsh Embassy	3.980203	0.202842	19.622202	5
50	Megenagna	5.43004	0.195398	27.789662	8
51	Megenagna	1.767998	0.023062	76.661886	27
52	Megenagna	2.679399	0.102327	26.184681	8
53	Total	5.442271	0.191295	28.449554	8
54	Lamberet	13.699286	0.258606	51.171606	18
55	Ahmed Building	6.148813	0.213194	28.841353	9
56	St .Mecael	5.390722	0.195497	27.574391	8
57	Salite Mihret	6.821574	0.290783	23.459367	6
58	Signal	3.438762	0.182402	18.852652	5
59	Yeka Michael	13.817743	0.263126	51.110121	18
60	Gurd Shola	2.881112	0.114246	25.21857	7
61	Tikur Abay	2.678353	0.128594	20.827993	5
62	Kera Condminium	5.277898	0.209215	25.227135	7
63	Kera Sayiders	6.963727	0.271655	25.634415	7
64	Mazoriya	3.156102	0.146655	21.52058	6
65	Minilik School	3.165688	0.078789	40.179417	13
66	Bono Weha	1.593397	0.072851	21.872003	6
67	Yeha	3.990882	0.133607	29.870368	9
68	Gurara	5.172282	0.154892	33.392792	10

69	Gurara	4.380962	0.177378	24.698419	7
70	Kokebe Tsebah School	3.040383	0.14182	21.438392	6
71	Bret Dildy (Buno Weha)	4.996194	0.143369	34.848549	11
72	Aware Dildiy	4.712563	0.173825	27.110996	8
73	Aware Square	3.956178	0.161898	24.436212	7
74	Megenagna	3.943776	0.114999	34.294054	11
75	Shola	6.899064	0.23867	28.906284	9
76	Dinberwa Hospital	6.686334	0.22984	29.091308	9
77	Aware	4.018162	0.141043	28.488975	8
78	Kazanchis / Meles Foundation	2.679593	0.095276	28.124572	8
79	Cmc Square	2.463546	0.156943	15.697089	3
80	Megenagna	4.085895	0.130925	31.207954	10
81	Megenagna	13.423732	0.246639	53.990554	19
82	6 Kilo Tele	2.826485	0.131452	21.502086	6
83	6 Kilo	2.130699	0.10265	20.756872	5
84	Eyesus	4.420872	0.197914	22.337306	6
85	Hamle 19	3.67059	0.113347	32.383596	10
86	Feres Bet	2.381903	0.125961	18.909849	5
87	Ayat Square	5.447204	0.154152	35.336629	11
88	Ayat	1.823251	0.049727	36.665531	12
89	Condominium	3.248205	0.135955	23.89171	7
90	Cmc	3.679673	0.202259	18.192872	4
91	St. Micheal Church	3.153131	0.142772	22.085095	6
92	Century Mall	1.445775	0.070435	20.526282	5
93	Balderas	6.427965	0.241617	26.60389	8
94	Radison Blue	5.655627	0.1906	29.672712	9
95	Biherawi	6.029136	0.327806	18.392397	4
96	Legehar	10.64307	0.209261	47.966642	16
97	Tafo Mebrat Hail	1.770913	0.132282	13.387412	3
98	Kazzanchis	1.233609	0.033287	37.059942	12
99	Shola	7.173812	0.241587	29.694552	9
100	Shola Gebeya	6.046295	0.221362	27.314118	8
101	Menaheria	2.989344	0.094159	31.747962	10
102	Condominium	5.812923	0.2571	22.609586	6
103	Megenagna	2.388533	0.062593	38.159934	12
104	Gurd Shola	3.385441	0.108727	31.137192	10
105	Keste Demena	4.37277	0.132152	33.088952	10
106	Tafo Gebrael	5.018273	0.196282	25.566697	7
107	Tafo Condominium	2.772578	0.164616	16.842734	4
108	Tafo Condominium	1.996472	0.075437	26.465466	8
109	Wesen Michael	8.486511	0.265339	33.214929	11
110	Kara	4.857184	0.248228	19.567415	5
111	Gedera	2.97594	0.195783	15.200188	3
112	Tafo Adebabay	2.411444	0.100831	23.91572	7
113	Abissnia	5.179477	0.196184	26.401179	8
114	Hillside School	8.050985	0.287081	33.560928	11

115	Wosone	6.792694	0.238599	28.469054	8
116	Yabem Hotel	5.812923	0.247852	23.453212	6
117	Kara Chore Sefer	7.962964	0.251165	31.704164	10
118	Medhanialem	6.606513	0.272178	24.272768	7
119	Kara Condominum	3.129663	0.129158	24.231345	7

Annex.B5: Trip Generation by public bus for bus stops F-T (outbound direction)

Bus Stop ID	Bus Stop-Name	Trip Generation By Anbesa Bus	Trip Generation AI
0	Jalmeda	163	6
1	6kilo	72	4
2	Tafo	169	6
3	Amistegna Ber	169	6
4	Menafesha	169	6
5	Gebriel	169	6
6	Yeka No 1condominume	169	6
7	Ayat Adebabay	169	6
8	Ayat	492	13
9	Meri	492	13
10	Yetebaberut	492	13
11	St Mikale	492	13
12	Civil Service	492	13
13	Gedera	295	8
14	St Mikale	295	8
15	Kara	66	4
16	Wesen	66	4
17	Hillside School	104	5
18	Condominyem	208	7
19	Lamberat	339	9
20	Yetebaberut	492	13
21	Megenaga	6	3
22	Haya Hulet	5	3
23	Zerihun	41	3
24	Abebe Suk	34	3
25	Anbessa Gebi	156	6
26	Aware	91	4
27	5	157	6
28	Ayat Adebabay	323	9
29	6 Kilo Tele	157	6
30	Megenagna	33	3
31	Megazen	156	6
32	Kela	156	6
33	Kenean	156	6
34	Mazoria	157	6
35	Megenagna	32	3
36	Kokebe Tsebah	321	9
37	Kokeb Tsebay School	321	9

38	Lamberet	37	3
39	Misrak	52	4
40	Menelik Hospital	194	7
41	Shola Gebya	66	4
42	Shola	52	4
43	Shola	321	9
44	Shola Chaf	321	9
45	Signal	52	4
46	Waryt Square	52	4
47	Shola	460	13
48	Yesetoch Adebabay	52	4
49	Engilsh Embassy	321	9
50	Megenagna	339	9
51	Megenagna	536	14
52	Megenagna	532	14
53	Total	532	14
54	Lamberet	485	13
55	Ahmed Building	104	5
56	St .Mecael	492	13
57	Salite Mihret	104	5
58	Signal	52	4
59	Yeka Michael	339	9
60	Gurd Shola	460	13
61	Tikur Abay	492	13
62	Kera Condminium	104	5
63	Kera Sayiders	66	4
64	Mazoriya	313	8
65	Minilik School	32	3
66	Bono Weha	157	6
67	Yeha	157	6
68	Gurara	312	8
69	Gurara	312	8
70	Kokebe Tsebah School	321	9
71	Buno Weha)	157	6
72	Aware Dildiy	91	4
73	Aware Square	91	4
74	Megenagna	33	3
75	Shola	33	3
76	Dinberwa Hospital	52	4
77	Aware	91	4
78	Kazanchis / Meles Foundation	143	6
79	Cmc Square	492	13
80	Megenagna	485	13
81	Megenagna	339	9
82	6 Kilo Tele	32	3
83	6 Kilo	32	3
84	Eyesus	492	13
85	Hamle 19	49	3

86	Feres Bet	174	6
87	Ayat Square	323	9
88	Ayat	492	13
89	Condominium	1116	27
90	Cmc	492	13
91	St. Micheal Church	492	13
92	Century Mall	460	13
93	Balderas	52	4
94	Radison Blue	485	13
95	Biherawi	208	7
96	Legehar	537	14
97	Tafo Mebrat Hail	143	6
98	Kazzanchis	286	9
99	Shola	52	4
100	Shola Gebeya	19	3
101	Menaheria	339	9
102	Condominium	104	5
103	Megenagna	460	13
104	Gurd Shola	460	13
105	Keste Demena	169	6
106	Tafo Gebrael	169	6
107	Tafo Condominium 2	169	6
108	Tafo Condominium 1	104	5
109	Wesen Michael	169	6
110	Kara	295	8
111	Gedera	295	8
112	Tafo Adebabay	462	13
113	Abissnia	295	8
114	Hillside School	104	5
115	Wosone	66	4
116	Yabem Hotel	104	5
117	Kara Chore Sefer	104	5
118	Medhanialem	295	8
119	Kara Condominum	295	8

Annex.B6: Population served by bus stops F-T (Outbound direction)

Bus Stop ID	Bus Stop-Name	Coverage Area (A) In Km²	Number Of Parcels Inside Coverage Area(A) In Km²	Population Inside Coverage Area	Population served AI
0	Jalmeda	0.188232	1864	3728	18
1	6kilo	0.135092	214	428	4
2	Tafo	0.086636	99	198	3
3	Amistegna Ber	0.075708	19	47	3
4	Menafesha	0.150786	28	65	3
5	Gebriel	0.114596	76	185	3
6	Yeka No1condominum	0.151711	519	1038	7
7	Ayat Adebabay	0.127929	398	796	6
8	Ayat	0.16247	713	1426	8

9	Meri	0.209967	3023	6046	27
10	Yetebaberut	0.164652	471	942	6
11	St Mikale	0.161241	758	1548	9
12	Civil Service	0.128893	58	116	3
13	Gedera	0.223144	273	546	5
14	St Mikale	0.157733	298	596	5
15	Kara	0.302119	2107	4214	20
16	Wesen	0.289017	2896	5792	26
17	Hillside School	0.247902	1764	3528	17
18	Condominyem	0.332213	1120	2240	12
19	Lamberat	0.186507	498	996	6
20	Yetebaberut	0.164705	148	296	4
21	Megenaga	0.094031	357	714	5
22	Haya Hulet	0.20943	1664	3328	16
23	Zerihun	0.097784	799	1598	9
24	Abebe Suk	0.213205	1303	2606	13
25	Anbessa Gebi	0.087135	425	850	6
26	Aware	0.179271	1558	3116	15
27	5	0.183203	1837	3674	17
28	Ayat Adebabay	0.148746	512	1024	7
29	6 Kilo Tele	0.103701	48	96	3
30	Megenagna	0.136586	682	1364	8
31	Megazen	0.149321	1894	3788	18
32	Kela	0.142508	1609	3218	16
33	Kenean	0.120641	1295	2590	13
34	Mazoria	0.104663	751	1502	8
35	Megenagna	0.228269	1809	3618	17
36	Kokebe Tsebah	0.172934	455	910	6
37	Kokeb Tsebay School	0.136994	345	690	5
38	Lamberet	0.044389	251	502	5
39	Misrak	0.235782	1768	3536	17
40	Menelik Hospital	0.188892	1357	2714	13
41	Shola Gebya	0.195178	1280	2560	13
42	Shola	0.25778	2209	4418	20
43	Shola	0.255086	1836	3672	17
44	Shola Chaf	0.202446	1389	2778	14
45	Signal	0.243041	1885	3770	18
46	Waryt Square	0.196894	688	1376	8
47	Shola	0.071008	333	666	5
48	Yesetoch Adebabay	0.086462	772	1544	9
49	Engilsh Embassy	0.202842	538	1076	7
50	Megenagna	0.195398	1335	3037	15
51	Megenagna	0.023062	138	509	4
52	Megenagna	0.102327	576	1491	8
53	Total	0.191295	1893	3786	18
54	Lamberet	0.258606	1819	3638	17
55	Ahmed Building	0.213194	1476	2952	14
56	St .Mecael	0.195497	3058	6116	27
57	Salite Mihret	0.290783	1911	3822	18

58	Signal	0.182402	382	764	3
59	Yeka Michael	0.263126	1939	3878	18
60	Gurd Shola	0.114246	945	1890	11
61	Tikur Abay	0.128594	158	316	3
62	Kera Condminium	0.209215	950	1900	10
63	Kera Sayiders	0.251655	1823	3646	17
64	Mazoriya	0.146655	1219	2438	12
65	Minilik School	0.078789	248	496	4
66	Bono Weha	0.072851	562	1124	7
67	Yeha	0.133607	896	1792	10
68	Gurara	0.154892	1094	2188	11
69	Gurara	0.177378	1066	2132	11
70	Kokebe Tsebah School	0.14182	346	692	5
71	Buno Weha	0.143369	847	1694	9
72	Aware Dildiy	0.173825	1389	2778	14
73	Aware Square	0.161898	1088	2176	11
74	Megenagna	0.114999	474	948	6
75	Shola	0.23867	2134	4268	20
76	Dinberwa Hospital	0.22984	2114	4228	20
77	Aware	0.141043	1302	2604	13
78	Kazanchis / Meles Foundation	0.095276	717	1434	8
79	Cmc Square	0.156943	376	752	5
80	Megenagna	0.130925	691	1382	8
81	Megenagna	0.246639	1783	3566	17
82	6 Kilo Tele	0.131452	1040	2080	11
83	6 Kilo	0.10265	674	1348	8
84	Eyesus	0.197914	1089	2178	11
85	Hamle 19	0.113347	897	1794	10
86	Feres Bet	0.125961	94	188	3
87	Ayat Square	0.154152	532	1064	7
88	Ayat	0.049727	405	810	6
89	Condominium	0.135955	558	1116	7
90	Cmc	0.202259	536	1072	7
91	St. Micheal Church	0.142772	454	908	6
92	Century Mall	0.070435	493	986	6
93	Balderas	0.241617	2117	4234	20
94	Radison Blue	0.1906	1890	3780	18
95	Biherawi	0.327806	1018	2036	11
96	Legehar	0.209261	2006	4012	19
97	Tafo Mebrat Hail	0.132282	23	46	3
98	Kazzanchis	0.033287	144	288	3
99	Shola	0.241587	2052	4104	19
100	Shola Gebeya	0.221362	1825	3650	17
101	Menaheria	0.094159	374	748	5
102	Condominium	0.2571	1155	2310	12
103	Megenagna	0.062593	289	923	6
104	Gurd Shola	0.108727	499	998	6
105	Keste Demena	0.132152	480	960	6

106	Tafo Gebrael	0.196282	239	478	4
107	Tafo Condominium 2	0.164616	27	54	3
108	Tafo Condominium 1	0.075437	23	46	3
109	Wesen Michael	0.265339	2416	4832	22
110	Kara	0.248228	1496	2992	15
111	Gedera	0.195783	211	422	4
112	Tafo Adebabay	0.100831	133	266	3
113	Abissnia	0.196184	1923	3846	18
114	Hillside School	0.287081	1853	3706	18
115	Wosone	0.238599	1505	4214	20
116	Yabem Hotel	0.247852	1082	2164	11
117	Kara Chore Sefer	0.251165	1627	3254	16
118	Medhanialem	0.272178	1754	3508	17
119	Kara Condominum	0.129158	165	996	6

APPENDIX-C

Annex C1: Accessibility Index along with value of three parameters of all proposed bus stops (Inbound direction)

BusStop ID	Road Density	Trip generation by bus	Population served inside service Area	Accessibility Index
0	18.834295	64	3760	6
1	16.691535	64	350	5
2	21.7698	64	51	5
3	27.349905	47	56	5
4	30.815784	47	416	6
5	158.420	309	417	21
6	35.684619	47	1274	7
7	92.824251	47	192	11
8	14.683636	36	14	4
9	15.517498	66	400	5
10	22.072181	36	4028	6
11	24.150881	36	2186	6
12	30.509472	36	4264	7
13	25.289868	36	3666	6
14	18.536544	36	2162	5
15	19.922185	67	3552	6
16	32.630983	41	708	6
17	22.465664	41	3334	6
18	32.244301	41	1598	6
19	19.507291	58	2474	5
20	19.772863	528	684	7
21	21.315208	64	396	5
22	21.022058	149	3116	7
23	25.26796	58	1664	6
24	49.994601	13	520	8

25	35.88915	15	2552	7
26	108.537061	528	3704	18
27	21.813035	1069	788	11
28	28.02325	346	1406	8
29	47.297552	37	643	7
30	36.638678	451	472	9
31	24.783309	1082	2170	11
32	117.925462	455	3184	17
33	15.88735	64	2714	6
34	38.019568	74	80	6
35	30.73183	528	5098	10
36	114.051763	528	4702	18
37	69.862504	1069	3626	16
38	18.367666	74	382	5
39	21.609526	74	3082	6
40	28.278651	74	852	6
41	22.571838	1069	3668	13
42	125.423351	455	2370	18
43	28.690102	36	3394	7
44	29.888079	36	3102	7
45	30.399686	528	4148	10
46	109.157147	528	4670	18
47	29.06122	47	6190	8
48	24.687217	36	3744	6
49	31.864131	528	1636	10
50	22.512067	27	508	5
51	24.714908	36	1604	6
52	25.611831	36	1896	6
53	23.792723	36	3410	6
54	24.494347	46	586	5
55	26.537278	15	3748	6
56	27.865686	15	1776	6
57	23.535639	15	2246	6
58	24.698419	15	2132	6
59	27.110996	149	2778	7
60	32.97353	528	4304	10
61	28.488975	91	2604	7
62	31.086957	470	2990	9
63	28.124572	91	1434	6
64	17.546951	47	938	5
65	18.237219	74	296	5
66	25.761952	36	892	5
67	37.898489	47	688	6
68	32.273251	67	1180	6
69	27.408643	58	3636	7
70	17.93938	1069	2174	11
71	34.631517	1090	664	12
72	21.782395	1090	2020	12
73	20.756872	1090	1348	11

74	22.337306	25	2178	6
75	32.383596	25	1794	6
76	32.585025	47	2094	6
77	27.560734	47	6324	7
78	13.972567	74	882	4
79	17.959356	47	78	5
80	21.712645	74	910	5
81	26.966642	37	4012	6
82	22.837549	36	1932	6
83	25.522693	67	3526	6
84	20.921885	1069	1744	11
85	21.435126	1069	694	11
86	27.382003	47	1138	5
87	38.512166	47	770	7
88	37.059942	91	288	7
89	139.771162	51	4408	18
90	30.78387	36	4016	7
91	126.869287	346	3636	18
92	23.990332	77	3506	6
93	27.506352	36	4594	7
94	17.770725	66	380	5
95	24.175033	47	200	5
96	28.023052	47	42	5
97	25.81592	47	62	5
98	23.381414	47	28	5
99	32.255942	47	306	6
100	33.974508	47	180	6
101	169.09441	224	413	20
102	35.048748	47	1538	7
103	20.610726	47	1026	5
104	24.487197	74	112	5
105	18.085936	60	430	5
106	26.55744	60	2092	6
107	24.131424	36	328	5
108	16.632385	336	6	6
109	14.577774	36	66	3
110	22.465907	66	548	5
111	21.715327	67	3790	6
112	13.651302	109	4	4
113	56.054306	109	4409	10
114	56.248867	109	3504	10
115	14.977475	109	3022	6
116	15.797478	109	1247	5
117	1.22392	109	1247	4

Annex C2: Accessibility Index along with value of three parameters of all proposed bus stops (outbound direction)

Bus Stop ID	Road density	Trip generated by bus	Population served Inside Coverage Area	Accessibility Index
0	18.280903	163	3728	7
1	16.893418	72	428	5
2	25.308156	169	198	7
3	26.370812	169	47	7
4	25.747049	169	65	7
5	30.148798	169	185	8
6	35.659466	169	1038	10
7	37.909594	169	796	10
8	30.097009	492	1426	11
9	28.582954	492	6046	12
10	18.800423	492	942	8
11	22.726988	492	1548	9
12	23.881831	492	116	8
13	15.628123	295	546	5
14	24.967588	295	596	8
15	61.581307	66	4214	17
16	59.905268	66	5792	17
17	30.159644	104	3528	9
18	61.167927	208	2240	17
19	24.536458	339	996	8
20	20.606013	492	296	8
21	32.180605	6	714	8
22	22.110698	5	3328	7
23	32.244301	41	1598	9
24	23.508416	34	2606	7
25	26.191082	156	850	7
26	21.022058	91	3116	7
27	18.782676	157	3674	6
28	36.219211	323	1024	11
29	28.124791	157	96	8
30	26.386359	33	1364	7
31	26.744667	156	3788	8
32	24.459561	156	3218	8
33	34.538917	156	2590	10
34	23.265885	157	1502	7
35	23.497031	32	3618	7
36	15.347303	321	910	6
37	22.193521	321	690	8
38	47.297552	37	502	12
39	26.380696	52	3536	8
40	15.88735	194	2714	6
41	18.233101	66	2560	5
42	27.577693	52	4418	9

43	22.580035	321	3672	9
44	44.106705	321	2778	14
45	24.464958	52	3770	8
46	17.511265	52	1376	5
47	28.445404	460	666	10
48	34.224839	52	1544	9
49	19.622202	321	1076	7
50	27.789662	339	3037	10
51	76.661886	536	509	21
52	26.184681	532	1491	10
53	28.449554	532	3786	11
54	51.171606	485	3638	17
55	28.841353	104	2952	8
56	27.574391	492	6116	12
57	23.459367	104	3822	8
58	18.852652	52	764	5
59	51.110121	339	3878	16
60	25.21857	460	1890	9
61	20.827993	492	316	8
62	25.227135	104	1900	7
63	52.735415	66	3646	16
64	21.52058	313	2438	8
65	40.179417	32	496	10
66	21.872003	157	1124	7
67	29.870368	157	1792	9
68	33.392792	312	2188	10
69	24.698419	312	2132	9
70	21.438392	321	692	8
71	34.848549	157	1694	10
72	27.110996	91	2778	8
73	24.436212	91	2176	7
74	34.294054	33	948	8
75	28.906284	33	4268	9
76	29.091308	52	4228	9
77	28.488975	91	2604	8
78	28.124572	143	1434	8
79	15.697089	492	752	7
80	31.207954	485	1382	11
81	53.990554	339	3566	16
82	21.502086	32	2080	6
83	20.756872	32	1348	5
84	22.337306	492	2178	9
85	32.383596	49	1794	9
86	18.909849	174	188	6
87	35.336629	323	1064	11
88	36.665531	492	810	12
89	23.89171	1116	1116	12
90	18.192872	492	1072	8
91	22.085095	492	908	9

92	20.526282	460	986	8
93	26.60389	52	4234	9
94	29.672712	485	3780	12
95	18.392397	208	2036	7
96	47.966642	537	4012	17
97	13.387412	143	46	3
98	37.059942	286	288	10
99	29.694552	52	4104	9
100	27.314118	19	3650	8
101	31.747962	339	748	10
102	22.609586	104	2310	7
103	38.159934	460	923	12
104	31.137192	460	998	10
105	33.088952	169	960	9
106	25.566697	169	478	7
107	16.842734	169	54	5
108	26.465466	104	46	7
109	33.214929	169	4832	11
110	19.567415	295	2992	8
111	15.200188	295	422	5
112	23.91572	462	266	8
113	26.401179	295	3846	9
114	33.560928	104	3706	10
115	28.469054	66	4214	9
116	23.453212	104	2164	8
117	31.704164	104	3254	9
118	24.272768	295	3508	9
119	24.231345	295	996	8
120	53.346448	112	122	14
121	57.512326	112	95	14
122	46.665705	112	3157	13
123	35.460242	112	1792	10
124	15.66759	112	2387	5
125	27.170031	112	3700	9
126	10.982062	112	45	4

APPENDEX-D

Field Observation CheckList

Field Observation paper for both Inbound and Outbound Direction:

In this observation, it will be observe three bus stop categories such as Good, Moderate and Poor. Any anbesa bus services that passed on the selected bus stops and populations served in that buses was considered. So to fill below tables using direct observation on the field.

No	Bus Stop ID	Stop Name	Category of Bus Stop	Parameter	Obs.time After noon or Morning	Durationof Observation. time	Bus Trip per stop	Date of Observation	Satisfactory	
			Good	Trip generation by bus	4:00 - 5:30	1.5			Yes	No
1										
2										
3										
4										
5										
			Moderate		4:00 - 5:30	1.5				
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
		Stop Name	Poor		4:00 - 5:30	1.5				
1										
2										
3										
4										
5										
6										
7										
8										
9										

Annex D1: <u>Field Observed Data for Inbound Direction At Morning and Afternoon:</u>

No	Bus Stop ID	Stop Name	Category of Bus Stop	Parameter	Obs.time Morning	Duration of Observation time	Bus Trip per stop	Date of Observation	Satisfactory	
			Good	Trip generation by bus	8:00-9:30	1.5		14/10/19 to 17/10/19	Yes	No
1	5	Zone8		238			3			
2	26	Megenagna		626			5			
3	46	Shola gebaya		501			6			
4	91	Lamberet		300			4			
5	101	Keste Damena		196			2			
			Moderat		8:00-9:30	1.5				
1	7	Stop Name		1005			12			
2	31	Megenagia		1013			12			
3	37	Menelik Hospitial		797			10			
4	41	Shola		847			8			
5	70	Shola Gebeya		978			8			
6	71	British Embassy		952			9			
7	72	Minilik School		949			8			
8	73	6 Kilo Tele		1057			10			
9	84	6 Kilo		935			8			
10	85	Belgium Embassy		1017			10			
		Stop Name	Poor		8:00-9:30	1.5				
1	21	Anbessa Gebi		198			2			
2	24	Megenagna Terminal		507			4			
3	27	Kokeb Tsebay. S		833			6			
4	44	Kotebe		175			2			
5	74	Eyesus		55			1			
6	81	Legehar		137			2			
7	10	Kara		344			4			
8	93	Wesen Michael		387			4			
9	79	Civil Service		182			2			
10	80	Gurd Shola		141			2			
11	28	Lamberet		557			5			

No	Bus Stop ID	Stop Name	Category of Bus Stop	Observed Parameter	Obs.time After noon	Duration of Ob.time	Bus Trip per stop	Date of Ob.	Satisfactory	
			Good	Trip generation by bus	4:00 - 5:30	1.5		14/08/19 to 17/10/19	Yes	No
1	5	Zone8		302			3			
2	26	Megenagna		578			4			
3	46	Shola gebaya		534			6			
4	91	Lamberet		387			4			
5	101	Keste Damena		227			3			
			Moderat		4:00 - 5:30	1.5				
1	7	Stop Name		1146			13			
2	31	Megenagia		1042			12			
3	37	Menelik Hospitial		915			11			
4	41	Shola		1080			9			
5	70	Shola Gebeya		1056			12			
6	71	British Embassy		1056			13			
7	72	Minilik School		988			8			
8	73	6 Kilo Tele		1075			10			
9	84	6 Kilo		969			8			
10	85	Belgium Embassy		1080			10			
		Stop Name	Poor		4:00 - 5:30	1.5				
1	21	Anbessa Gebi		227			3			
2	24	Megenagna Terminal		404			7			
3	27	Kokeb Tsebay. S		921			10			
4	44	Kotebe		492			6			
5	74	Eyesus		139			4			
6	81	Legehar		236			3			
7	10	Kara		512			6			
8	93	Wesen Michael		412			5			
9	79	Civil Service		337			4			
10	80	Gurd Shola		319			5			
11	28	Lamberet		688			8			

Annex D2: Field Observed Data for Outbound Direction at Morning and Afternoon:

No	Bus Stop ID	Stop Name	Category of Bus Stop	Parameter	Obs.time Morning	Durationof Observation time	Bus Trip per stop	Date of Observation	Satisfactory	
			Good	Trip generation by bus	8:00-9:30	1.5		21/10/19 to 24/10/19	Yes	No
1	15	Kara1		98			1			
2	16	Wesen1		109			1			
3	18	Condominium		556			6			
4	51	megenagna		446			4			
5	59	Yeka michael1		301			3			
			Moderat		8:00-9:30	1.5				
1	7	Ayat Adebabay		321			4			
2	9	Meri		272			3			
3	38	Lamberet		213			1			
4	52	Megenagn		575			7			
5	53	Total		405			5			
6	65	Minilik School		364			4			
7	68	Gurara		347			4			
8	71	Bret Dildy		279			3			
9	96	Legehar		537			7			
10	104	Gurd Shola		409			5			
		Stop Name	Poor		8:00-9:30	1.5				
1	12	Civil Service		318			4			
2	15	Kara		227			3			
3	19	Lamberat		310			4			
4	25	Anbessa Gebi		338			3			
5	30	Megenagna		379			4			
6	41	Shola Gebya		268			3			
7	42	Shola		187			2			
8	64	Mazoria		228			3			
9	106	Tafo Gebrael		143			2			
10	109	Wesen Michael		186			2			

No	Bus Stop ID	Stop Name	Category of Bus Stop	Parameter	Obs.time Afternoon	Duration of Observation time	Bus Trip per stop	Date of Observation	Satisfactory	
			Good	Trip generation by bus	4:00 -5:30	1.5		10/19 to 24/10/19	Yes	No
1	15	Kara1		152			2			
2	16	Wesen1		125			2			
3	18	Condominium		210			2			
4	51	megenagna		525			6			
5	59	Yeka michael1		345			4			
			Moderat		4:00 -5:30	1.5				
1	7	Ayat Adebabay		401			4			
2	9	Meri		418			4			
3	38	Lamberet		359			4			
4	52	Megenagn		730			7			
5	53	Total		588			6			
6	65	Minilik School		864			9			
7	68	Gurara		426			6			
8	71	Bret Dildy		294			3			
9	96	Legehar		348			4			
10	104	Gurd Shola		571			6			
		Stop Name	Poor		4:00 -5:30	1.5				
1	12	Civil Service		517			5			
2	15	Kara		391			4			
3	19	Lamberat		481			4			
4	25	Anbessa Gebi		402			4			
5	30	Megenagna		492			5			
6	41	Shola Gebya		625			7			
7	42	Shola		315			4			
8	64	Mazoria		342			4			
9	106	Tafo Gebrael		249			3			
10	109	Wesen Michael		247			3			

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Annex E1: The Anbesa City Bus Transport Information Data. Source: (ACBSE).

Route No	Bus No	Bus trip /M onth	Passenger Per Month	Terminal	Passenger per Day	No- of Bus	Origin-Destination
0001	8	38	2978	Megenagna	100	4	Megenagna-Karalo --Yekaabado
0002	31	824	44117	Addis Ketema	1471	4	Kore Mekanissa - Mexico--Addis Ketema
0003	81	2782	211240	MinilikAdebaba	7042	8	Ayer Tena - Torhayloch- Menelik Squar
0004	20	135	9094	Addis Ketema	304	6	Kaliti - Gotera--- Addis Ketema
0005	37	886	53776	MinilikAdebaba	1793	3	Kore Mekanissa Mexico - Menelik Squar
0006	104	2685	191450	MinilikAdebaba	6382	8	Kera -Mexico -- Semen Gebeya Squar
0007	20	670	79556	Megenagna	2652	3	Megenagna - Legedadi -- Aleltu
0009	14	59	3439	MinilikAdebaba	115	3	Bole Brass Clinic -Kasanchese----- Piassa
0010	115	2330	137918	MinilikAdebaba	4598	6	Kotebe College - Megenaga-- Piassa
0011	6	25	1486	Addis Ketema	50	4	Kolfe - Giyorgese- Menelik Hospital
0012	79	3166	198772	Addis Ketema	6626	6	Gurara Ferensay Kela -6kilo- Addis Ketema
0013	15	80	4323	Addis Ketema	145	3	Italy Embassy - 6kilp-- Addis Ketema
0014	5	32	2239	MinilikAdebaba	75	6	Saris Abo - Menelik Squar
0015	68	456	32728	Addis Ketema	1091	4	Megenagna - 4kilo--- Addis Ketema
0016	24	946	48460	Addis Ketema	1616	8	Kidanimihret - Giyorgese-- Addis Ketema
0017	28	183	10658	Addis Ketema	356	6	Kusqum - 6kilo-- Addis Ketema
0018	38	287	19872	Addis Ketema	663	8	Keraniyo - 18mazoriya-- Addis Ketema
0019	128	10833	663124	MinilikAdebaba	22105	5	Sansusi - Wingate-- Piassa
0020	1	5	405	Addis Ketema	14	3	Dil Ber - Rufale-- Addis Ketema
0021	17	1078	57445	Addis Ketema	1915	5	Felidoro - Fetno Derash--Addis Ketema
0022	41	490	30474	Legehar	1016	6	Summit - Megenaga-- Legehar
0023	98	2188	145749	Addis Ketema	4859	3	Lamberet - 6kilo-- Addis Ketema
0024	16	157	15990	Addis Ketema	533	4	Dire Sololiya - Asko--Addis Ketema
0025	5	18	992	Legehar	34	4	Legehar - Sariswabo-- Akaki
0026	49	880	69063	Addis Ketema	2303	3	Addis Ketema - Ayertena-- Sebeta
0027	63	2397	147813	Legehar	4928	8	Legehar - Sariseabo-- Kaliti
0028	64	882	63250	Addis Ketema	2109	4	Asko Sansuzi - Wingateaddis Ketema
0030	42	1004	93317	Addis Ketema	3111	5	Sululta - Adisucebeya---Addis Ketema
0031	55	944	61371	Legehar	2046	8	Legehar - 4kilo--Shiro Meda
0032	49	245	15200	Legehar	507	6	Hana Mariam - Megenaga--Legehar
0033	58	668	43883	MinilikAdebaba	1463	5	Kotebe Gebriel - Megenga-- Arat Kilo
0034	3	8	532	Addis Ketema	18	3	German Squar - Kera-- Addis Ketema
0036	42	844	49492	Legehar	1650	4	Kara Kore - Torhayloch-- Legehar
0037	24	288	23965	MinilikAdebaba	799	4	Keraniyo --Torhayloch Menelik Squar
0038	10	38	2189	MinilikAdebaba	73	4	German Squar - Mexico-- Sidist Kilo
0040	10	54	3672	Addis Ketema	123	3	Karalo - Megenaga-- Addis Ketema

0041	6	62	2945	Addis Ketema	99	5	Eyesus -- 4kilo-- Addis Ketema
0042	11	40	1727	Legehar	58	3	Bole Bora-Gerge- Summit Condimminium
0043	4	23	1700	Addis Ketema	57	2	Menagesha - Asko-- Addis Ketema
0044	89	3370	277365	Addis Ketema	9246	2	Legedadi - Megenaga-- Addis Ketema
0045	7	99	5603	Legehar	187	6	Legehar - Giyorgese-- Dil Ber
0046	3	11	400	MinilikAdebaba	14	6	Gerji - Megenaca-- Arat Kilo
0048	22	117	8552	MinilikAdebaba	286	6	Bola Mekale- Meskele Square- Menelik Sq
0049	52	817	74810	Megenagna	2494	6	Chefe Ayate; - Cmc-- Megenagna
0050	96	714	49070	Megenagna	1636	4	Tore Hailoch - Ayertena- Welete Adebabaye
0051	40	1099	50524	Addis Ketema	1685	4	Bethel Hospital - Torhayloch- Addis Ketema
0052	3	6	562	Addis Ketema	19	8	Gerji - Meskelesequare - Addis Ketema
0053	13	222	13282	MinilikAdebaba	443	4	Bole Michael - 4kilo-- Shiro Meda
0055	35	1633	89397	Legehar	2980	4	Legehar - 4kilo-- Gurara Ferensay Kella
0057	20	138	12140	Legehar	405	4	Kara - Megenaga-- Legehar
0058	31	481	32034	Legehar	1068	3	Legehalr -Torhayloch-- Alem Bank
0059	64	1936	126401	MinilikAdebaba	4214	6	Bethel Hospital –Rhayloch- Menelik Squar
0060	70	2241	143158	Legehar	4772	10	Debr Zeit - Kaliyy-- Legehar
0061	56	491	37642	Legehar	1255	6	Chefe Ayate - Megenaga-- Legehar
0062	39	651	46506	Legehar	1551	3	Sebeta - Ayertena-- Legehar
0063	2	4	177	Addis Ketema	6	3	Addis Ketema - Efoyta--Mikililand
0064	48	2300	160426	MinilikAdebaba	5348	4	Gurara - 4kilo--Megenagna
0065	59	1775	108126	Addis Ketema	3605	3	Addis Ketema - Torhayloch-- Alem Bank
0066	71	1607	95156	Addis Ketema	3172	4	Addis Ketema - Torhayloch-- Kara Qorre
0067	52	690	52842	Legehar	1762	8	Legehar - Sarbate-- Jemmo Mekanissa
0068	3	13	853	Legehar	29	6	Menelik Hospital -Mexico-- Tore Hailoch
0070	31	238	18978	Legehar	633	4	Aware Square -Mixico-- Ayer Tena
0072	1	1	41	Legehar	2	4	Hana Mariam -Damhotele-- Sari Abo
0073	34	1184	68845	Legehar	2295	6	Legehar -Torhayloch-Ring Road Vis Winget
0074	6	14	672	Addis Ketema	23	6	Samitecondminem-Megenaga-Addis Ketema
0075	2	7	335	MinilikAdebaba	12	4	Sidist Kilo - Olompiya-- Qera
0076	39	311	25263	Megenagna	843	3	Megenagna - Sariseabo-- Kaliti
0077	42	503	39430	Legehar	1315	2	Ayer Tena - Totale-- Kera
0078	2	4	213	Megenagna	8	3	Megenagna - Mixico-- Gofa Condiminium
0079	22	150	9712	MinilikAdebaba	324	4	Arat Kilo -Megenaga-- Semit Condiminium
0080	13	56	4916	MinilikAdebaba	164	6	Semen Gebeya Squar - Giyorgise-- Kasancese
0081	6	23	1719	MinilikAdebaba	58	3	Sidist Kilo -Addisu Gebeya--Sansusi
0082	58	2024	165054	Legehar	5502	6	Goro Adebabay -Megenaga-- Balcha Hospital
0083	33	448	35375	MinilikAdebaba	1180	6	Chefe Ayate - Megenaga--Sidist Kilo
0084	1	5	309	Legehar	11	3	Kolfe Efoyta -Coc Cola-- Legehar

0085	36	896	63286	Addis Ketema	2110	2	Addis Ketema - Mengesh--Holeta
0086	9	44	3224	Legehar	108	4	Ayer Tena - Hanamaryam-- Sariseabo
0087	47	1148	110459	Addis Ketema	3682	7	Winget -Torhayloch-- Ayer Tena
0088	16	287	34483	Addis Ketema	1150	3	Addis Ketema -Sululta--Chancho
0089	35	583	58430	Addis Ketema	1948	3	Addis Ketema -Karalo--Sendafa
0090	36	300	19979	Legehar	666	6	Betel Hospital -Torhayloch-- Legehar
0091	9	210	19670	Addis Ketema	656	2	Addis Ketema - Sebeta--Teji
0092	44	737	51904	Legehar	1731	4	Hana Mariam -Sarebete-- Balcha
0093	10	30	2572	Megenagna	86	4	Bole Bulbula - Bole-- Megenanga
0094	3	24	1537	MinilikAdebaba	52	4	Piassa - Wingate-- Mikililand
0095	27	497	39756	Addis Ketema	1326	3	Addis Ketema - Menagesh-- Addis Alem
0096	4	33	2852	Megenagna	96	3	Megenagna - Gerg M/Hayle Goro Sefera
0097	43	689	52721	Megenagna	1758	6	Megenagna - Ayate-- Legetafo Mission
0098	26	324	25723	Legehar	858	3	Dukem - Kality-- Saris Abo
0099	8	21	1990	Legehar	67	3	Ayer Tena -Welte Alem Gena Michael
0100	53	455	34413	Addis Ketema	1148	4	Addis Ketema - Abente-- Jemo
0101	85	2407	162454	Megenagna	5416	6	Megenagna - Gudushla-- Aba Kirros Sq.
0102	21	322	25188	Legehar	840	6	Kara - Megenaga-- Legehar
0103	93	1813	155157	MinilikAdebaba	5172	6	Jemo - Mixico-- Piassa
0104	9	15	1944	Legehar	65	2	Kality - Sariseabo-- Kera
0105	37	1192	59901	Legehar	1997	4	Anfo Meda - Torhayloch-- Legehar
0106	23	113	8968	Megenagna	299	3	Bolearabesa - Ayate--Megenaga
0108	3	6	527	MiniliAdebaba	18	3	Asko Addisu Sefer - Autobusetera18 Sq .Menelik Sq.
0109	33	340	21933	Legehar	732	3	Saris Abo - Kality-- Tulu Dimetu
0110	1	1	112	Legehar	4	3	Sidist Kilo -Gotera--Tulu Dimetu Square
0111	91	977	63968	MinilikAdebaba	2133	4	Dire Sololiya - Piassa
0112	169	3340	287748	MinilikAdebaba	9592	6	Circular Route With In Ring Road 4 Turning Points
0113	41	823	55393	Legehar	1847	2	Kaliti Total - ,Ilinto-- Feche Koye
0114	89	954	72337	Legehar	2412	2	Gelan - Sarise--Leghare
0115	41	2423	151306	Legehar	5044	2	Lebu Muziqa Bet - Germen Sequare-- Mexico Square
0116	1	2	230	Legehar	8	2	Michael Sq - Jomo2--Weltea
0117	76	3854	263254	Legehar	8776	2	Hayle Garmente- Sarebete-Mexico Square
0118	20	121	10107	Addis Ketema	337	2	Merkato - 18mazoriya-- Tateq Kella
0119	57	720	48593	Megenagna	1620	3	Megenagna - Cmc- Summit Condiminnium
0120	55	793	61667	Addis Ketema	2056	2	Burayu Keta - Wingate-- Tore Hiloch
0121	76	3223	248559	Legehar	8286	2	Jemo Qedus-- Gebreal - Mexico Square
0122	29	329	24164	Legehar	806	2	Arat Kilo - Addisugebeya--Entoto Mariam
0123	5	14	989	Megenagna	33	3	Megenaga---Karalo--Yeka Abado
0124	137	9993	804852	Megenagna	26829	3	Megenaga-----Goro--Tulu-Dimtu