ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

GENERALIZED COST OF PUBLIC TRANSPORTATION USAGEIN CITY OF ADDIS ABABA

BY

BEREKET KEBEDE

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GENERALIZED COST OF PUBLIC TRANSPORTATION USAGE IN CITY OF ADDIS ABABA

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BEREKET KEBEDE

A thesis submitted to the School of Graduate Studies of Addis Ababa University in partial fulfillment of the requirements for the Degree of Master of Science in Civil and Environmental Engineering (Road and Transport Engineering)

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ABBREVIATIONS

AALRT – Addis Ababa Light Rail Transit

ANOVA – Analysis of Variance

df – degree of freedom

DL – Discomfort Level

E.C. – Ethiopian Calendar

ETB – Ethiopian Birr

Ethio – Ethiopia

LOS – Level of Service

LRT – Light Rail Transit

MNL – Multinomial Logit Model

N - Number

NGO – Non-governmental Organization

TRANSIP – Ethiopia Transportation System Improvement Project

TRB – Transportation Research Board

SPSS –Statistical Package for the Social Sciences

Sig. –Significance

Std. – Standard

ABSTRACT

An effective transportation planning and policy making requires a good understanding of the association between mode choice and transportation users as well as non-users costs.Once an individual decides to make a trip to a particular location, travel time and cost are the primary factors influencing which mode and what route he or she will take. The traveler may also consider factors such as the perceived reliability, comfort, convenience, and safety of the transportation service. The type and quality of information about the service or route may also influence decisions. All of these factors refer to a set of generalized costs.

In this study the generalized cost of travel is express in multiple linear regression function with explanatory variables of in-vehicle travel time, walking time, waiting time, and passenger fare. Among the different modes of transportations which currently provide services along the East-West corridor of the Addis Ababa City, this research paper focus on the three mostly used mode of public transportation which is Anbesa City Bus, Minibus taxi and Addis Ababa Light Rail Transit (AALRT) to estimate the generalized cost of travel in monetary unit per trip for a route length of 8.3km from Ayat Square to Megenagna.

To achieve the intended objectives of the study, a reasonable volume of data were collected through questionnaires, travel surveys, anddocument reviews. Then, the analysis were done using SPSSVersion 20.0 software.The output of the analysis showsthat currently the generalized cost of travel per trip is very high and it is significantly affected by the explanatory variables of passenger fare and waiting time in the selected route. It is also indicated in this study that in comparison among the selected modes of public transportation,the generalized cost of travel per trip using Anbesa City Bus is very high whereas the AALRT has a minimum generalized cost of travel at different time of the day.

Key Terms: Mode choice, user and non-user costs, generalized cost of travel, explanatory variables, public transportation, multiple linear regression.

CHAPTER ONE

INTRODUCTION

1.1. General Background

Once an individual decides to make a trip to a particular location, travel time and cost are the primary factors influencing which mode and what route he or she will take. The traveler may also consider factors such as the perceived reliability, comfort, convenience, and safety of the transportation service. The type and quality of information about the service or route may also influence decisions. As briefly expressed by Ortuzar-Willumsen (2004: 199-200), when users choose the means of transportation, they associate the choice of the mode with utility (what individual seeks to maximize). A high utility with the certain means of transportation reflects public confidence and willingness to use that mode of transportation.

Mode choice affects the general efficiency with which we can travel in urban areas,the amount of urban spaces devoted to transportation functions. For example, almost without exception, public transportation modes make use of road space more efficiently than the private car(Ortuzar-Willumsen, 2004), and also high public transportation usage have a positive impact in order to minimize the overall cost of transportation (Thi Phung and Tu Anh, 2016). Therefore, it is crucial to develop and use models which are sensitive to those attributes of travel that influence individual choices of mode.

Even though each modal choice is characterized differently in terms of utility, it is well known that each means of transportation impose some degree of disutility on users as well as on non-users. As indicated by Christopher Z. and Todd L. (1997), and Ortuzar-Willumsen (2004), an effective transportation planning and policy making require a good understanding of the association between modal choice and transportation users (internal) as well as non-users (external) cost. In the recent years, researchers in the field of transportation and economics try to estimate transportation user and non-user costs of different modes of transportation.

It is often convenient to use a measure combining all the main attributes related to the disutility of a journey and this is referred to as the generalized cost of travel. Different authors such as Casello and Hellinga (2010); Lesley (2009); Ortuzar-Willumsen (2004); Debasis and Bhargab (2006) and Mintesnot and Shin-ei (2008) tried to associate modal choice with the generalized cost of travel because selecting the mode with the smallest value of generalized cost of travel is equivalent to selecting the mode with the largest value of expected utility. Therefore, the generalized cost of travel can be used in explaining the benefits of using a particular means of transportation when compared to other.

Different research works indicate that the non-user transportation cost is related to the transportation user cost and modal choice. Therefore, it is possible to minimize the external costs of transportation by minimizing the users' costs and by proper modal choice. For example, if we provide a minimum generalized cost of travel for public transportation or improved public transportation services, particularly in urban areas, it would help to reduce the tendency for passengers to upgrade to private transportation as soon as they can afford to have it (Doddy, 2009). And it may also motivate the private vehicle owners to use public transportation services which minimize the overall traffic congestion, air pollution and accident level. As mentioned by Iles (2005), in many cases, if expenditure on urban road improvements were invested sensibly in appropriate public transportation measures, the benefit would be far greater.

In most developing countries, including Ethiopia, the demand for public transportation is generally inelastic due to inadequate services and limited available alternatives (Annika K., 2008). Now a time, the low-income groups of the population, who are completely dependent on the available public transportation mode, have continued to endure the poorly performing public transportation system. Inadequate public transportation services have a detrimental effect on the economy and there would be far reaching benefits if the demand for public transportation could be satisfied in order to enable people to go about their business without unnecessary hindrance. Currently, the City of Addis Ababa public transportation system is struggling to cope with the excess demand to serve the needs of mobility of its residents with fast, safe, cheap, and comfortable amenities.

For the sake of public transportation users to make a comparison on which mode of public transportation has a high generalized cost of travel per tripat different time of the day,it is important to quantify the current generalized cost of travel per trip for public transportation service in the City of Addis Ababa which enable the users to minimize cost of travel per trip by choosing the appropriate means of transportation; and it also used for public transportation service providers to improve their services in order to satisfy their customers.

The generalized cost of travel can be estimated by different attributes. For example, Kumar, et al (2004) express the generalized cost of travel by rural bus with in-vehicle travel time, discomfort level, travel fare and service headway. Goodwin (1976) used a three-component approach to estimate generalized cost of travel in terms of time spent, effort spend and money spent on transport activities. Similarly, Ortuzar-Willumsen (2004) represent the generalized cost of travel by in-vehicle travel time, walking time, waiting time, interchange time, fare, parking cost and modal penalty. Here, the generalized cost of travel is expressed in multilinear regression function of in-vehicle travel time, walking time to and from stops, waiting time at stops and passenger fare.

1.2. Statement of the Problem

Even though Addis Ababa city currently manifested by low motorization rates by global standards,the transportation system of the city is characterized by frequent congestion and delay, high rate of road traffic accidents and air pollution (TRANSIP, 2016). It is also indicated in TRANSIP (2016) that the city cannot able to satisfy the transportation needs of its residents in respect of: travel time, safety,cost-effectiveness, comfort, environmental friendliness and sustainability.These growing externalities make the transportation system economically unsustainable and expensive to society.As further stated in TRANSIP (2016), the increase in the number of population, the undergoing significant urbanization and recent growth in private vehicle ownership in the city is aggravating the challenges to provide reliable, efficient and safe mode of transportation system.

In the city the demand for public transportations are higher than the service rate due to inadequate services and limited available alternatives. Therefore, public transportation users choice the type of the modes mainly based on either passenger fare or accessibility of the mode rather than considering the generalized cost of travel per trip. There is also limited information on the main explanatory variables of the generalized cost of travel per trip at different time of the day.Due to this and other reason the generalized cost of travelper trip become very high for public transportation users. Therefore, it is important to estimate the generalized cost of travel per trip in order to give some guidance for public transportation users to choose public transportation which impose minimum generalized cost of travel per trip.

1.3. Objectives of the study

General Objective

The aim of this study is to estimate the generalized cost of travel per tripfor different public transportation service in Addis Ababa City at different times of the day.

Specific Objective

- ❖ to identify which sub-mode of the three mostly used public transportation service providers, that is Anbesa City Bus, Minibus taxi, and Addis Ababa Light Rail Transit, has a maximum generalized cost of travel per trip at different time of the day along the East-West corridor of the cityregarding with:
    - Travel time which includes in-vehicle travel time, walking time to /and from stops (stations) and waiting time at stops (stations); and
    - Passenger fare charged.

1.4. Research Questions

How much are the generalized cost of travel per trip by Anbesa City Bus, Minibus taxis and Addis Ababa Light Rail Transit (AALRT)?

At what time of the day is the generalized cost of travel become maximum using the public transportation services of Anbesa City Bus, Minibus taxi and Addis Ababa Light Rail Transit?

Among the three sub-modes which mode is recommended for use to minimize the generalized cost of travel at different time of the day?

1.5. Scope and limitation of the study

Among different types of public transportation services providers from Ayat Square to Torhailoch, this study is limited to Anbesa City Bus, Minibus taxi and Addis Ababa Light Rail Transit (AALRT) for route length of 8.3 km from Ayat Square to Megenagna. And only four explanatory variables are used to express the generalized cost of travel per trip.

In this research, it should be noted that the result of this study is not definitive because all the explanatory variables are tentative which depends on the time of the research, the existing environment, and the willingness of the respondents. However, it provides some guidelines and areas for future research.

1.6. Relevance of the study

The final findings of this study can be used:

- by public transportation service users to choose the mode that charge minimum generalized costs of travel per trip;
- to indicate the performance of existing public transportation services in Addis Ababa City;
- by public transportation service providers in Addis Ababa City to assess their objectives and goals in providing services to the users;
- to recognize the gap between the existing and expected level of public transportation services in Addis Ababa and enable the stakeholders to work on it; and
- as initial reference for further studies in the estimation ofgeneralized costs of public transportation services.

1.7. Conceptual framework of the study

Here, generalized cost of travel for the three mode of public transportation is expressed in multiple linear regression function of in-vehicle time, walking to and from stations, waiting time at Stops, and passenger fare. The origin i and the destination j can either be Megenagna or Ayat. The generalized cost of travel equation along the selected route stated as follows:

$$\mathbf{C_{ij} = a_1 t^v_{ij} + a_2 t^w + a_3 t^t + a_4 F_{ij} + a_0} \text{...... } \textbf{(Generalized Cost Eq.1.1)}$$

Where: $\mathbf{C}_{ij}$: generalized cost of travel between i and j;

t^v_{ij}: in-vehicle travel time between i and j;

t^w: walking time to and from the stops (stations);

t^t: waiting time at station (stops);

F_{ij}: fare to travel between i and j;

a_0: constant and a_1, a_2, a_3, and a_4 are weights attached to each variables.

1.8. Organization of the Research

This research work is organized into five chapters. Chapter one presents: introduction, statement of the problem, objectives of the study, research questions, scope and limitation of the study, relevance of the study and the conceptual framework of the study. Chapter Two presents the literature review based on referred sources. The research methodology, the data collection and data analysis are presented in Chapter Three. Chapter Four presents the results and discussionson the output of the analysis and the last chapter, Chapter Five presents the summary of the whole work with conclusions and recommendations.

CHAPTER TWO

LITERATURE REVIEW

Introduction

Mobility is a basic human need and transportation fulfills these basic needs of humanity. Transportation is the movement of people, animals or goods from one location to another. It plays a major role in any place worldwide, as it enables the movement of people (passengers) and goods from one point to another (Iles, 2005).Moreover transportation is one of the driving tools for any economy, which enables any country to reach development and sustainability. Economically and socially vibrant urban areas cannot exist without a system for moving people, goods and services. The health of cities, and their ability to generate income and wealth for their inhabitants, is improved if the transportation system is efficient, and if its construction and operation considers its impacts on citizens, land use, the environment and economic development (Terry Moore and Julia Pulidindi).

2.1. Transportation System

As indicated by Ortuzar-Willumsen (2004:7), transportation system can be seen as made up of:

- ❖ Infrastructure: the fixed installations that allow a vehicle to operate on. It consists of a way, a terminal and facilities for parking and maintenance. (e.g. a road network);
- ❖ Management system: a set of rules, for example driving on the right; and control strategies.
- ❖ A set of transport modes and their operators; and
- ❖ Passengers, goods and services.

Transportation modes are the means by which people and freight are carried. The modes of transportation can be classified on the basis of the way, the vehicle, the motive power used and terminals:

- ❖ Traditional mode of transportation (non-wheel)
    - Walking;
    - Human porterage;
    - Pack animals; and

- Cattle on hoofs

❖ Intermediate mode of transportation (wheeled but not motorized)
  - Animal carts;
  - Wheelbarrows; and
  - Bicycles

❖ Conventional mode of transportation
  - Roads;
  - Railways;
  - Pipeline;
  - Maritime; and
  - Aviation

❖ Multimodal transportation is combination of modes

❖ Exotic transportation modes are exciting and unusual:
  - Space transport; and
  - Hover crafts/hydrofoils/land-water service etc.

2.1.1. Characteristics of transportation systems

Some of the transportation systems characteristics that makes its diverse and complex are: -

❖ Multi-modal: covering all modes of transportation; air, land, and sea for both passengers and freight.

❖ Multi-sector: encompassing the problems and viewpoints of government, private industry, and public.

❖ Multi-problem: ranging across a spectrum of issues that includes national and international policy, planning of regional system, the location and design of specific facilities, carrier management issues, and regulatory, institutional and financial policies.

❖ Multi-objective: aiming at national and regional economic development, urban development, environment quality, and social quality, as well as service to users and financial and economic feasibility.

❖ Multi-disciplinary: drawing on the theories and methods of engineering, economics, operations research, political science, psychology, other natural, and social sciences, management and law.

Figure 2.1 illustrates a schematic representation of the sector of transportation system.

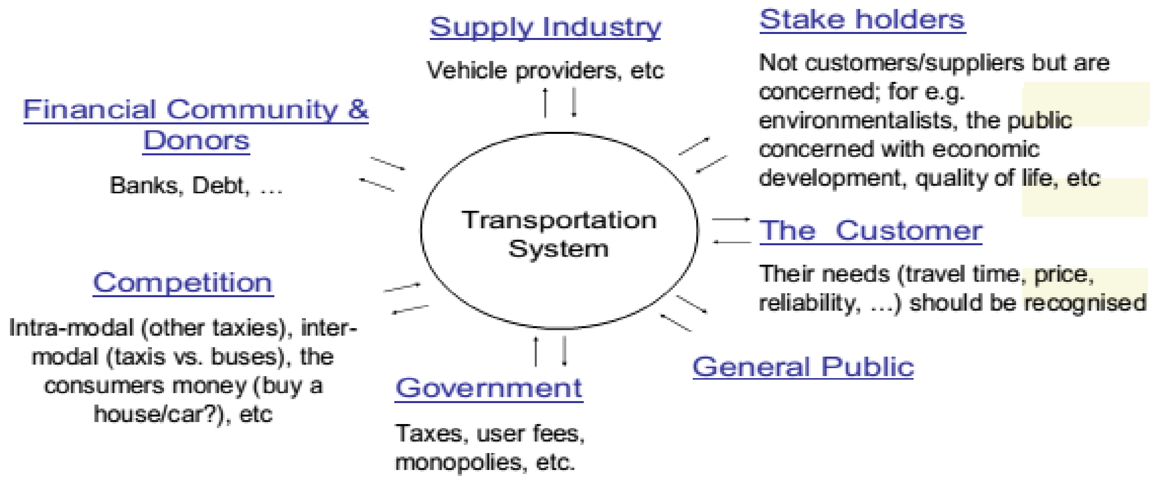

Figure 2.1: Sector of transportation system

2.1.2. Role of transportation in society

Transportation is a non-separable part of any society. There is a strong correlation between the quality of transportation facilities and standard of living. As mentioned by Caro (2013) and Tom (2017), advances in transportation has made possible changes in the way of living and the way in which societies are organized. Today, researchers in the field of transportation are continuously in search of new modes of transportation that better comply with the current requirements and exploring optimization possibilities of existing transportation modes. As clearly mentioned by Tom (2017), the role of transportation in different section of the society are briefly stated as below.

(i) Economic role of transportation

Goods have little values unless it gives utility, that is, the capacity for being useful and satisfying wants. Transportation contributes two kinds of utilities: place and time utility, simply mean having goods where they are wanted and when they are needed, essential functions that can also be applied to the movement of people.

(ii) Social role of transportation

Transportation has always played an important role in the formation of settlements, size and pattern of settlements, and also in the growth of urban centers.

(iii) Political role of transportation

The world is divided into numerous political units which are formed for mutual protection, economic advantages and development of common culture. Transportation plays an important role in the functioning of such political units.

(iv) Environmental role of transportation

Even though transportation play an important role in our day-to-day life, it has unfortunate impact on the society, for example it consumes a lot of resources like time, fuel, materials and land.There are numerous categories into which the environmental effects have been categorized such as:

- Safety

Along with the growth of transportation the negative impact of transportation is increasing from time to time in terms of traffic accidents. Accidents result in loss of life and permanent disability, injury, and damage to property. Today worldwide death and injuries from road accidents have reached epidemic proportions. Accident also causes numerous non-quantifiable impacts like loss of time, grief to the near ones of the victim, and inconvenience to the public.

Among different factors that makes the road traffic accident very severe is the collision (impact) speed of the vehicle. Figure 2.2 shows the fatality risk with the collision speed:

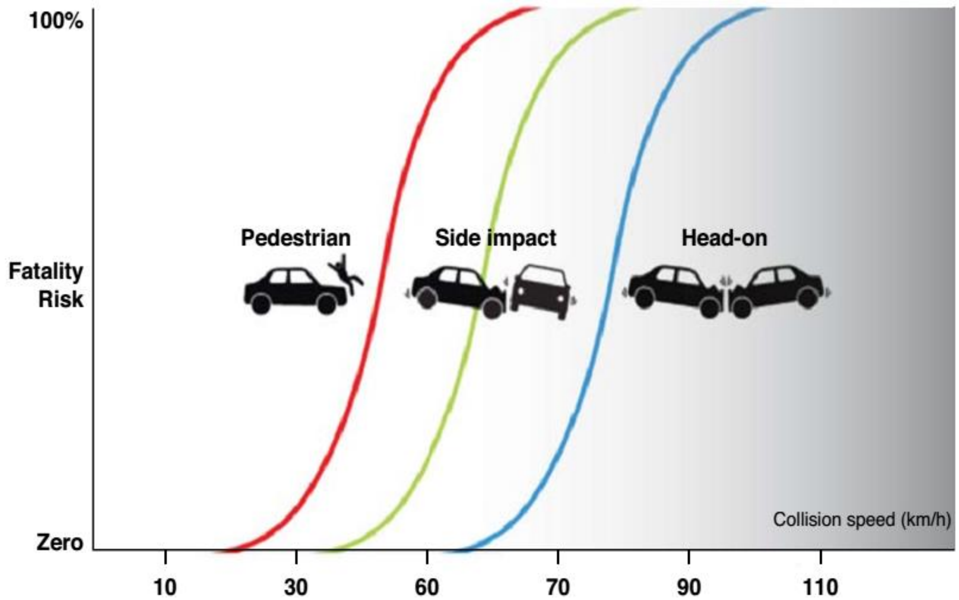

Figure 2.2: Crash types and indicative fatality risk at speeds; **Source:** Wramborg, (2005).

- Air Pollution

All transportation modes consume energy and the most common source of energy is from the burning of fossil fuels like coal, petrol, diesel, etc. The combustion of fuels releases several contaminants into the atmosphere, including carbon monoxide, hydrocarbons, oxides of nitrogen, and other particulate matter. Hydrocarbons are the result of incomplete combustion of fuels.

- Noise pollution

Transportation is one of a major contributor of noise pollution, especially in urban areas. Noise is generated during both construction and operation. During construction, operation of large equipment causes considerable noise to the neighborhood. During the operation, noise is generated by the engine and exhaust systems of vehicles, aerodynamic friction, and the interaction between the vehicle and the support system (road-tire, rail-wheel). Extended exposure to excessive sound has been shown to produce physical and psychological damage.

- Energy consumption

The spectacular growth in industrial and economic growth during the past century have been closely related to an abundant supply of inexpensive energy from fossil fuels. Generally, the transportation sector consumes less than half of the petroleum products. Comparing with private vehicles, the public transit consume less energy per person.

2.2. Key performance measures of public transportation system

Public transportation is one component of urban transportation; it is a shared passenger transportation service which is available to use by the general public. As described by Eugen et al (2014), public transportation plays a very critical role in the socio-economic development of any nation. It also plays a critical role in the management of a city or a country as a whole, in the reduction of pollution, congestion and road accidents; and also in fulfilling the travel needs of people in the cities of the developing world. As stated by Nyarirangwe and Mbara (2007) further, public transportation also offers an affordable means of transportation.

Currently, the large and mostly impoverished populations of African Cities are dependent on public transportation to provide them with accessibility and mobility. However, for most cities, the public transportation system is increasingly becoming inadequate, inefficient, unreliable and unaffordable.

Therefore, it is important to evaluate the existing service quality of the public transportation using performance indicators which can be used to improve the service. Different performance indicators can be selected to examining the level of service. For example, journey time, accessibility, reliability, affordability, level of comfort and convenience, and traveler's level of satisfaction can be used as the key performance indicators to evaluate the existing public transportation service. These performance indicator are briefly described as follows:

- **Journey times**

Journey time is the total time spent to reach a destination from a given origin. The journey time from origin to destination can be separated into different parts. Each part has its own value and weighting. A typical urban public transportation journey starts with a walk to the origin station, a wait for the departure, a ride on the vehicle, and then a walk to the final destination. On some journeys there may also be a change of route, requiring a walk between stops and a further wait for the new departure (Lesley L., 2009).

As described by Lesley L., (2009), the in-vehicle ride time is perceived by passengers at about the same as clock time. This means that a ten minute ride in a bus feels like ten minutes of clock time. Waiting time however has a much higher perceived value. Values as high as 2.2 x clock time have been reported. This means that every minute of waiting time saved (e.g. by a more regular service) has the same benefit as reducing in-vehicle riding time by about 2 minutes. Passengers also value vehicle comfort and safety but for most urban journeys these are rather small compared to the components of travel time.

As described by Russell and Anjum (1997), the journey time depends on the overall average speed, taking into account running speeds, delays in traffic, and in-route stopping to enable passengers to board and alight. It should not be more than two to three hours per day. Excessive journey time reflects inadequate public transportation supply or poor scheduling or routing (Armstrong-Wright et al, 1987 as cited by Abreha, 2007).

Travel time is one of the largest costs of transportation, and travel time savings are often the primary justification for transportation infrastructure improvements (Transportation Cost and Benefit Analysis –Travel Time Costs, 2004). Travel time costs refer to the value of time spent in travel. Although some travel time has zero or negative costs when people want to spend time traveling. Some of the characteristics of travel time costs values are:

- Travel time costs tend to be higher for driving under congested conditions, and for passengers under uncomfortable conditions.
- Travel time costs tend to be particularly high for unexpected delays.
- Some travel time has a low cost or positive value because people enjoy the experience, for example, for a pleasant drive or recreational train trip.
- Under pleasant conditions, walking and cycling can have positive values, but under unpleasant or insecure conditions (for example, walking along a busy highway or waiting for a bus in an area that seems dirty and unsafe), time spent walking, cycling and waiting for transit has costs two or three times higher than time spent traveling.

The value of time saved from travel will depend on the traveler, the circumstances of the trip, and the available transportation options (Roberto, 2014).

❖ **Accessibility**

Guidelines for public transportation planning usually specify access to public transportation in terms of spacing between public transportation stops or distance to stops (Rhonda and Corinne, 2011). Carruthers et al (2005) describe accessibility as the ease with which all categories of passenger can use public transportation and also the ease of accessing the bus stop or station.

Accessibility measures the walking distance to public transportation facilities (Yolandi Roux, 2013). As indicated by Mkonnen Mammo (2010), walking distance is an indicator of the coverage of the service. As mentioned by Yolandi Roux (2013), the maximum walking distance that people are willing to walk to public transportation stops and services depends on the context and population of a country or city. It is indicated in TRB (2003) as cited by Yolandi Roux (2013) that the maximum walking distance should not be more than 1,000m (1km); while Armstrong-Wright (1993) as cited by Yolandi Roux (2013), for a dense urban area the maximum walking distance should be between 300 and 500m and in low density areas the distance can be between 500m and 1,000m.

- **Reliability**

Reliability measures the amount of time passengers must wait at public transportation stop (station) for a public transportation vehicle to arrive. Reliability affects the amount of time passengers need to wait at a transit stop for a vehicle (Kamrul and Vandebona, 2010). As described in TRB (2003), vehicle carrying capacity has a determining effect on the reliability of public transportation; for example, if a vehicle is full (carry more people than its capacity) when it arrives at a stop, the public transportation is considered as unreliable to the passengers waiting. Armstrong-Wright (1993) as cited by Yolandi Roux (2013), suggested that in order to achieve a reasonable level of service, the average waiting time should be in the range of 5-10 minutes and the maximum waiting time should be in the range of 10-20 minutes.

- **Affordability**

According to Carruthers et al (2005), affordability refers to the extent to which the financial cost of journeys put an individual or household in the position of having to make sacrifices to travel or the extent to which they can afford to travel when they want to. So Carruthers et al (2005) consider affordability as the ability to make necessary journeys without having to curtail other essential activities. Affordability varies widely with income and distance travelled.

As indicated by Nyarirangwe and Mbara (2007), the status of public transportation can best be explained by concept of affordability, as it applies to different groups of people. Among the low-income groups, fares charged are the main decision making variable. For the high-income groups, modal choice decisions center on service quality (waiting time, travel time, comfort, etc.).

There is a norm that a passenger should not spend more than 10% of his disposable income on public transportation (Armstrong-Wright, 1993; TRB, 2003 as cited by Yolandi Roux, 2013).The affordability patterns of the low-income groups are very critical in the overall sustainability of urban public transportation.

- **Level of Comfort and Convenience**

As indicated in Iles (2005); Height and Cresswell (1979) as cited by Mkonnen M. (2010), comfort and convenience includes good seats with available space to move easily, good heating and ventilation systems, high proportion of seated to standing passengers, low step heights (to facilitate access by disabled passengers), low level of crowding, good protection and resting facilities for waiting passengers at stops and stations, ease of payment, availability and accuracy of information.

The level of comfort and convenience are measured in the public transportation system in terms of seating comfort (Ali A. N., 2010). Public transportation service is less attractive when passengers must stand for long periods of time, especially when the public transportation vehicles are very crowded. Crowded vehicles also tend to slow down public transportation operations because it takes more time for passengers to get on and off the vehicles. Clean, attractive public transportation stops, stations and vehicles can improve the image of public transportation.

In most developing countries, where the demand for public transportation is generally inelastic due to inadequate services and limited available alternatives, the existing level of comfort and convenience of the public transportation system are found in a very poor conditions. The situation becomes even more critical where commuting distances are relatively long (Nyarirangwe and Mbara, 2007).

- **Travelers' level of satisfaction**

Level of satisfaction is an important performance measure for transportation service providers and a determinant of mode choice. A high level of satisfaction with public transportation services reflects public confidence and the willingness of people to use the service. People tend to be satisfied when their perceptions of the service they receive match their expectations. When the service falls short of their expectations, they tend to be dissatisfied. Different factors such as efficiency, reliability of the service and responsiveness of the service providers contribute to people's perceptions and levels of satisfaction with service. The absence of some of these factors can have a strong impact on dissatisfaction levels. (Mintesnot and Shin-ei, 2008).

2.3. Overview of public transportation service in Addis Ababa city

Public transportation is not just a social good or an alternative to private car travel, but it is the only motorized mode available to the vast majority of the urban population in most African cities (Koster, 1999); which include Addis Ababa. As stated by Iles (2005), number of populations in most developing countries are increasing much faster than car ownership level, thus due to this disproportion between these two elements, the majority of the population in those countries relay more on public transportation for short journeys as well as for long voyages. For example, the research paper by Mintesnot and Shin-ei (2008), show that in Addis Ababa City around 82% of the movement are covered by public transportation which is indicated by the mode split of 64% bus, 18% taxi, 12% walk and the remaining was other modes of transportation such as private vehicle. As stated by Tilahun (2014), about 2.2 million people in Addis Ababa are using public transportation of which 3.6 million trips happen in the city on daily basis and another research carried by Addis Ababa City Government (2006) indicated that the modal share of the public transportation system is around 46% in theCity, as shown in Figure 2.3.

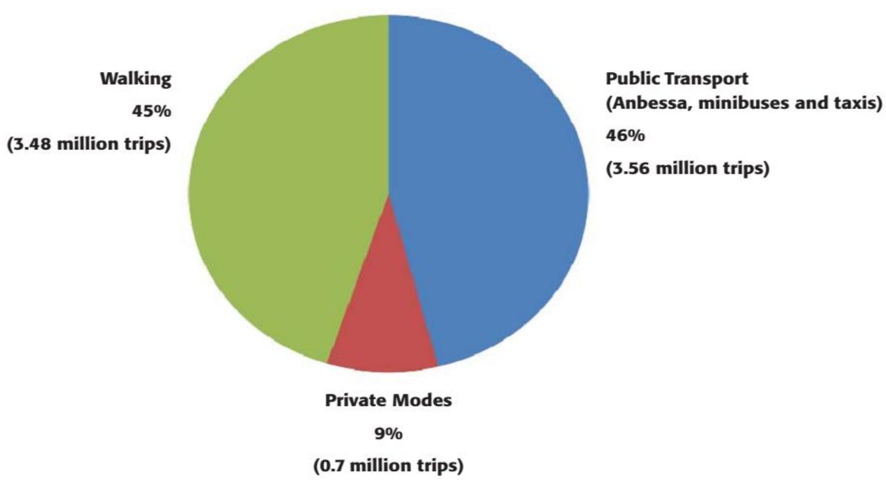

Figure 2.3: Addis Ababa City Modal Share (2006). **Source:** Transportation challenges in a booming city: Coordination of the Mass Transit Network and Urban Development in Addis Ababa, Oct. 2012.

In 2015, the city's total vehicle fleet was estimated at 300,000 (60% of the total fleet of the country) and in 2016 the total number of registered vehicles in the city became 447,669 (63.2% of the total number of vehicle registered in the country) which rose by 147,669 (49.2%). Even though Addis Ababa city currently manifests by low motorization rates in global standards, one of the challenges that the city currently facing is the provision of reliable, efficient and safe mode of transportation system. The transportation system in the city is characterized by frequent congestion and delays, high rate of road traffic accidents and air pollution, and the recent growth in private vehicle ownership is aggravating the challenges. These growing externalities make the transportation system economically unsustainable and expensive to society (TRANSIP, 2016). The following figures illustrate the aggravating challenges and the prevailing externalities of public transportation in Addis Ababa.

Figure 2.4: Overview of the current transportation situation in Addis Ababa City

Addis Ababa, the capital city and principal commercial center of Ethiopia, is experiencing rapid urban growth, rise in economic status of the society and increase in number of the population which increase the need in transportation and parking spaces to facilitate the movements. The undergoing significant urbanization of the city enhances the transportation problems and also increase the user and non-user cost in the city. In order to fulfil the need in transportation, ownership and use of private vehicle transportation is increasing from time to time which enhance the users and non-users cost of transportation; as briefly mentioned by Christopher (1997), such mode of transportation system is expensive and inefficient in terms of user costs, road and parking facility construction and maintenance costs,congestion, accidents, land costs, energy consumption, and pollution.

As stated briefly by Ortuzar-Willumsen (2004), economic growth provides the first impetus to increase car ownership. More car owners means more people wanting to transfer from public transport to car; this in turn means fewer public-transport passengers, to which operators may respond by increasing the fares, reducing the frequency (level of service) or both. These measures make the use of the car even more attractive than before and induce more people to buy cars, thus accelerating the vicious circle. After a few cycles (years), car drivers are facing increased levels of congestion; buses are delayed, are becoming increasingly more expensive and running less frequently; the accumulation of sensible individual decisions results in a final state in which almost everybody is worse off than originally. This simple representation can also help to identify what can be done to slow down or reverse this vicious circle. Figure 2.4 below illustrates car and public transport vicious circle and subsequently Figure 2.5 illustrates breaking the car / public transport vicious circle.

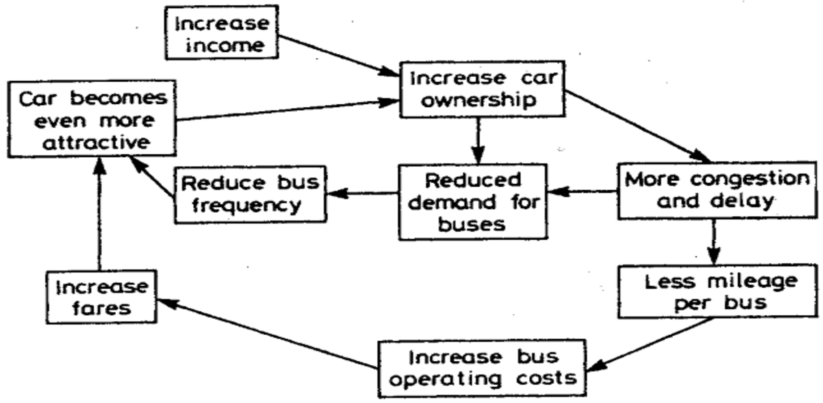

Figure 2.5: Car and public transport vicious circle; **Source:** Ortuzar-Willumsen(2004: 8)

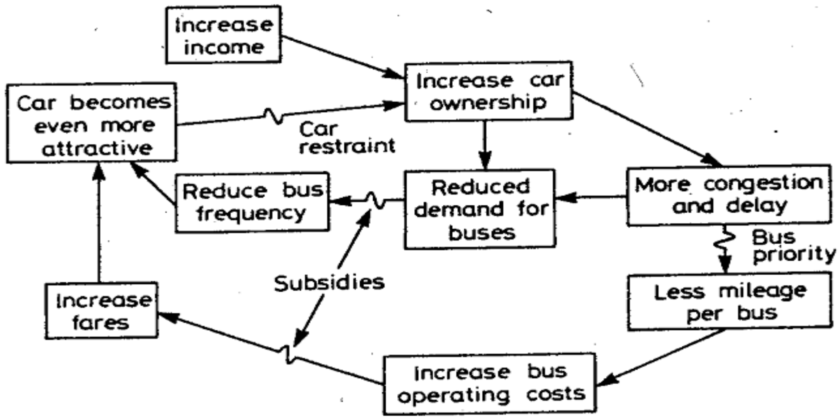

Figure 2.6: Breaking the car/public transport vicious circle;**Source:**Ortuzar-Willumsen(2004:9)

Therefore, the solution to transportation problems must be analytically based, economically sound, socially credible, environmentally sensitive, practically acceptable and sustainable. Alternatively, the transportation solution should be safe, rapid, comfortable, convenient, economical, and eco-friendly for both passengers and materials.

In order to promote the usage of high capacity mode of public transportation in the city, it is important to minimize the generalized cost of travel for mode users. As indicated in different research paper that the non-user transportation cost is related to the transportation user cost and modal choice. Therefore, it is possible to minimize the external cost of transportation by minimizing the users cost and by proper mode choice. For example, if we provide a less generalized cost of public transportation, the private vehicle owners can be motivated to use the public transportation services which minimize the overall traffic congestion, air pollution and accident level.

2.4. Modal Choice

The issue of mode choice is probably the single most important element in transportation planning and policy making since it affects the general efficiency with which we can travel in urban areas, and the amount of urban space devoted to transportation function (Ortuzar-Willumsen, 2004). When people move from place to place for different purposes at different times of the day, different factors influence their modal choices; here are some of the factors that influence the choice of modes: -

(i) Characteristics of the trip maker:

- Car availability and / or ownership;
- Possession of a driving licence;
- Household structure (young couple, single, retired, etc.);
- Income;
- Decisions made elsewhere, for example the need to use a car at work, take children to school, etc.; and
- Residential density.

(ii) Characteristics of the journey:

- Trip purpose; and
- Time of the day when the journey is undertaken.

(iii)Characteristics of the transport facility. These can be divided into two categories.

Firstly, quantitative factors such as:

- Relative travel time: in-vehicle, waiting at stops, and walking times to and from stops
- Relative monetary costs (fares, fuel and direct costs);
- Availability and cost of parking.

Secondly, qualitative factors such as:

- Comfort and convenience;
- Reliability and regularity;
- Protection, security….etc.

Transport users associate their mode choice with utility of the mode; however, in transportation there is a subjective and objective disutility of movement which is expressed as the generalized cost of travel. A good mode choice model should include the most important of the above factors.

A rationale passenger seeks to minimize the sum of monetary expenses (fares) and time costswhen travelling. Hence, a passenger would rather choose a faster and more expensive transport mode than a cheap and slow alternative if it implies lower generalized costs for the journey (Terje, 2006). As indicated by Mintesnot and Shin-ei (2008), selecting the mode with the largest value of utility is equivalent to selecting the mode with the smallest value of expected generalized cost of travel. Therefore, it is important to quantify the generalized cost of travel so that transportation users choose the most efficient mode of transportation.

Trips from an origin i to a destination j are distributed to the different modes of transportation by modal choice models. Where the travel choices are made between two modes, it is called binary logit model. If the modes are multiple (greater than two modes) it is called multinomial logit model.

Let there be two modes (m = 1, 2); then, the proportion of trips by mode 1 from zone i to zone j is P^1_{ij}. Let C_{ij}^1 be the cost of traveling from zone i to zone j using mode 1, and C_{ij}^2 be the cost of traveling from zone i to zone j by mode 2. Based on the above, there are three cases:

- If $C_{ij}^2 - C_{ij}^1$ is positive, then mode 1 is chosen.
- If $C_{ij}^2 - C_{ij}^1$ is negative, then mode 2 is chosen.
- If $C_{ij}^2 - C_{ij}^1$ equal to Zero, then both modes have equal probability.

Different researchers defined the generalized cost of travel depending on the attributes they used to quantify it. For example, Ortuzar-Willumsen (2004) defined the generalized cost of travel as the combination all the main attributes related to the disutility of a journey, while Balcombe et al. (2004) define as the sum of monetary and time costs. Even though different models, different combinations of component of variables and different methods of estimations have been used to express the generalized cost of travel, the generalized cost of travel should be considered as a linear sum of its component variables, each with a coefficient reflecting its relative importance. The variables to be included are time and money costs. Time spent in different activities (namely, in-vehicle, walking and waiting) should be separately identified and given separate coefficients (Goodwin, 1976).

Phani Kumar et al (2004), express the generalized cost of travel for rural bus in Midnapur district, West Bengal, India, in terms of in-vehicle travel time, discomfort level, travel fare and service headway.

$$C_{ij} = a_1\, tt_{ij} + a_2\, (dl_{ij} - 1)*(tt)_{ij} + F_{ij} + \delta \;\ldots\ldots\ldots\ldots \text{(Generalized cost Eq. 2.1)}$$

Where

C_{ij} is the generalized cost of travel from origin i to destination j;

tt_{ij} is the in-vehicle travel time between origin i and destination j;

dl_{ij} represents the discomfort level experienced;

F_{ij} is the direct cost of travel from i to j;

δ is the modal penalty representing all attributes not included in generalized cost (e.g., safety, convenience, reliability etc.);

a_1 and a_2 are weights attached to each disutility.

Phani Kumar et al (2004) used the disutility of travel modeled based on stated choice data collected from trip-makers traveling along the selected study area. Multinomial Logit Model (MNL) is used to develop utility equations and the total disutility of travel is estimated in the form of generalized cost. The perceived values associated with in-vehicle travel time, service headway, and comfort level for the study route are estimated and found to be significant. Phani Kumar et al (2004) also used the experts and trip-makers discussions to describe the level of the attributes.

According to Phani Kumar et al. (2004), the condition of travel used to represent the discomfort level value as shown in Table 2.1 below.

Table 2.1: Discomfort level value

Condition of Travel	**DL value**
Seating	1
Standing comfortably	2
Standing in crowd	3

The researcher developed a database to quantify the generalized cost of travel for a rural bus. The database consists of information related to route, trip, respondent's socio-economic characteristics, and finally respondent's preference in the form of "choice". Route characteristics include length of the route, number of bus stops, fare structure, and schedule. Trip characteristics are origin, destination, purpose, duration of the trip, and fare paid. Socioeconomic characteristics of the respondents included: age, gender, education, profession, and income. Preference data is collected in the form of choices where respondents choose an alternative from the three alternatives given in the choice set (Phani Kumar, et al, 2004).

Another researcher Goodwin (1976) used a three-component approach to express the generalized cost of travel in terms of: time spent, effort spent and money spent in transport activities. Assume that a particular journey consists only of two activities 1 and 2 (e.g. walk and ride). In this case, the true generalized cost is formulated as:

$$G = k_t (T_1 + T_2) + k_e (E_1 + E_2) + k_m M \text{ .... (Generalized cost Eq. 2.2)}$$

Where

G is the generalized cost;

T_i is time spent in activity i (walking, in-vehicle, etc.);

E_i is effort spent in activity i;

M is money spent; and

k_t, k_e and k_m are the true coefficient of time, effort and money respectively.

Ortuzar and Willumsen (2004), express the generalized cost of travel with the variable of in-vehicle travel time, walking time, waiting time, interchange time, fare, parking cost and modal penalty. A linear function of the attributes of a journey is weighted by coefficients which attempt to represent their relative importance as perceived by travelers for different modes from origin i to destination j.

$$\mathbf{C}_{ij} = a_1 t^v_{ij} + a_2 t^w_{ij} + a_3 t^t_{ij} + a_4 t_{nij} + a_5 F_{ij} + a_6 \Phi_j + \delta \text{...... (Generalized Cost Eq. 2.3)}$$

Where

$\mathbf{C}_{ij}$ is the generalized cost of travel from origin i to destination j;

t^v_{ij} is the in-vehicle travel time between i and j;

t^w_{ij} is the walking time to and from stops (stations);

t^t_{ij} is waiting time at stops;

t_{nij} is the interchange time, if any;

F_{ij} is the fare charged to travel between i and j;

Φ_j is a terminal (typically parking) cost;

δ is a modal penalty, a parameter representing all other attributes not included in the generalized measure so far, e.g. safety, comfort and convenience; and

$a_{1\ldots}a_6$ are weights attached to each element of cost.

The cost element may be considered in terms of distance, time or money units. As stated by Lesley L. (2009), and Ortuzar-Willumsen (2004), there are some theoretical and practical advantages in measuring generalized cost in time units. For example, the effect of income levels increasing with time would increase the value of time and therefore increase generalized costs and apparently make the same destination more expensive. If, on the other hand, generalized costs are measured in time units, increased income levels would appear to reduce the cost of reaching the same destination, and this seems intuitively more acceptable. Generalized costs which is expressed using a time base allows historic and international data to be compared directly and also provide an inverse relationship with demand, directly equivalent to the classical economic Demand Curve. As well as making public transportation user forecasts possible for changes to existing transportation services, Generalized costs also allow user forecasting, when completely new modes of transportation to be introduced. This is possible using pair-wise probability analysis, comparing the generalized cost of an existing mode with that of the new mode (Lesley L., 2009).

If the generalized cost is measured in money units then a_1 is sometimes interpreted as the value of time (or more precisely the value of in-vehicle time) as its units are money per time. In that case, a_2 and a_3 would be the values of walking and waiting time respectively. As Ortuzar-Willumsen (2004), P. B. Goodwin (1976) and in many practical studies the recommended coefficients of walking and waiting time are each given a weight twice that of in-vehicle travel time. However, there is variation in some studies on which this recommendation is based. For example, Rogers et al (1970), giving waiting 1.7 and walking 2.4 compared with in-vehicle time; Davies and Rogers (1973), giving waiting 3.2 and walking 2.5; Steele and Rogers (1973), giving waiting 2.1 and walking 2.8; as cited by Goodwin, P.B. (1976). If the generalized cost is measured in money units, a_5 is normally fixed to one. (Ortuzar-Willumsen, 2004)

As stated clearly by Ortuzar-Willumsen (2004), it is often convenient to use a measure combining all the main attributes related to the disutility of a journey and this is normally referred to as the generalized cost of travel. Here for this particular research paper, the generalized cost of travel is expressed in the linear function of: in-vehicle travel time, walking time to and from stops, waiting time at stops, and passenger fare. Equation 2.4 below is developed accordingly.

$$\mathbf{C}_{ij} = a_1 t^{v}_{ij} + a_2 t^{w}_{ij} + a_3 t^{t}_{ij} + a_4 F_{ij} + a_0 \text{ ………… (Generalized Cost Eq. 2.4)}$$

Where the variables are the same as above equation number 2.3. The coefficient of variables, which are $a_{0,}$ a_1, a_2, a_3, and a_4, in the generalized cost function can be calibrate by multiple linear regression (Ortuzar-Willumsen, 2004: 208).

CHAPTER THREE

RESEARCH APPROACH AND METHODOLOGY

3.1. Study Area

Addis Ababa is the capital city of Ethiopia with a total area of 540 square km which divided into 10 sub-cities and 116 Woredas. The city is the country's political and economic center, and is also the seat of the Head Office of the African Union and United Nations Economic Commission for Africa. In 2004 E.C., the population density of Addis Ababa City was 5,645.61 people per km sq. which is one of the densest populated areas in the country (Socio-Economic profile of Addis Ababa, 2013). Figure 3.1 below shows the Administrative Map of Addis Ababacity along with Addis Ababa Light Rail Transit Alignment.

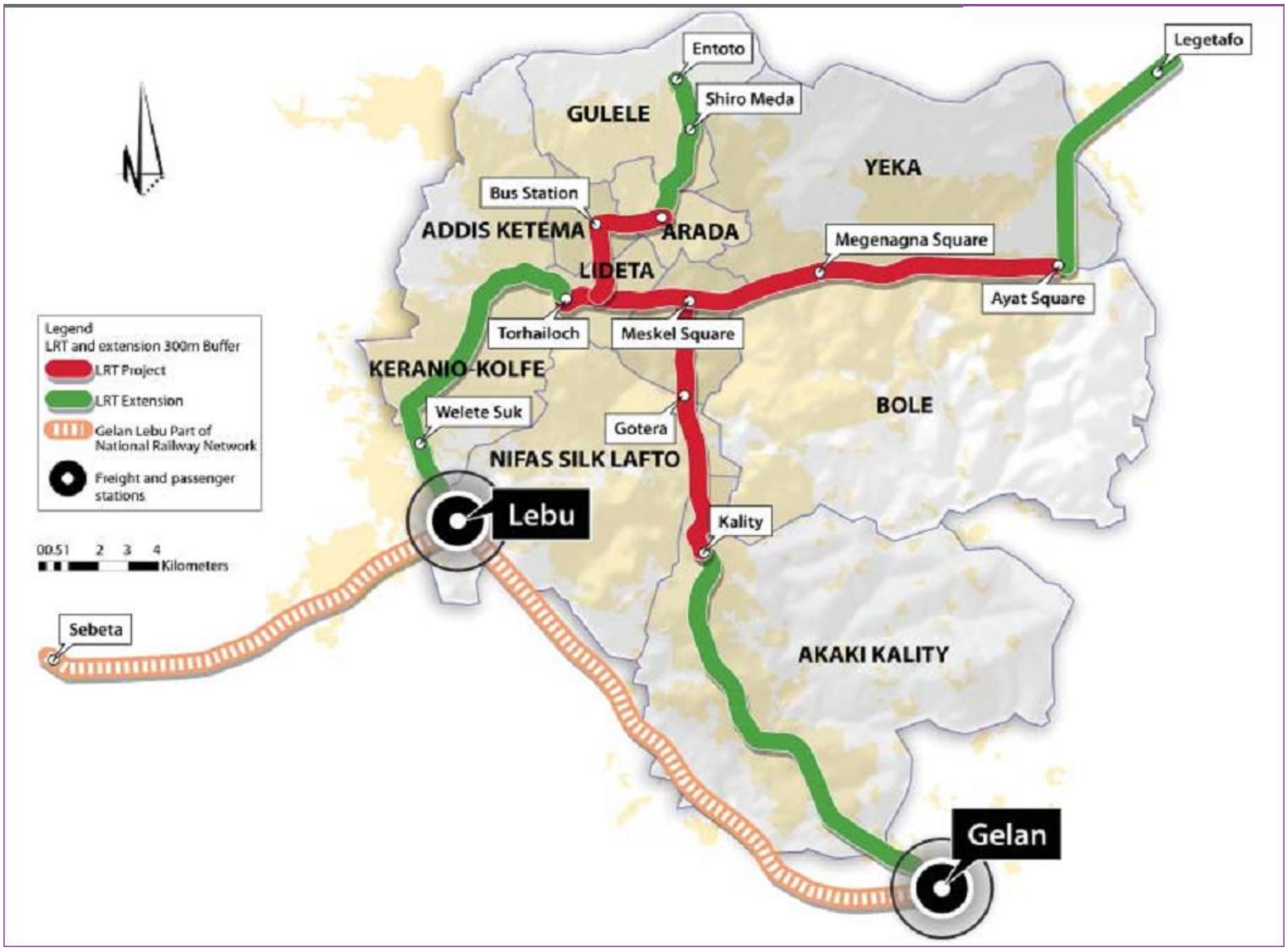

Fig. 3.1 Addis Ababa Light Rail Transit Alignment with Extension lines: **Source:** Ethiopian Railway Corporation (ERC)

Currently the population of the city use different means (modes) of transportation in order to fulfill their mobility needs such as; walking, bicycling, Bajaj, private automobiles, saloon or small taxi (Lada), metro taxi, minibus taxis (white-blue taxi), supported white minibuses, Anbesa City Bus, Higer bus, Public bus, Star Alliance bus, Sheger bus, Supported Cross-Country bus and Addis Ababa Light Rail Transit, etc.

Among different modes of public transportation system currently providing service to the population in the city, this research paper focuses on the three largely used modes of public transportation and these are: Anbesa City Bus, Minibus taxi (or supported white Minibus) and the Addis Ababa Light Rail Transit (AALRT) that operates along the East-West corridor of the city, specifically from Ayat Square to Megenagna for a route length of 8.3km.

❖ **Addis Ababa Light Rail Transit (AALRT)**

The Addis Ababa Light Rail Transit (AALRT) has two lines with the total length of 31.6 kilometer and track gauge of 1435mm standard gauge. Of the two rail lines of the city the East-West line extends for 17.4 kilometers stretching from Ayat Square to Torhailoch, and passing through Megenagna, Meskel Square, Legehar and Mexico Square. The North-South line, which is 16.9 kilometers in length, passes through Menelik II Square, Merkato, Lideta, Legehar, Meskel Square, Gotera and Kaliti. The two lines have a common track of about 2.7 km from St. Lideta church (West) to Meskel Square (East). Currently, the AALRT has 41 stations of this 22 stations are along the East-West and 19 stations along the North-South line. The East-West trains are colored green and white, whilst the North-South trains are colored blue and white. Each train has a carrying capacity of 286 passengers with the maximum speed limit of 70km/h(https://en.wikipedia.org/wiki/Addis_Ababa_Light_Rail).Figure 3.2 illustrate the train types.

Figure 3.2: Train types

❖ **Anbesa City Bus**

The single Anbesa City Buses has a capacity of 30 seats and 70 standing spaces while the articulated buses have a total passenger capacity of 170. The buses are operating all over the city along 124 routes. One of the routes is between Ayat and Megengna with a distance of 8.3 kilometers. Figure 3.4 below shows articulated and rigid buses.

Figure 3.3: Types of Anbesa City Bus

- **Minibus taxi**

The Minibus taxi operate around 364 routes and carry more than 1.1 million passengers per day. On average a Minibus taxi covers about 138 km per day and makes 15 trips. The capacity of each Minibus is 12 seats, including driver (Mulu Eshete, 2015). Figure 3.5 below shows the types of Minibuses with different colors.

Figure 3.4: Types of Minibus taxi

3.2. Research design

To come up with the intended objective and to answer the research questions this paper incorporates the following activities: -

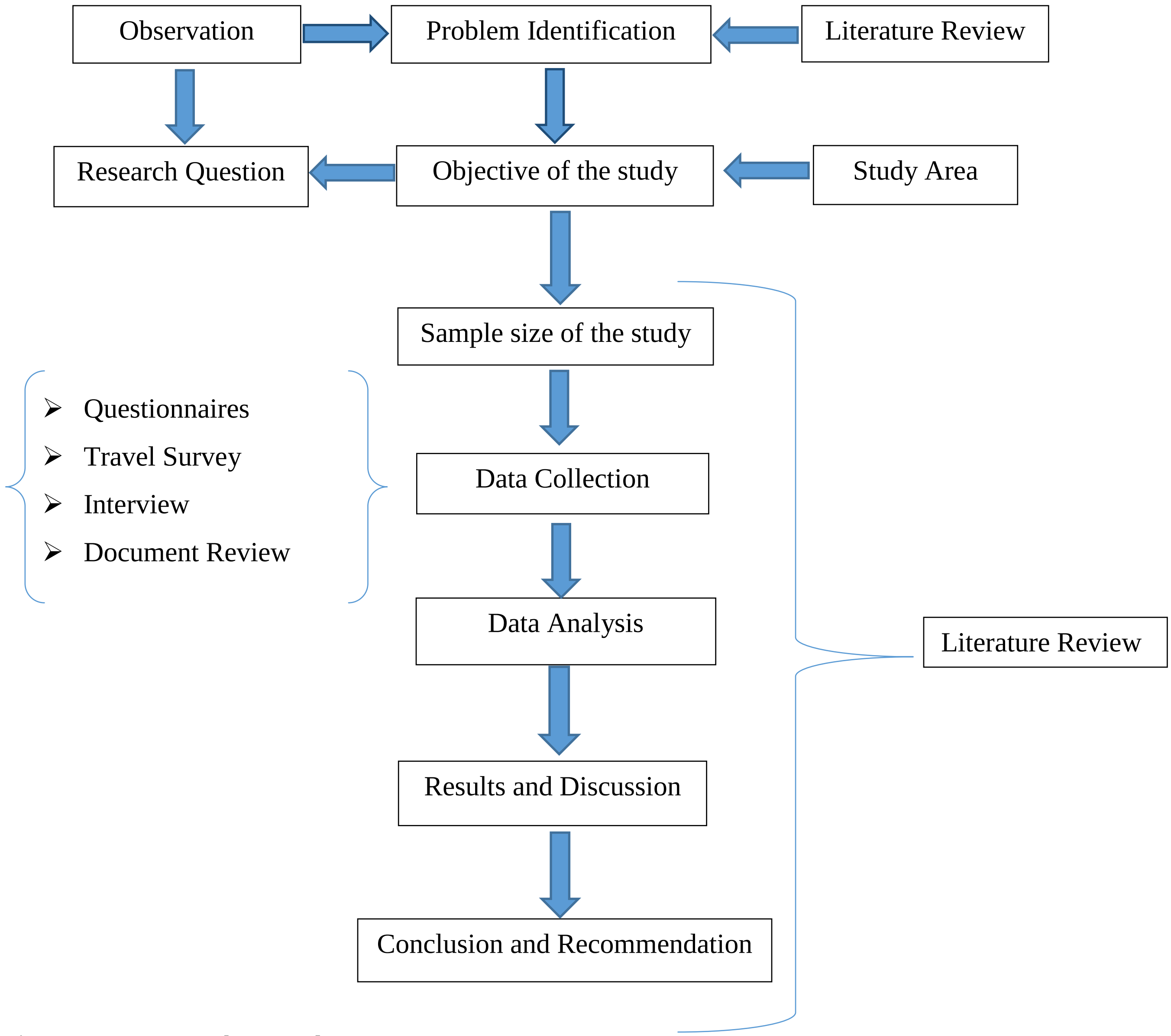

Figure 3.5: Research Procedure

3.3. Sample size of the study

The Sample size of the study is determined using Equation 3.2 which is developed by Montgomery and Runger (2003: 265-267). In situations where the sample size can be selected, n can be choose to be 100 (1- α) % confident that the error is less than some specified value *E* where it set to be$E$ = $Z_{\alpha/2}\sqrt{p(1-p)/n}$and solve for n, the appropriate sample size is

$$n = \left(\frac{z_{\alpha/2}}{E}\right)^2 p(1-p)$$ ……………………… equation 3.1.

Where: - n: sample size

Z: standard normal random variable

E: error

p: proportion of the population

α:confidence coefficient.

However, to use the above equation we need information concerning the value of *p*, either from a preliminary sample or from past experience. By doing so, we could use a smaller sample while maintaining both the desired precision of estimation and level of confidence.

Another approach to choosing n uses the fact that the sample size from equation 3.1, will always be a maximum for p= 0.5 [that is, $p(1-p) \leq 0.25$ with equality for $p = 0.5$], and this can be used to obtain an upper bound on n. To determine the sample size of the study, it is necessary to construct confidence intervals on a population proportion. Therefore, equation 3.1 becomes

$$n = \left(\frac{z_{\alpha/2}}{E}\right)^2 (0.25)$$ ………………………… equation 3.2

In this research, the sample size n of the study is determined by being at least 95% confident that the estimate p^* of the true proportion p was within 0.05 regardless of the value of p, an approximate 385 sample size n is found as calculated below.

$$n = \left(\frac{z_{0.025}}{E}\right)^2 (0.25) = \left(\frac{1.96}{0.05}\right)^2 (0.25) \cong 385$$ ……… Where E = 0.05, and $Z_{\alpha/2}$= 1.96

3.4. Data collection

To come up with the intended objective of the study and to answer the research questions, primary and secondary data were used. The primary data were gathered through questionnaires, travel surveys, and interviews while secondary data were collected by referring to documents and literature review.

Thequestionnaires,travel survey and the interviews were used to gather the explanatory variables of the generalized cost of travel per trip which is expressed in multilinear regression function of the average in-vehicle travel time, average walking time, average waiting time and average passenger fareof the three modes of public transportation at different time of the day. The collected data were primarily used to quantify the generalized cost travel per trip for the selected modes of public transportation which currently provide service to users along the East-West from Ayat Square to Megenagna.

From October/1/2016 to February/28/2017 G.C. around 465 questionnaires were distributed and collected. Among the collected sample questionnaires, 46 were not complete and consistent; therefore, only 419 (90%) responses were used for frequency and descriptive statistical analysis. The questionnaires consisted twelve questions as shown in Appendix A. Most of the questions were closed choice or fixed type of questions which makes the questionnaire easy to respond, classify and quantify. Even though the questionnaires were intended to use for collecting the average in-vehicle travel time from origin to destination, the average walking time to and from stops (stations), average waiting time at stops (stations), average passenger fare to use the public transportation mode, and the estimated generalized cost of travel per trip in the selected route, butit also include some of the basic factors which can influence the choice of mode such as: demographic, socio-economic characteristics of the trip maker, and characteristics of the journey and the transportation facility.

In order to quantify the generalized cost of travel per trip at different time of the day the explanatory variables for the selected modes were estimated using travel survey from Ayat Square to Megenagna for three months from January 1, 2017 to March 31, 2017.

3.5. Data Analysis

The data analysis were done depending on the acquired data through questionnaires, travel surveys and document review. Before the analysis, the collected data were checked and adjusted to make sure that they give the intended results and to able to answer the research questions. Incomplete and inconsistent questionnaires were discarded. The whole analyses of the collected data were done using SPSS (Statistical Package for the Social Sciences) Version 20.0 software and Microsoft Excel 2013 since the Software were appropriate to manage, analyze and present the data.

As mentioned in the Ortuzar-Willumsen, (2001), the generalized cost of travel can be expressed in terms of distance, time or money units. Here, the following steps were carried out to express the generalized cost of travel per trip in terms of money units (Birr).

Step 1: Scatter Plot Matrix: The first step of any statistical analysis is to plot graphically the data. The graphical plots are called scatter plots. Scatter plots can show visually the strength of the relationship between the variables, the direction of the relationship between the variables, and whether outliers exist.

Step 2: Correlation Analysis: this step used to see how variables are related with one another.

Step 3: Multiple Linear Regression Analysis: depending on the scatter plot and the correlation analysis the final step of the analysis is to calculate the generalized cost of travel per trip using multiple linear regression analysis.Using multiple linear regression analysis the weights attached to each element of cost (explanatory variables) are determined.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

Introduction

In this chapter, the frequency and the descriptive statistics of the questionnaires, the scatterplots, the correlation matrix, the multilinear regression analysis and the generalized cost of travel per trip along with their discussions are presented.

4.1. Frequencies and Descriptive Statistics

The demographic characteristics of the respondents, socio-economic characteristic of the respondents and the characteristic of the selected mode of public transportation are presented in tabulation.

The collected data from the respondents in respect of sex, 65.9% were male and 34.1% were female In addition, 70.2% of the respondents' average monthly income was below Birr 3,000 (about US$135, considering 1US$ = ETB 22.3). This shows that the majority of the respondents are low-income earners. About 15% of the respondents were students, 34.4% government employees, 21.5% private company employees, 22.2% operate their own private businesses, and 2.9% were unemployed and the remaining 4.0% works in different offices like NGO. About 95.4 % of the trips (journeys) were made at the peak period of the time and 84.6% of the respondent have an average household size of six. The majority of the trip purposes were commuting which is 64.7%, school 17.2%, shopping 11.7% and others 6.4%. Around 58.9% of the respondent choose Minibus taxis, 21.5% Anbesa City bus and 19.6% AALRT. In general, the majority of the public transportation users are not satisfied in the current services. The output of the analysis are illustrated in the following tables.

Table 4.1: Gender

Gender	Frequency	Percent(%)	Cumulative Percent(%)
Female	143	34.1	34.1
Male	276	65.9	100.0
Total	419	100.0	

Table 4.2: Age

Age	Frequency	Percent(%)	Cumulative Percent(%)
19-30	203	48.4	48.4
31-45	170	40.6	89.0
46-65	36	8.6	97.6
>65	10	2.4	100.0
Total	419	100.0	

In Table 4.1 and 4.2 above it was noticed a difference in gender and age, this was only due to the willingness of the respondents to the questionnaires.

Table 4.3: Possession of driving licence

Possess driving licence	Frequency	Percent (%)	Cumulative Percent (%)
Yes	105	25.1	25.1
No	314	74.9	100.0
Total	419	100.0	

In Table 4.3 above, 25.1% of the respondents possess driving licenses which indicates that either the ownership of vehicle or the potential (for some of them) to own vehicles in the near future.

Table 4.4: Modal choice of public transportation

Mode of Transportation	Frequency	Percent(%)	Cumulative Percent(%)
Bus	90	21.5	21.5
Minibus taxi	247	58.9	80.4
LRT	82	19.6	100.0
Total	419	100.0	

Regarding with the three public transportation the majority of the respondent (58.9%) prefer to use Minibus taxi as shown in table 4.4 above.

Table 4.5: Family Size

Family Size	Frequency	Percent(%)	Cumulative Percent (%)
1-3	164	39.2	39.2
4-6	189	45.1	84.3
7-9	60	14.3	98.6
>10	6	1.4	100.0
Total	419	100.0	

Table 4.6: Average Monthly Income

Average monthly income in ETB	Frequency	Percent(%)	Cumulative Percent (%)
0-900	88	21.0	21.0
901-3000	206	49.2	70.2
3001-8000	105	25.0	95.2
>8000	20	4.8	100.0
Total	419	100.0	

Table 4.7: Trip purpose

Trip purpose	Frequency	Percent (%)	Cumulative Percent (%)
Work	271	64.7	64.7
School	72	17.2	81.9
Shopping	49	11.7	93.6
Other	27	6.4	100.0
Total	419	100.0	

The demand for transportation is derived, it is not an end in itself. People travel in order to satisfy their needs (work, school, leisure, health, etc.) to their respective destinations. The first two trip purpose (work and school) are compulsory trips and the other are optional trips. The less routine purposes are categorized as other trip purpose.

Table 4.8: Trip making time of the day

Trip making time	Frequency	Percent (%)	Cumulative Percent (%)
Peak period	396	94.5	94.5
Off-peak period	23	5.5	100.0
Total	419	100.0	

As shown in table 4.8 above, the most important trips (about 81.9% which are work and school) are executed at the peak period of the day (from 6:00 a.m. to 9:00 a.m. and from 4:00 p.m. to 8:00 p.m.). In the city, the demand for transportation is concentrated on a few hours of a day during peak periods where most of the congestion takes places.

Table 4.9: Level of Satisfaction

Level of Satisfaction	Frequency	Percent (%)	Cumulative Percent (%)
Satisfied	46	11.0	11.0
Less Satisfied	251	59.9	70.9
Not Satisfied	122	29.1	100.0
Total	419	100.0	

As shown in table 4.9 above, the majority of the respondent (89%) are not satisfied with the current public transportation service.

In table 4.10, 4.11 and 4.12, the descriptive statistics of the explanatory variables and the generalized cost of travel are presented for Anbesa City Bus, Minibus taxi and AALRT in the selected route from Ayat Square to Megenagna.

Table 4.10: Descriptive statistics of Anbesa City Bus

	N	Mean	Std. Deviation
In vehicle travel time (Minute)	50	27.12	7.06
walking time (Minute)	50	18.46	6.77
waiting time (Minute)	50	33.10	12.49
passenger fare (Birr)	50	2.61	0.58
Generalized cost of travel (Birr)	50	8.84	2.53

Advantages and disadvantages of Anbesa City Bus

- ❖ Advantages
  - Minimum passenger fare charged(Affordable); and
  - Flexible compared to AALRT.
- ❖ Disadvantages
  - High waiting time and unpredictable in-vehicle travel time; and
  - Uncomfortable (overcrowded).

Table 4.11: Descriptive statistics of Minibus taxi

	N	Mean	Std. Deviation
In vehicle travel time (Minute)	50	25.00	7.82
walking time (Minute)	50	16.50	6.79
waiting time (Minute)	50	25.72	10.17
passenger fare (Birr)	50	4.32	0.63
Generalized cost of travel (Birr)	50	7.88	2.19

Advantages and disadvantages of Minibus taxi

- ❖ Advantages
  - Even if the comfort level of the seat is different, passengers can get a seat;
  - Flexible to get inand get off ; and
  - Comparatively minimum walking time (short walking distance).
- ❖ Disadvantages
  - High fare compared to the other two mode (Bus and AALRT);
  - Unpredictable in-vehicle and waiting time; and
  - Sometimes rude 'woyalas' (money collectors) or bad driver behaviors.

Table 4.12: Descriptive statistics of AALRT

	N	Mean	Std. Deviation
In vehicle travel time (Minute)	50	21.28	2.27
walking time (Minute)	50	22.30	8.09
waiting time (Minute)	50	14.50	3.56
passenger fare (Birr)	50	2.41	0.52
Generalized cost of travel (Birr)	50	5.48	2.20

Advantages and disadvantages of Addis Ababa Light Rail Transit (AALRT)

- Advantages
  - Predictable in-vehicle and waiting time; and
  - Affordable or comparatively minimum fare charged.
- Disadvantages
  - Uncomfortable (most of the journeys without having seats for most passengers and overcrowded);
  - Comparatively high walking time to reach the stations; and
  - Difficult to get in/off at mid-stations (less flexible).

4.2. Scatter Plot

Prior to inverstigating the relationship between two quantitative variables, it is always helpful to creat a graphical representation that includes both of these variables. Such a graphical representation is called a scatter plot. The purpose of a scatter plot is to provide a general illustration of the relationship between the two variables.

The overall pattern of a scatter plot can be described by the direction, form, and strength of the relationship.The slope provides information on the strength of the relationship. The strongest linear relationship occurs when the slope is 1. This means that when one variable increases by one, the other variable also increases by the same amount. The strength of the relationship between two variables is a crucial piece of information. Relying on the interpretation of a scatterplot is too subjective. More precise evidence is needed, and this evidence is obtained by computing a coefficient that measures the strength of the relationship under investigation.

The Scatter Plot between the generalized cost of travel per trip and the explanatory variables for the selected three modes are presented in the following graphs. The strength of the linearity can be expressed as strong, moderate or weak depending on the slope or R^2 linear of the graph.

4.2.1. Scatter Plot for Anbesa City Bus

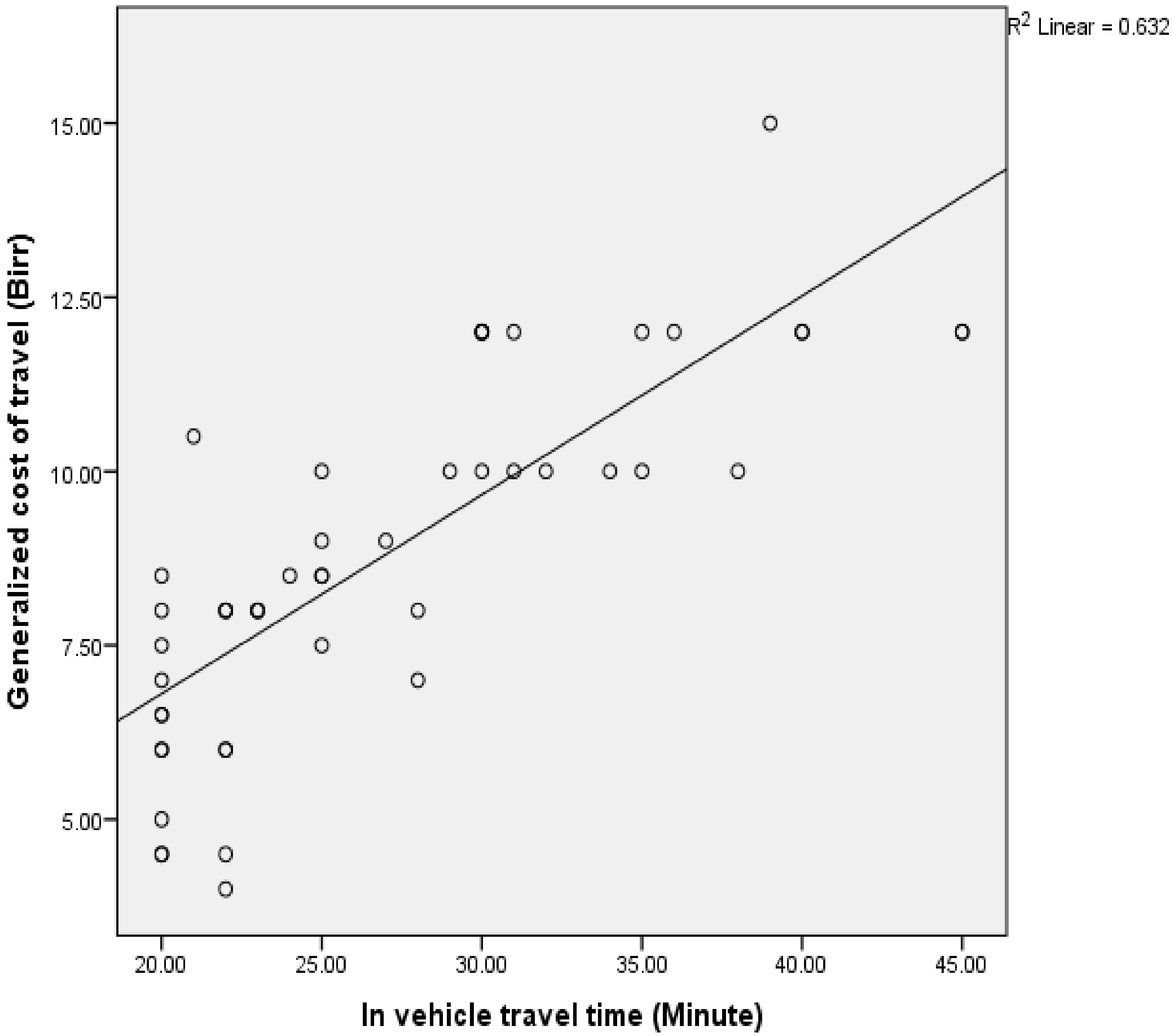

Fig. 4.1: Scatter plot of In-vehicle travel time and generalized cost of travel for Anbesa City Bus

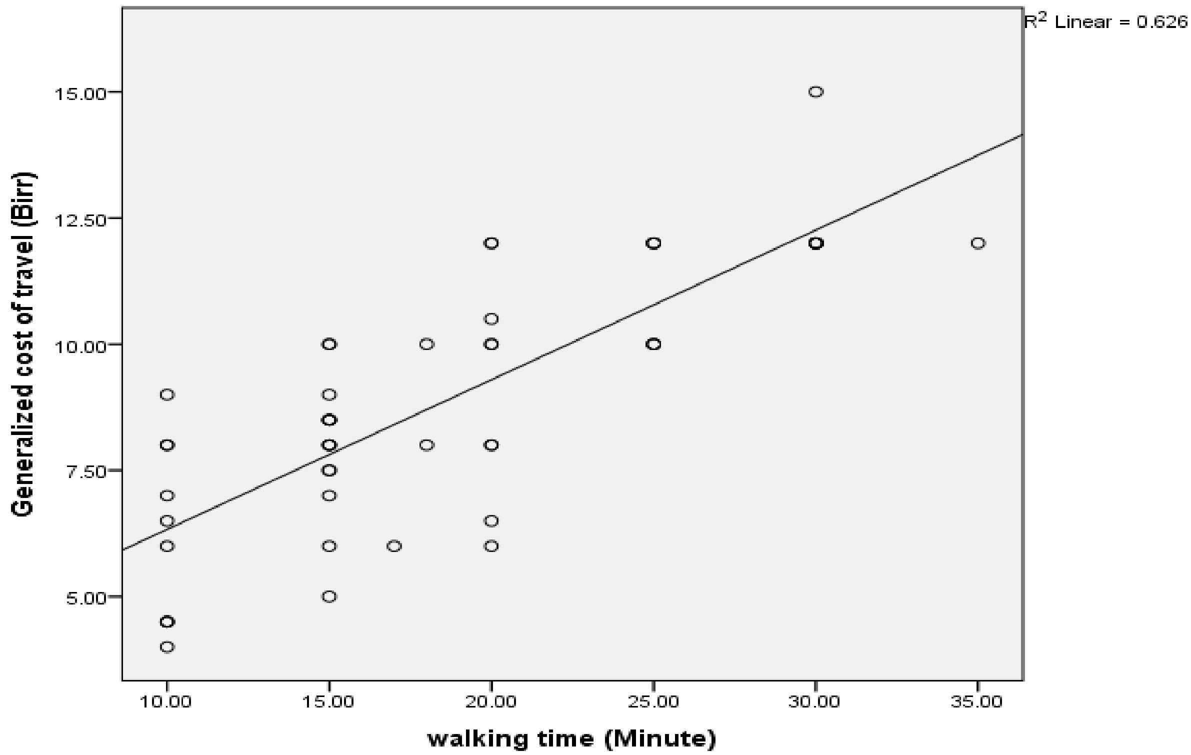

Fig. 4.2: Scatter plot of walking time and generalized cost of travel for Anbesa City Bus

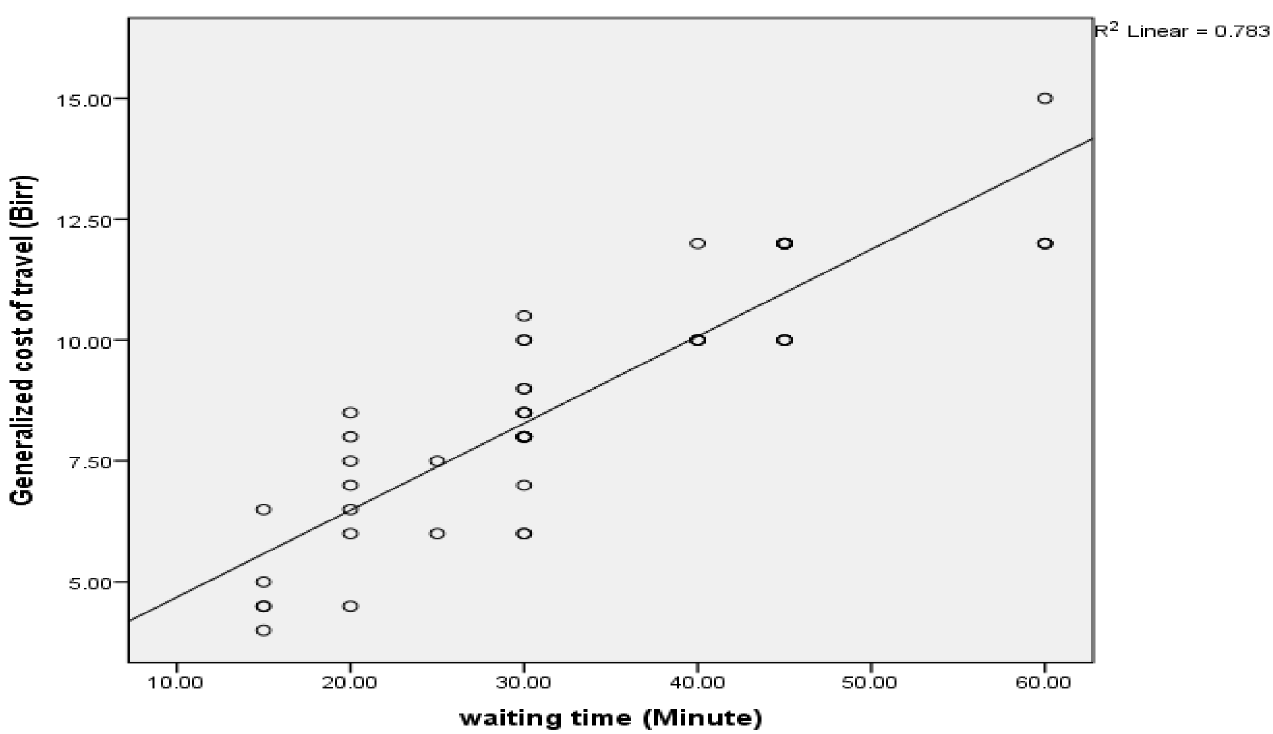

Fig. 4.3: Scatter plot of waiting time and generalized cost of travel for Anbesa City Bus

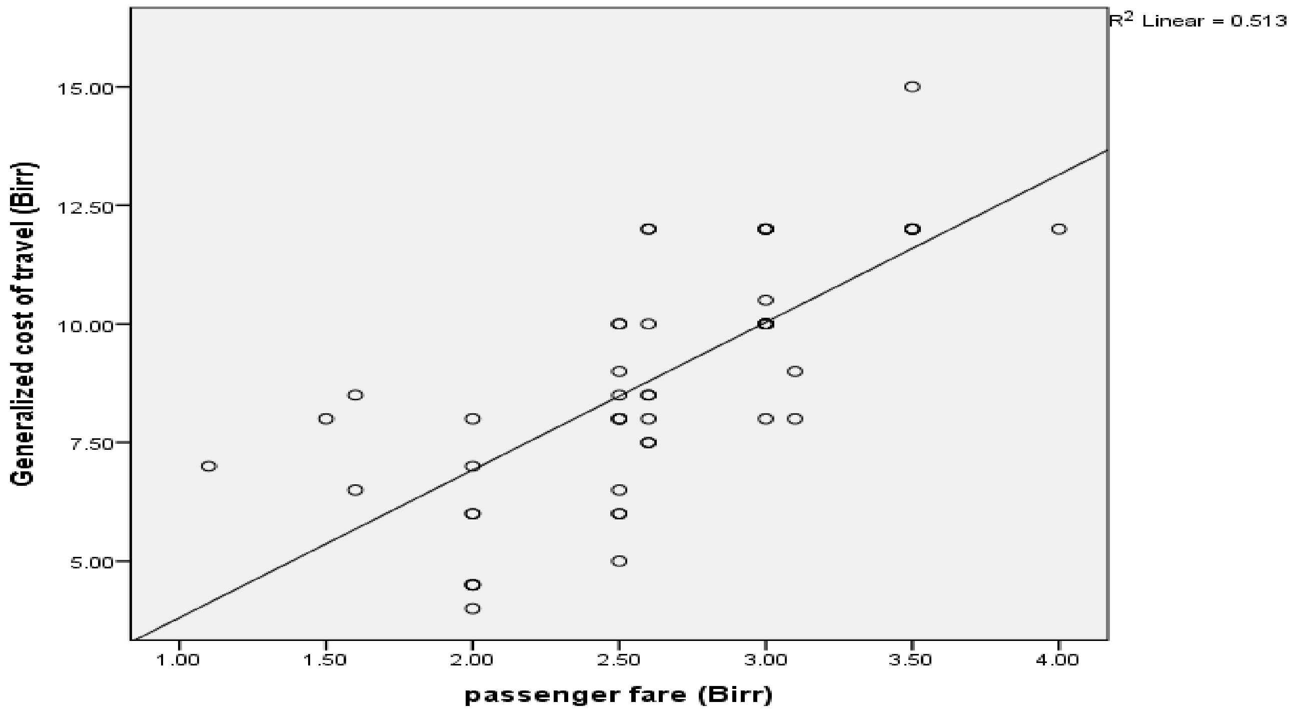

Fig. 4.4: Scatter plot of passenger fare andgeneralized cost of travel for Anbesa City Bus

4.2.2. Scatter Plot for Minibus Taxi

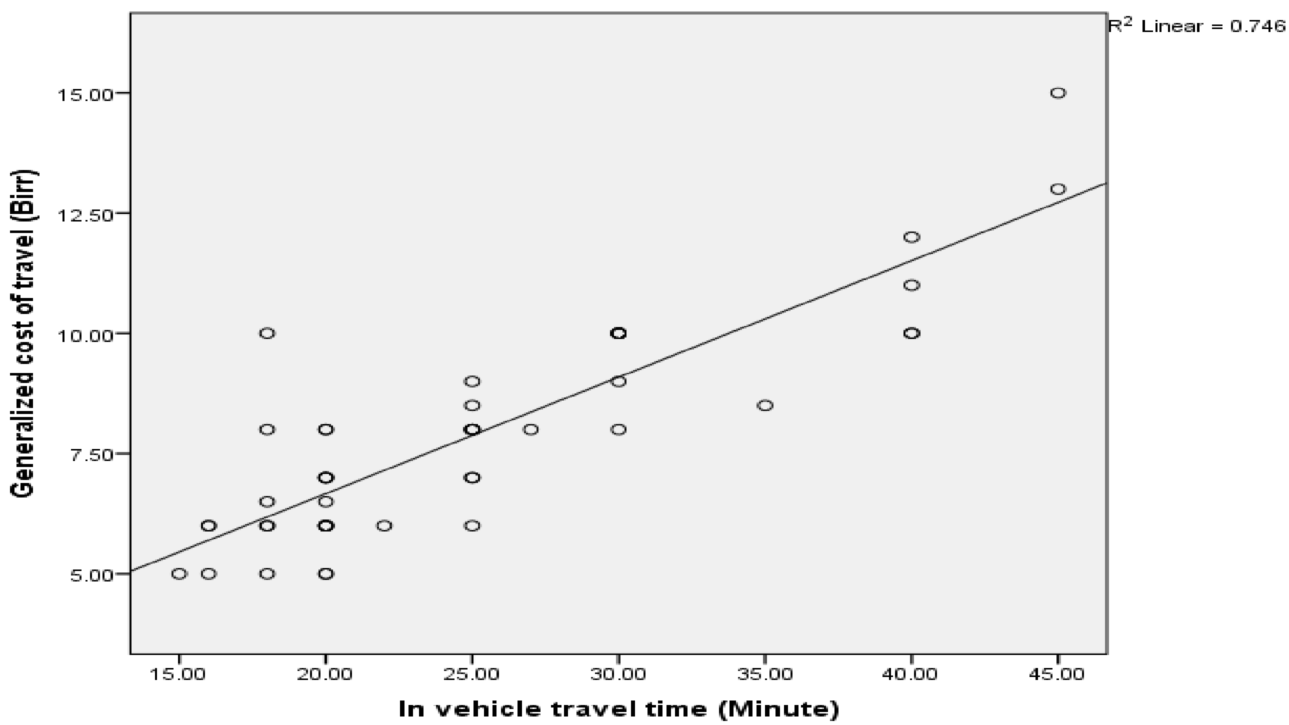

Fig. 4.5: Scatter plot of In-vehicle travel time and generalized cost of travel for Minibus taxi

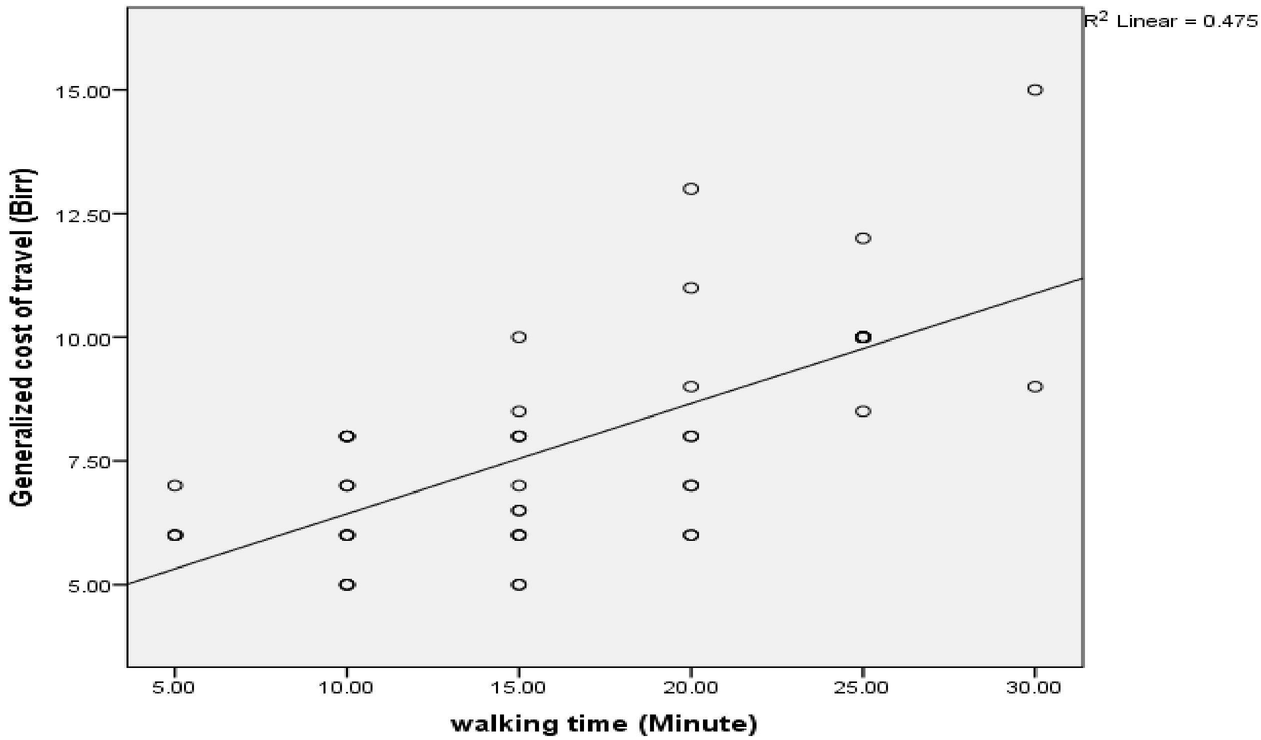

Fig. 4.6: Scatter plot of walking time and generalized cost of travel for Minibus taxi

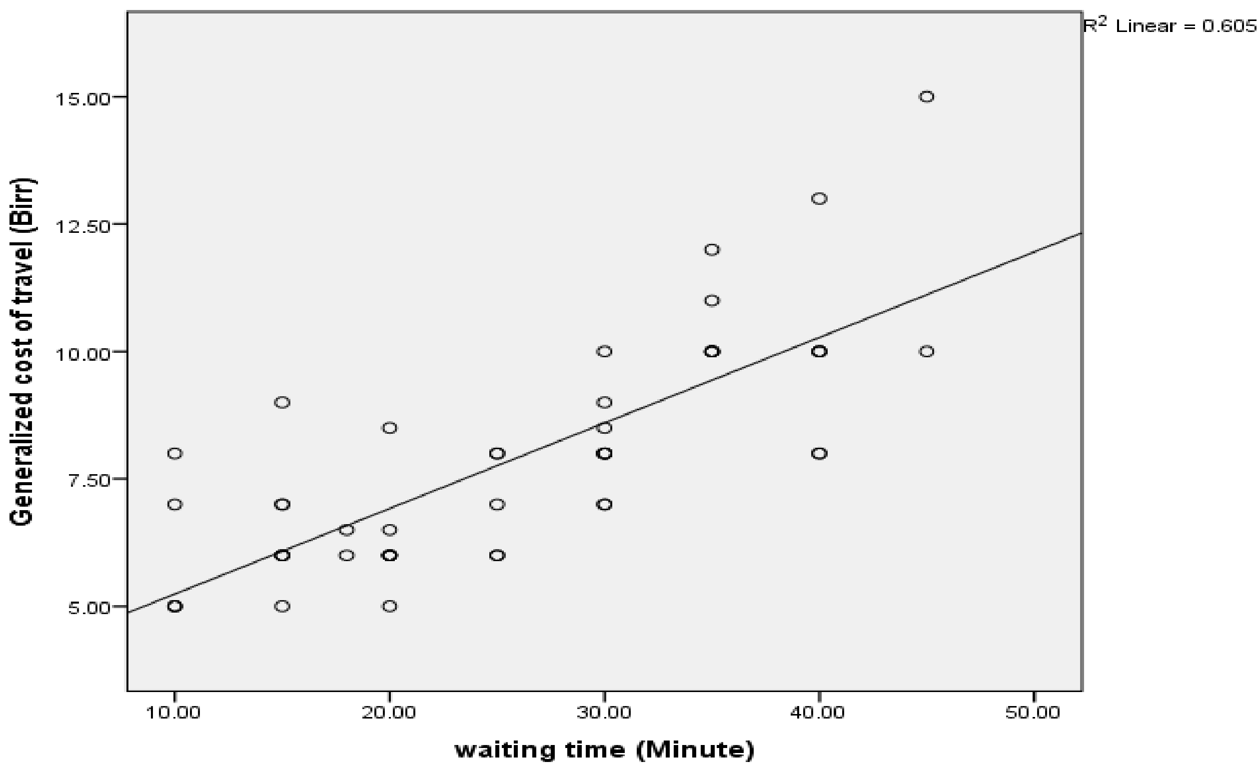

Fig. 4.7: Scatter plot of waiting time and generalized cost of travel for Minibus taxi

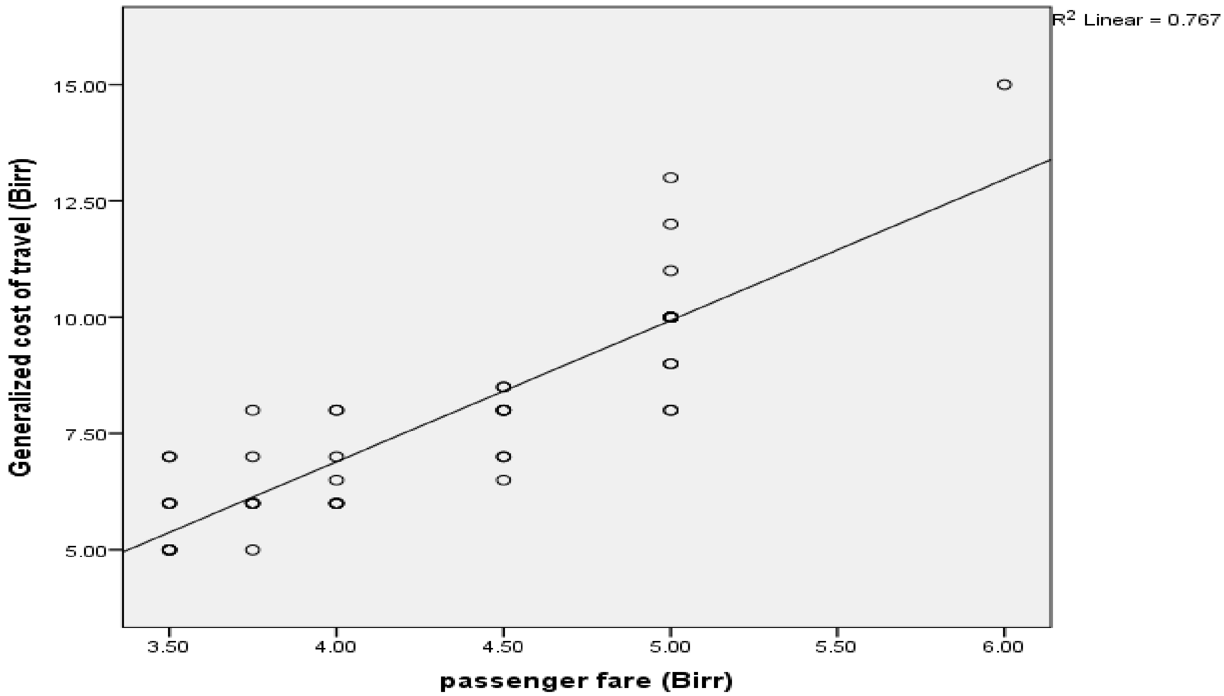

Fig. 4.8: Scatter plot of passenger fare andgeneralized cost of travel for Minibus taxi

4.2.3. Scatter Plot for AALRT

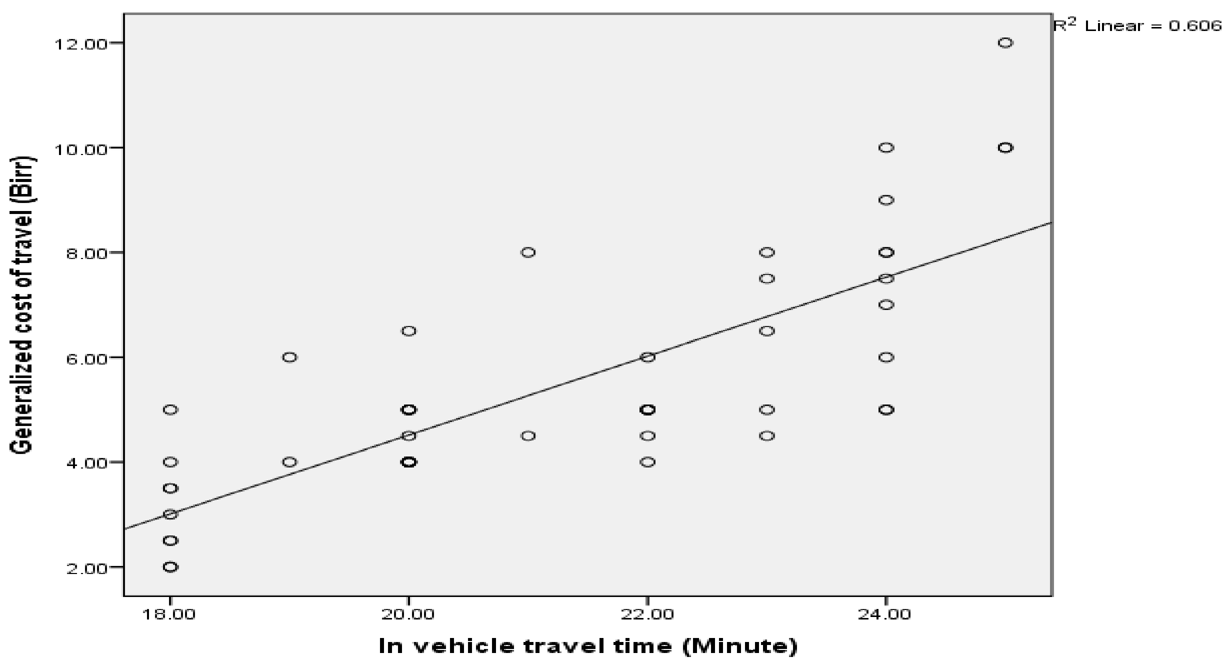

Fig. 4.9: Scatter plot of in-vehicle travel time andgeneralized cost of travel for AALRT

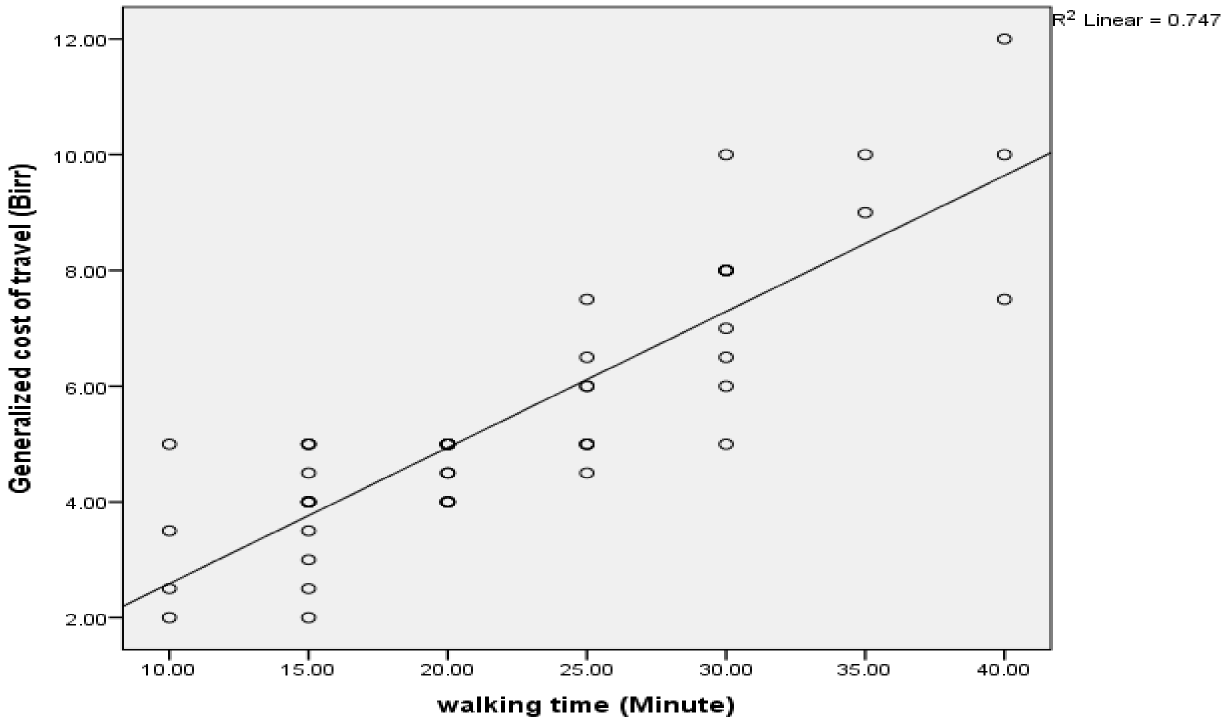

Fig. 4.10: Scatter plot of walking time and generalized cost of travel for AALRT

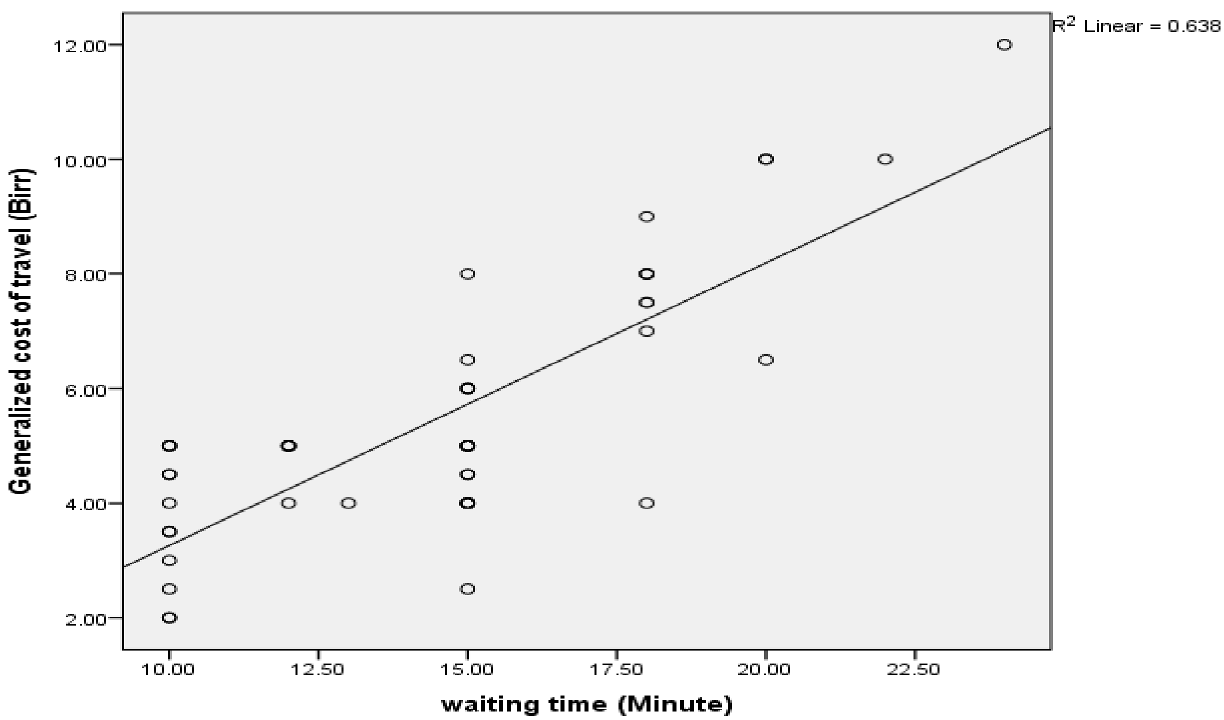

Fig. 4.11: Scatter plot of waiting time andgeneralized cost of travel for AALRT

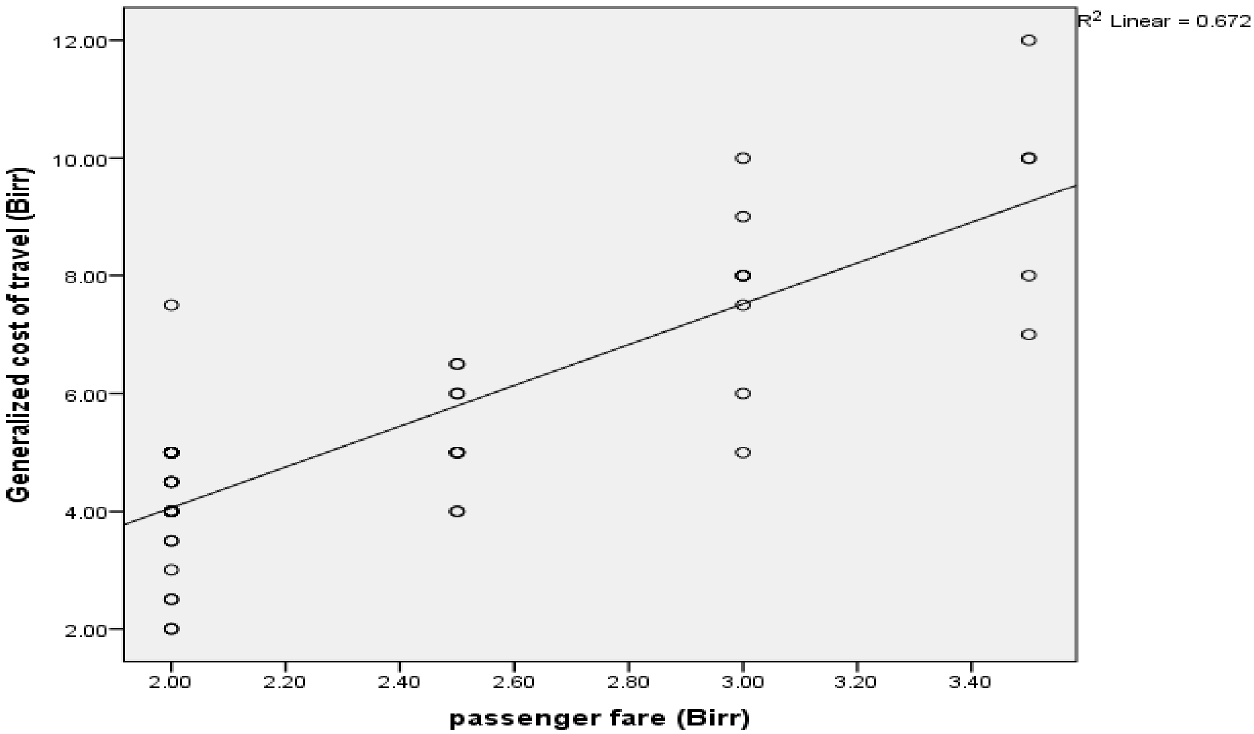

Fig. 4.12: Scatter plot of passenger fare andgeneralized cost of travel for AALRT

4.3. Correlation Analysis

Correlation measure how variables are related. The correlations table displays Pearson correlation coefficients, significance value (2-tailed), and the number of cases with non-missing values (N). The values of the correlation coefficient range from -1 to 1. The sign of the correlation coefficient indicates the direction of the relationship. The absolute value of the correlation coefficient indicates the strength, with larger absolute values indicating stronger relationships. The correlation coefficients on the main diagonal are always 1, because each variable has a perfect positive linear relation with itself.

The significance of each correlation coefficient is also displayed in the correlation table. The significance level (or p-value) is the probability of obtaining results as extreme as the one observed. If the significance level is very small (less than 0.05) then the correlation is statistically significant and the two variables are linearly related. If the significance level is relatively large than 0.05, then the correlation is not significant and the two variables are not linearly related.

Table 4.13: Correlation Matrix result for Anbesa City Bus

		Generalized cost of travel	In vehicle travel time	walking time	waiting time	passenger fare
Generalized cost of travel	Pearson Correlation	1	.795**	.791**	.885**	.716**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	50	50	50	50	50
In vehicle travel time	Pearson Correlation	.795**	1	.705**	.880**	.531**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	50	50	50	50	50
walking time	Pearson Correlation	.791**	.705**	1	.831**	.614**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	50	50	50	50	50
waiting time	Pearson Correlation	.885**	.880**	.831**	1	.578**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	50	50	50	50	50
passenger fare	Pearson Correlation	.716**	.531**	.614**	.578**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	50	50	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.14: Correlation Matrix for Minibus Taxi

		Generalized cost of travel	In vehicle travel time	walking time	waiting time	passenger fare
Generalized cost of travel	Pearson Correlation	1	.863**	.689**	.778**	.876**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	50	50	50	50	50
In vehicle travel time	Pearson Correlation	.863**	1	.612**	.595**	.725**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	50	50	50	50	50
walking time	Pearson Correlation	.689**	.612**	1	.564**	.702**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	50	50	50	50	50
waiting time	Pearson Correlation	.778**	.595**	.564**	1	.696**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	50	50	50	50	50
passenger fare	Pearson Correlation	.876**	.725**	.702**	.696**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	50	50	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.15: Correlation Matrix for AALRT

		Generalized cost of travel	In vehicle travel time	walking time	waiting time	passenger fare
Generalized cost of travel	Pearson Correlation	1	.779**	.864**	.798**	.820**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	50	50	50	50	50
In vehicle travel time	Pearson Correlation	.779**	1	.712**	.629**	.640**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	50	50	50	50	50
walking time	Pearson Correlation	.864**	.712**	1	.681**	.690**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	50	50	50	50	50
waiting time	Pearson Correlation	.798**	.629**	.681**	1	.634**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	50	50	50	50	50
passenger fare	Pearson Correlation	.820**	.640**	.690**	.634**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	50	50	50	50	50

**. Correlation is significant at the 0.01 level (2-tailed).

4.4. Multiple Regression Analysis

Multiple linear regression analysis were conducted to show the significance of the explanatory variables, the association between the explanatory variables and the generalized cost of travel per trip, and the weights attached to each variable. The multiple regression analysis results are presented in respect of modal summary, ANOVA (analysis of variance) and coefficients tables.

- ❖ Model summary table shows the multiple correlation coefficient or R, coefficient of multiple determination or R-Square, adjusted R-Square and the standard error of the estimate.

The multiple correlation coefficient R shows the relationship between the dependent variable and the explanatory variables. The coefficient of multiple determination measures how much the variability in the outcome is accounted for by the explanatory variables. The adjusted R Square gives some idea of how well the model generalized, and ideally a value very close to the value of R square is most preferred.

- ❖ In the analysis of variance (ANOVA) table the Sum of Squares, the degree of freedom df, Mean Square, the F statistic and the significance or Sig. of the explanatory variables on the dependent variable. The *P*-value ("Sig." for "significance") shows the explanatory variables effect on the dependent variable and *P*-values are less than 0.05 and are generally considered "statistically significant."
- ❖ The Coefficients table shows the unstandardized coefficients or B, standardized coefficients or beta, t value, Sig. and the confidence interval for B. If a regression carried out on original (unstandardized) variables, it will produce unstandardized coefficients. Standardized coefficients or beta are the estimates resulting from a regression analysis that have been standardized so that the variances of dependent and independent variables are 1. Here, the "unstandardized coefficients," are preferred to the "standardized coefficients" since the explanatory variables were not standardized.

In the following pages the model summary tables, ANOVA tables and coefficients tables are summarized for Anbesa City Bus, Minibus taxi and Addis Ababa Light Rail Transit in selected route from Ayat Square to Megenagna.

Table 4.16: Model Summary for Anbesa City Bus

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.921[a]	.848	.834	1.03424

a. Predictors: (Constant), passenger fare (Birr), In vehicle travel time (Minute), walking time (Minute), waiting time (Minute)

Table 4.17: ANOVA[a] (Analysis of Variance) for Anbesa City Bus

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	267.585	4	66.896	62.540	.000[b]
	Residual	48.135	45	1.070		
	Total	315.720	49			

a. Dependent Variable: Generalized cost of travel (Birr)

b. Predictors: (Constant), passenger fare (Birr), In vehicle travel time (Minute), walking time (Minute), waiting time (Minute)

Table 4.18: Coefficients [a] for Anbesa City Bus

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	.418	.808		.518	.607	-1.209	2.046
	In vehicle travel time (Minute)	.018	.044	.049	.398	.693	-.072	.107
	walking time (Minute)	.022	.041	.059	.532	.598	-.061	.105
	waiting time (Minute)	.127	.032	.623	3.973	.000	.062	.191
	passenger fare (Birr)	1.279	.326	.294	3.927	.000	.623	1.936

a. Dependent Variable: Generalized cost of travel (Birr)

Using unstandardized coefficient (B) the generalized cost of travel for Anbesa City bus can be expressed by the following equation: - $\mathbf{C_{ij} = 0.018t^{v}_{ij} + 0.022t^{w}_{ij} + 0.127t^{t}_{ij} + 1.279F_{ij} + 0.418}$

To express the generalized cost of travel per trip in money unit (Birr) the passenger fare coefficient is divided to in-vehicle travel time, walking time and waiting time coefficients. It becomes

$$\mathbf{C_{ij} = 0.014t^{v}_{ij} + 0.017t^{w}_{ij} + 0.099t^{t}_{ij} + F_{ij} + 0.327 \ldots. \text{(Gen. Eq. 4.1)}}$$

Table 4.19: Model Summary for Minibus taxi

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.953[a]	.909	.901	.69216

a. Predictors: (Constant), passenger fare (Birr), waiting time (Minute), walking time (Minute), In vehicle travel time (Minute)

Table 4.20: ANOVA [a] (Analysis of Variance) for Minibus taxi

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	214.721	4	53.680	112.048	.000[b]
	Residual	21.559	45	.479		
	Total	236.280	49			

a. Dependent Variable: Generalized cost of travel (Birr)

b. Predictors: (Constant), passenger fare (Birr), waiting time (Minute), walking time (Minute), In vehicle travel time (Minute)

Table 4.21: Coefficients [a] for Minibus taxi

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-2.278	.815		-2.797	.008	-3.919	-.637
	In vehicle travel time (Minute)	.121	.019	.430	6.350	.000	.082	.159
	walking time (Minute)	.007	.021	.022	.336	.738	-.035	.049
	waiting time (Minute)	.053	.014	.247	3.851	.000	.025	.081
	passenger fare (Birr)	1.307	.280	.377	4.666	.000	.743	1.871

a. Dependent Variable: Generalized cost of travel (Birr)

Using unstandardized coefficient (B) the generalized cost of travel for Minibus taxi can be expressed by the following equation: - $\mathbf{C_{ij} = 0.121t^{v}_{ij} + 0.007t^{w}_{ij} + 0.053t^{t}_{ij} + 1.307F_{ij} - 2.278}$

To express the generalized cost of travel per trip in money unit (Birr) the passenger fare coefficient is divided to in-vehicle travel time, walking time and waiting time coefficients. It becomes

$$\mathbf{C_{ij} = 0.093t^{v}_{ij} + 0.005t^{w}_{ij} + 0.041t^{t}_{ij} + F_{ij} - 1.743 \text{ .... (Gen. Eq. 4.2)}}$$

Table 4.22: Model Summary forAALRT

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.946[a]	.895	.886	.74462

a. Predictors: (Constant), passenger fare (Birr), waiting time (Minute), In vehicle travel time (Minute), walking time (Minute)

Table 4.23: ANOVA [a] (Analysis of Variance) for AALRT

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	212.530	4	53.132	95.829	.000[b]
	Residual	24.950	45	.554		
	Total	237.480	49			

a. Dependent Variable: Generalized cost of travel (Birr)

b. Predictors: (Constant), passenger fare (Birr), waiting time (Minute), In vehicle travel time (Minute), walking time (Minute)

Table 4.24: Coefficients [a] for AALRT

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	-5.493	1.163		-4.722	.000	-7.836	-3.150
	In vehicle travel time (Minute)	.161	.071	.167	2.264	.028	.018	.304
	walking time (Minute)	.099	.022	.365	4.546	.000	.055	.143
	waiting time (Minute)	.158	.044	.255	3.598	.001	.069	.246

	passenger fare (Birr)	1.263	.304	.299	4.156	.000	.651	1.876

a. Dependent Variable: Generalized cost of travel (Birr)

Using unstandardized coefficient of B the generalized cost of travel for AALRT can be expressed by the following equation: - $\mathbf{C_{ij} = 0.161t^{v}_{ij} + 0.099t^{w}_{ij} + 0.158t^{t}_{ij} + 1.263F_{ij} – 5.493}$

To express the generalized cost of travel per trip in money unit (Birr) the passenger fare coefficient is divided to in-vehicle travel time, walking time and waiting time coefficients. It becomes

$$\mathbf{C_{ij} = 0.127t^{v}_{ij} + 0.078t^{w}_{ij} + 0.125t^{t}_{ij} + F_{ij} - 4.349 \text{ …. (Gen. Eq. 4.3)}}$$

4.5. Generalized cost of travel

In this section, the generalized cost of travel per trip along East-West corridor of Addis Ababa City for the trip length of 8.3km from Ayat Square to Megenagna for the selected three modes is estimated in money unit (Birr) at different time of the day.

Before the estimation of the generalized cost of travel per trip,the explanatory variables at different time of the day were quantified using questionnaires, travel survey and document review. The walking time and passengers fare charge were taken from questionnaires and established passenger fare respectively; therefore, they are uniform throughout the day. Then, the explanatory variables substituted into the generalized cost of travel per trip equation of the selected modes. The average explanatory variables and the estimated generalized cost of travel per trip are shown in the following tables.

Table 4.25: Average Explanatory variables value at different time of the day for Anbesa City Bus

Explanatory Variables	6:30 a.m. – 9:00 a.m.	9:00 a.m. – 12:00 p.m.	12:00 p.m. – 4:00 p.m.	4:00 p.m. – 6:00 p.m.	6:00 p.m. – 8:00 p.m.
Average in-vehicle travel time (minute)	40	23	21	25	33
Average Walking time (minute)	18.5	18.5	18.5	18.5	18.5
Average Waiting time (minute)	36	28	31	30	38
Fare charged (Birr)	2.40	2.40	2.40	2.40	2.40

Substitute the above explanatory variables to generalized cost of travel per trip equation 4.1, it will give the estimated generalized cost of travel per trip money unit (Birr) as shown in table 4.26.

Table 4.26: Generalized cost of travel per trip at different times of the day for Anbesa City Bus

Time of the day	C_{ij} of Anbesa City Bus (Birr)
6:30 a.m. – 9:00 a.m.	7.16
9:00 a.m. – 12:00 p.m.	6.14
12:00 p.m. – 4:00 p.m.	6.40
4:00 p.m. – 6:00 p.m.	6.36
6:00 p.m. – 8:00 p.m.	7.27

Table 4.27: Average Explanatory variables value at different time of the day for Minibus taxi

Explanatory Variables	6:30 a.m. – 9:00 a.m.	9:00 a.m. – 12:00 p.m.	12:00 p.m. – 4:00 p.m.	4:00 p.m. – 6:00 p.m.	6:00 p.m. – 8:00 p.m.
Average in-vehicle travel time (minute)	40	18	20	24	32
Average Walking time (minute)	16	16	16	16	16
Average Waiting time (minute)	20	20	15	30	35
Fare charged (Birr)	3.75	3.75	3.75	3.75	3.75

Substitute the above explanatory variables to generalized cost of travel per trip equation 4.2, it will give the estimated generalized cost of travel per trip money unit (Birr) as shown in table 4.28.

Table 4.28: Generalized cost of travel per trip at different times of the day for Minibus taxi

Time of the day	C_{ij} of Minibus taxi (Birr)
6:30 a.m. – 9:00 a.m.	6.627
9:00 a.m. – 12:00 p.m.	4.581
12:00 p.m. – 4:00 p.m.	4.562
4:00 p.m. – 6:00 p.m.	5.549
6:00 p.m. – 8:00 p.m.	6.498

Table 4.29: Average Explanatory variables value at different time of the day for AALRT

Explanatory Variables	6:30 a.m. – 9:00 a.m.	9:00 a.m. – 12:00 p.m.	12:00 p.m. – 4:00 p.m.	4:00 p.m. – 6:00 p.m.	6:00 p.m. – 8:00 p.m.
Average in-vehicle travel time (minute)	22	21	20	21	23
Average Walking time (minute)	19	19	19	19	19
Average Waiting time (minute)	17	14	14	13	16
Fare charged (Birr)	2	2	2	2	2

Substitute the explanatory variables of AALRT to generalized cost of travel per trip equation 4.3, then the estimated generalized cost of travel per trip money unit (Birr)is as shown in table 4.30.

Table 4.30: Generalized cost of travel per trip at different times of the day for AALRT

Time of the day	**C_{ij} of AALRT (Birr)**
6:30 a.m. – 9:00 a.m.	4.052
9:00 a.m. – 12:00 p.m.	3.55
12:00 p.m. – 4:00 p.m.	3.42
4:00 p.m. – 6:00 p.m.	3.42
6:00 p.m. – 8:00 p.m.	4.05

As shown in table 4.25, 4.27 and 4.29, explanatory variables value of Anbesa City Bus, Minibus taxi and AALRT respectively, the in-vehicle travel time for Anbesa City Bus and Minibus taxi is almost twice that of the AALRT at the peak period of the day; because the roads are congested due to high volume of vehicles both moving and parked along the route, large number pedestrians on the cross walking (Zebra) and erratic driving behaviors, whileAALRT has a line which is only dedicated for its movement. The average walking time or the walking distance to access the public transportation is higher than the expected even though it did not significantly affect the generalized cost of travel per trip on the selected route. However, the waiting time for both Anbesa City Bus and Minibus taxi are very high and significantly affect public transportation users.

Table 4.31: Summary of the generalized cost of travel at different time for the selected mode

Time of the day	C_{ij} of Anbesa City Bus (Birr)	C_{ij} of Minibus taxi (Birr)	C_{ij} of AALRT (Birr)
6:30 a.m. – 9:00 a.m.	7.16	6.627	4.052
9:00 a.m. – 12:00 p.m.	6.14	4.581	3.550
12:00 p.m. – 4:00 p.m.	6.40	4.562	3.423
4:00 p.m. – 6:00 p.m.	6.36	5.549	3.425
6:00 p.m. – 8:00 p.m.	7.27	6.498	4.054

Even though currently the public transportationis characterized by high generalized cost of travel at different time of the day in comparison AALRT has a minimum cost of travel in the selected route. In contrast, Anbesa City Bus characterize by high generalized cost of travel.

CHAPTER FIVE

CONCLUSIONs AND RECOMMENDATIONs

5.1. Conclusions

In this research work the generalized cost of travel per trip using public transportation modes (specifically for Anbesa City Bus, Minibus taxi and Addis Ababa Light Rail Transit (AALRT)) are estimated at different time of the day along East-West corridor of Addis Ababa City from Ayat Square to Megenagna for route length of 8.3km. The in-vehicle travel time, walking time to and from stops, waiting time at stops and the passenger fare were used as the explanatory variable to express the generalized cost of travel per trip. All the explanatory variables used to express the generalized cost of travel show a linear relationship with the generalized cost of travel per trip and were found statistically significant, even though their significance vary from mode to mode.

Even though, traditionally the transportation economists have placed most emphasis on the value of in-vehicle travel time in large measure because of the importance of car travel and the way in which road investments are evaluated, the results of this research show that the existing public transportation users are significantly influenced by passenger fare, waiting time, and walking time than the in-vehicle travel time. So it indicate to place most emphasis on minimizing the passenger fare charge, waiting time at the stations, walking time to/from station,and also on enhancing the level of comfort and convenience to maximize the travelers' level of satisfaction.

It is also indicated in this research that the generalized cost of travel per trip is very higher for the public transportation at pick period of the time which makes the transportation system unsafe, economically unsustainable and expensive to the users as well as non-users. Among the selected modes AALRT has a minimum cost of travel per trip in the selected route while in contrast, Anbesa City Bus characterize by high generalized cost of travel. Here, it is important to notice that selecting the mode with the smallest value of generalized cost to travel per trip is equivalent to selecting the mode with the largest value of expected utility. So, public transportation users can use the mode with minimum generalized cost of travel per trip to maximize their utilities.

In general, it was envisaged that the finding of this research work will help to evaluate the current performance of the public transportation services in Addis Ababa city.

5.2. Recommendations

Based on the limitations and the finding of the research, the following points are forwarded:

- ❖ Even though the output of this research result found rational and plausible, the research work only include three modes of public transportation services and four explanatory variables to express the generalized cost of travel per trip. Therefore, in the future researches it is recommended to include all transportation modes and all the other significant explanatory variables like transit time, comfort and convenience etc. to make the study more reliable; and to give different mode choice in comparison of the generalized cost of travel per trip for public transportation usersas well as private vehicle users before commencing mobility from their origins.
- ❖ In this research work the data were collected only for three month but it is important to collect data for a long period of time in a more organized manner in order to minimize the variability of data and to produce a reliable generalized cost of travel per trip.
- ❖ It is recommended for passenger fare establisher to take into consideration all the explanatory variables of generalized cost of travel during passenger fare establishment to

make the passenger fare charge more rational and convincingly acceptable by users,not only consider the oil price in the international market and the route length of the journey.

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Appendix A: <u>Questionnaire</u>

Dear respondent:

This questionnaire is design to gather data to estimate generalized cost travel per trip for public transportation in the city of Addis Ababa. The response that you replay will only be used for this research purpose and I kindly request you to respond appropriately. I thank you for your collaboration.

1. Sex: Male ☐ Female ☐
2. Age:______________________________
3. Occupation:________________________
4. Family Size:________________________
5. Average Income per month in Birr:______________________________
6. Average number of trip per day: ________________________________
7. Which mode of public transport do you usually use?
   Anbesa City Bus ☐ Minibus taxi ☐ AALRT ☐ Private Car ☐
   other: __________________________________
8. Do you have a driving license? Yes ☐ No ☐
9. Trip making time of the day:____
10. Purpose of the trip: ____

In-vehicle travel time (Minute) per trip	Walking time (Minute) per trip	Waiting time (Minute) per trip	Passenger Fare (Birr) per trip	Generalized cost of travel (Birr) per trip

11. How much are you willing to pay an extra Birr to get a satisfied comfort and convenience?

…………………………………………………………………………………………...

12. Are you satisfied with the current public transportation service? Yes ☐ No ☐

Appendix B: Anbesa City Bus explanatory variables and generalized cost of travel per trip

in-vehicle travel time (Minute) per trip	walking time (Minute) per trip	waiting time (Minute) per trip	passenger fare (Birr) per trip	Generalized cost of travel (Birr) per trip
25	15	30	1.6	8.5
30	30	45	3.5	12
23	15	30	1.5	8
25	15	30	2.6	8.5
45	30	60	3	12
40	25	45	2.6	12
40	35	60	3.5	12
25	25	45	2.5	10
20	10	15	2	4.5
25	15	20	2.6	7.5
20	15	25	2.6	7.5
20	10	20	2	6
30	25	45	3	12
24	15	30	2.6	8.5
22	10	20	3.1	8
35	15	40	2.6	10
20	17	30	2.5	6
28	15	30	1.1	7
22	20	30	2.5	6
45	25	60	2.6	12
35	30	45	3.5	12
28	15	30	3	8
22	15	25	2	6

22	10	15	2	4
29	25	30	3	10
20	10	15	2.5	6.5
23	20	30	2.5	8
21	20	30	3	10.5
27	10	30	2.5	9
30	20	40	4	12
22	20	30	2.6	8
25	15	30	3.1	9
20	20	20	1.6	6.5
31	30	45	3	12
38	18	40	3	10
20	15	15	2.5	5
22	10	20	2	4.5
39	30	60	3.5	15
32	15	40	2.5	10
20	15	30	2	8
34	20	45	3	10
23	18	30	2.5	8
30	20	45	3	12
20	10	20	2	7
20	15	20	2.5	8.5
36	30	45	3.5	12
22	10	30	2.5	8
31	20	30	3	10
20	10	15	2	4.5
30	25	45	3	10

Appendix C: Minibus taxi explanatory variables and generalized cost of travel per trip

in-vehicle travel time (Minute) per trip	**walking time (Minute) per trip**	**waiting time (Minute) per trip**	**passenger fare (Birr) per trip**	**Generalized cost of travel (Birr) per trip**
40	25	35	5	10
20	20	25	4	6
18	10	30	4.5	8
20	20	18	4	6
35	25	20	4.5	8.5
18	15	10	3.5	5
25	15	25	4.5	7
25	20	10	5	8
18	10	15	3.5	6
20	20	30	4.5	7
22	10	20	3.75	6
25	5	20	3.5	6
40	25	35	5	12
45	30	45	6	15
15	15	10	3.5	5
30	25	45	5	10
27	20	40	3.75	8
20	10	30	4	8
18	25	40	5	10
30	15	40	4.5	8
30	25	40	5	10
20	5	15	4	7
30	25	35	5	10

20	15	30	5	8
25	10	30	4.5	8
18	15	25	3.75	6
30	25	35	5	10
20	10	15	3.75	5
18	15	20	4	6.5
30	20	15	5	9
16	15	20	3.75	6
25	15	30	4.5	8.5
20	10	15	3.5	7
20	10	30	3.75	7
40	20	35	5	11
45	20	40	5	13
20	5	15	3.75	6
25	10	25	4.5	8
30	25	40	5	10
25	30	30	5	9
20	5	15	4	6
16	10	20	3.5	5
30	15	35	5	10
16	15	20	3.5	6
20	10	10	3.5	5
20	10	20	4	6
20	15	18	4.5	6.5
25	20	10	3.5	7
40	25	30	5	10
25	15	25	4	8

Appendix D:AALRT explanatory variables and generalized cost of travel per trip

in-vehicle travel time (Minute) per trip	walking time (Minute) per trip	waiting time (Minute) per trip	passenger fare (Birr) per trip	Generalized cost of travel (Birr) per trip
18	15	10	2	3.5
23	30	20	2.5	6.5
20	20	13	2	4
20	25	15	2	4.5
18	15	10	2	3
19	15	12	2	4
24	20	15	2.5	5
22	15	18	2	4
24	25	12	2	5
22	20	12	3	5
20	15	15	2.5	4
23	20	15	2	5
24	25	15	3	6
24	30	18	3.5	7
20	15	15	2	4
24	40	18	2	7.5
22	25	15	2.5	6
20	20	12	2.5	5
22	25	10	2	5
23	30	15	3.5	8
23	25	18	3	7.5
20	10	12	2.5	5
24	30	18	3	8

18	10	10	2	3.5
20	15	12	2	5
22	15	15	2	5
21	15	10	2	4.5
21	30	18	3	8
25	30	20	3	10
22	20	10	2	5
18	25	15	2	5
24	40	20	3.5	10
20	15	15	2	5
25	40	24	3.5	12
19	30	15	2.5	6
24	30	18	3	8
23	20	15	2	4.5
24	35	18	3	9
20	25	15	2.5	6.5
18	15	10	2	2.5
22	20	10	2	4.5
25	35	22	3.5	10
18	15	10	2	2
18	10	15	2	2.5
18	20	15	2	4
22	30	10	2.5	5
20	20	15	2	4
20	15	15	2	4
18	10	10	2	2
20	20	10	2.5	4

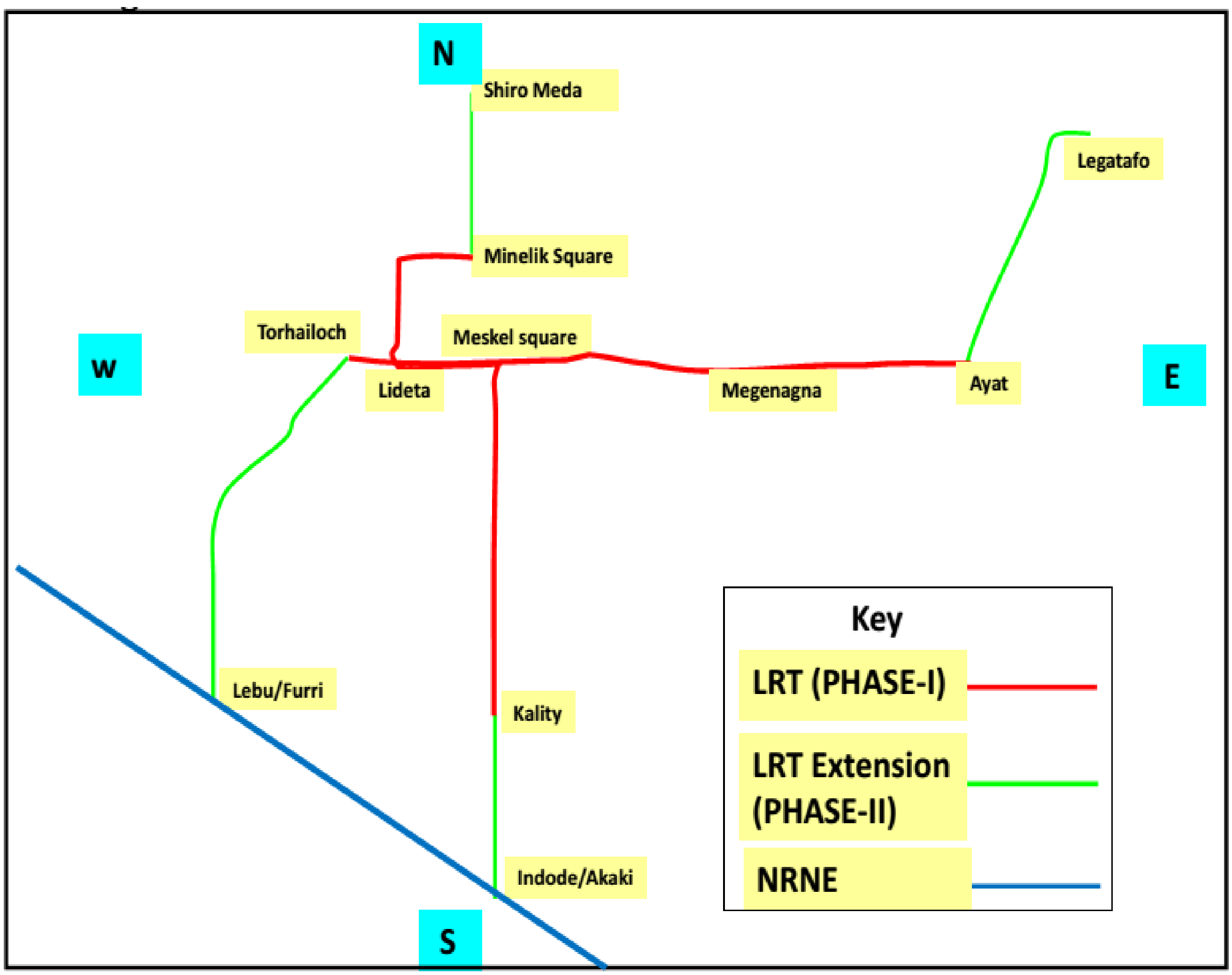
Appendix E: Registered number of vehicles in Ethiopia until June 30, 2008 E.C.

እስከ ሰኔ 30/ 2008 ዓ.ምድረስየተመዘገቡየተሽከርካሪዎችብዛት

Office	Total Number of vehicles registered
Addis Ababa	447669
Amhara	47036
Diredawa	16951
Tigray	28322
Oromia	88047
South	54090
Afar	4592
Somali	10678
Gambela	788
Benshangul Gumz	4600
Harar	5643
Total	**708416**

Source: Federal Transport Authority (2009 E.C.)

Appendix F: Addis Ababa Light Rail Transit (AALRT) Alignment with Extension



Source: Ethiopian Railway Corporation (ERC), July 2012.