ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING

ROAD & TRANSPORT ENGINEERING STREAM

Sustainability Assessment of Exclusive Bus Rapid Transit System -B6 Route in the case of Addis Ababa

A THESIS SUBMITTED TO ADDIS ABABA UNIVERSITY SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING IN PARTIAL FULFILLMENT OF THEREQUIREMENT FOR THE DEGREE OF MASTERS OF SCIENCE IN ROAD AND TRANSPORT ENGINEERING

BY

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ADVISOR

BIKILA TEKLU WODAJO (Ph. D)

OCTOBER 2020 E.C

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DECLARTION

I endorse that this research work entitled “Sustainability Assessment of Exclusive BRTS in the case of Addis Ababa city” has been carried out by me under the supervision of my research Advisor Dr. Bikila Teklu and has not been presented as a thesis for a degree in any university .All sources of materials used for this thesis have been duly Acknowledged.

Student name Tadesse Negash

Signature _____

ADVISOR

Dr. BIKILA TEKLU

Place: AddisAbaba Institute of Technology

Addis Ababa University

Addis Ababa

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ABSTRACT

This study aspires to explore Addis Ababa city mass transport improvement in the pre and post opening of the planned Bus Rapid Transit System (BRTS). This new system was proposed in order to improve travel time, waiting time, Comfort of commuters and also non motorized transport system (NMT) such as walk way, pedestrian crossing, dedicated biking lane facility assessment. The study explain that the system must be Exclusive (dedicated) lane at the centers of median and Bus rapid transit system (BRTS) without any intervention by general traffic. It is an innovation and it is up gradation to the present transport system.

Based on the multiple regression model results, Safety, Cost, Reliability, Comfort, Travel speed) explain 61.3% variability on the dependent variable (Modal shift for BRT). Reliability causes modal shift more than the other independent variables while travel speed exerts the lowest pressure on modal shift.

The one way ANOVA is used to test significant level for Reliability, Travel speed, Comfort, Cost and Safety to verify different modal shift in to BRTS in the study area.

Coefficient of determination (R^2) was about 0.613 while adjusted Coefficient of determination (R^2) the same and equal with Coefficient of determination (R^2) which was 0.613 from multiple regression model results. Safety, Cost, Reliability, Comfort, and Travel speed determine the level of BRT modal shift as follow. Modal shift for BRT = .675 + .155 Reliability + .048 Travel speed + .167 Comfort +.149 Cost + .314 Safety

For the modal shift to BRT, Reliability causes modal shift than the other independent variables while travel speed exerts the lowest pressure on modal shift.

Key words: - Bus Rapid Transit system, Urban transport, sustainable transport, modal shift, BRT commuter.

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ACRONYMS

AACRA	Addis Ababa city road authority
ERA	Ethiopia road authority
BTRB	Bus Rapid Transit
SPSS	Statistics package for social sciences
SP	stated preference
RP	Reveled preference
AACATO	Addis Ababa city administration transport office
MOT	Ministry of transport
BRTS	Bus rapid transit system
NMT	None motorized transport
AACPCO	Addis Ababa city plan commission office
ITS	Intelligent transport system
FTA	Federal transit administration
GTZ	Deutche Gesellschaft fur Internationale Zusammenarbeit
PT	public transport
AAU	Addis Ababa university
TRB	transport research board
AA	Addis Ababa
AAIT	Addis Ababa Institute of technology

CHAPTER ONE

1.0. Introduction

1.1. General back ground

Bus Rapid Transit system is explained as a accessible, very recital rapid transit mode that join a diversity of substantial, operating and system elements into a permanently integrated system with a quality image and unique identity. The main essentials of BRTS broadly include Running ways operating travel speeds reliability and uniqueness. The options available for running ways ranges from general traffic lanes to fully grade separated way.

Stations as the entrance point to the system are the single most important customer interface affecting accessibility, comfort, reliability, safety and security, as well as dwell times and system image. BRT stations options vary from simple stops with basic shelters to complex inter- modal terminal with many amenities (GIZ, 2013).

Modern world in urban transportation becomes advanced in to mass transport system than private car riding due to environmental pollution, congestion, safety, delay, mobility and accident. For sustainable development of urban transport different transportation technologies are applicable in the world. Now a day's Bus rapid transit (BRT) is the best urban transport system. Bus rapid transit can be exclusive BRT which mean segregated lane by provide ding the lane as a elevated platform and inclusive BRT means shares the lane with others general traffic or mixed with other traffic((BRT STANDARD, 2013).

Addis Ababa is the capital city of Ethiopia so that one of the most densely populated cities in the country and has a population of almost 7 million which is expected to rise to 10 million in 2030 (UN habitat, 2015). The city currently suffers from various impacts caused by lack of affordable, inclusive, efficient and safe transport mode for mobilization of its people. Insufficient malfunctioning old small buses and some informal Para transit against the demand of such an enormous population causes several externalities; congestion, accidents, air pollution, and climate change. Due to increasing pressure on public transport it has become necessary to pot for a more effective means of transport mode for moving passengers. So that to solve the problem of congestions and

provide a safe, affordable, comfortable and environmentally friendly the research must be conducted and solved by bus rapid transit system (BRTS) has to be introduced to Addis Ababa city. Among the 15 BRT projects B6 routs which is from Torehailoch up to Bole. (feasibilty study of BRT -B6 rout, 2019)

It is said that the lack of a good road system causes a country's wheels of development to be mired in mud. Addis Ababa's current economic and political status and future growth potential, an effective multi-modal transportation system, which includes both motorized and non-motorized forms of transport, is essential to supporting continued accessibility and mobility, as well as economic development.

Transportation and land use are closely linked aspects of urban development. Urban development, growth and infrastructure influence travel patterns and transport mode; for example, the spatial match of home and work, shopping and recreational activities determine travel patterns. These patterns are also affected by the quality of supporting infrastructure. The contours as well as the inner workings of urban transportation systems impact growth patterns, economic activity and performance, the environment and quality of life. Transportation is the means for making a city accessible for its residents; a well-maintained, multi-modal, efficient transportation system is essential to a healthy, sustainable city.

1.2. Statement of the Problem

All researchers are conducted to solve the problem and grant a solution for urban transport problem through the recent some decade. Over recent years, with very rapid population growth, density, traffic congestion, poor access to mobility, lack of improved transport system, lack of smooth traffic flow, air pollution, and land value escalation cause for mobility tumbles. There is pressure to seek effective means of moving passengers, to reduce travel time, to solve the difficulty of delay time and improve long queuing at intersection. In this study area there are about two main problems to solve by this study.

I. In order to identify the gaps of feasibility study to be sustainable in new proposed BRT-B6 route with respect to pedestrians and bicycles infrastructure, station, fare collection type and intersection treatment according to different literature done in different country. Addis Ababa city lacks safe pedestrian facility for walking at least up to 800m and also lack of pedestrian crossing with in optimum distance and traffic accidents are common during pedestrian crossing. There is no dedicated Biking lane and parking for bicycles at transit station and no bicycle locking facility for safety of the commuters.

II. Improve the existing public transport system and so that a number of passengers shift due to the implementation of the new system called BRT-B6 route especially private car drivers who drive due to lack of safe, comfortable, reliable, short travel time and low cost. The study assess the way of modal shift be relevant for the implementation of BRTS and through analysis identifying the outcomes of implementation of this new BRT system. Then evaluate performance of before implementation and after implementation of the new transport system. Investigation of feasible modal shift to the new system is base on the calculated willingness to shift as clearly pre stated mode choice.

1.3. Objective

1.3.1. The General objectives of study

The main objective of the Research is to assess the most appropriate BRT system relative to its transport demand and to provide the most convenient urban mobility for people to commence the public transportation system significant function in creating safe, sustainable, high level of service and equitable urban mobility in the case of Addis Ababa city.

1.3.2. Specific objectives

The objective of the study is to appraise the sustainability of BRT-B6 in Addis Ababa city. The Following are the specific objectives for the research study:

- Sustainability Assessment with regard to passenger's comfort on BRTS-B6 route in Addis Ababa city.
- To assess attitude of people for modal shift in to the proposed BRTS-B6 route based on their willingness to choice the mode.

1.4. Research Questions

It is necessary to answer the following research questions.

- How does BRTS-B6 route assessed with regard to passenger's comfort in the case of Addis Ababa city?
- What are the main factors for modal shift from the existing mode of transport to the proposed new BRTS-B_6 route mode for travel in the study area?

1.5. Significance of the study

The importance of this Research to the city of Addis Ababa is to select and provided the most suitable BRT system in the quest to continue to satisfy commuters regarding delay on travelling, service reliability, travel time, poor service condition, long waiting time at station and traffic congestion by public transport and also recommended to provided NMT system pedestrian walking, pedestrian crossing facility, dedicated biking lane, bicycle parking and bicycle locking facility.

By analyzing the modal shift of private car drivers, minibus, taxi and small bus vehicles due to the implementation of BRTS

- ✓ Reduce environmental pollution through emission from that much number of private cars, minibus, taxi and small bus vehicles due to shifting into the new implementation BRTS which is less in number and high capacity.

1.6. Scope and limitation of the study

1.6.1. Scope of the study

The research covers the area from tor Hailoch, Mauritania, Karl RA, pushikin R/A, Kera, Gotera IC, Welosefer R/A, and Bole that considers urban mobility to be reliable, safe and covenant to passengers in the city. scope of this study will be an in depth assessment and recommendation of the most appropriate BRT system which will be properly addressed by a theoretical history of BRT system and by gathering a lot of information to get an in depth knowledge of BRT in the world and then by a means of physical assessment and critical review of the literature.

1.6.2. Limitations of the study

Limitations of the study are listed as follow due to different uncontrolled factors.

- ➢ During conducting this thesis, the researcher stands with so much confronts such as lack of BRTS history in the city due to new public transport in the city. Scarcity of traffic data, stated and reveled preference questionnaires survey, literatures, local manuals, local BRTS institutes and so on due to new urban transport innovation in our country Ethiopia which make the study difficult.
- ➢ Passengers work and education trip are taken to study characteristics of workers and students but there are probability of having trip to picnic, church, mosque, to visit family or friends and so on.

1.8. Land utilization of Addis Ababa city

Land of the city is not managed properly for residential area, Schools, Governmental and nongovernmental office and commercial area. Commercial areas are most probably at the centers of the city but residential areas are all most at the border of the city that cause in morning at 7:00 up to 8:30 am and evening at 5:00pm up to 6:30 pm time traffic congestion, delay, very long passenger queuing due to shortage of transport and road access. Schools, Governmental and nongovernmental office are also at the center of the city which cause for the same transport problem. There for the best public transport must be planned and implemented to solve this problem in the city of Addis Ababa for near future (Addis Ababa city profile , 2017).

1.9. Population of Addis Ababa city

Population of Addis Ababa city is higher than other cities in Ethiopia since it is the capital city of the country. In the last census in 2007 the population of the city was about 3,384,567. As estimated in 2017 grow to about above 4,000,000 population and no updated census is known up to 2020 but expected to be about 10,000,000 populations.

CHAPTER TWO

2.0. LETRATUER REVIEW

2.1. Introduction

This chapter provides a detailed literature review on related background studies. such as journals of article, thesis desertion, work shop report, books, and different Addis Ababa city feasibility study concerning to BRTS, modal shift modeling, corridor selection, feasibility assessment, economic evaluation, environmental impact, accident safety, city land value and land use with respect to public transport sector in the urban area.

BRTS in every literature have been reported by assuming that organization, societal, economic, ecological, city forecast and different technical issues considered as it was nominal and obvious (Cervero & Kang, 2011))

(kaksu, 2015) By witnessing that in Asia-pacific region most countries show rapid motorization rate. The rate in extremely motorized countries, such as Australia, Japan, New Zealand and Korea were increased from 402-796 in 2014 to 417-819 in 2015 (number of vehicles per 1000 inhabitants), and a smaller amount of motorized countries, such as Indian, Pakistan, Philippines and Viet Nam increased from 20-36 in 2014 to 22-38 in 2015. This is why the increasing of private car has been front to traffic congestion which causes for environmental hazard for the city that cause for different economical loss, energy consumption, and air pollution.

2.2. Definitions ‘of Bus Rapid Transit system (BRTS)

As stated as follow in different literatures the definition of BRT and what BRT means.

Bus Rapid Transit system is means mass urban transport that supply best intensity of overhaul for commuters who travel in the city. Bus Rapid Transit System was planned for more reliable, comfortable and accessible urban mass transport mode. BRTS can be accomplished with minimum cost than building LRT system as examined by a document (Bulgaria, 2012).

(Rogat, et al., 2015) Define as that Bus Rapid Transit (BRT) is a successful continuous transport ways that can support shifting from passenger car to the BRT system. BRT is also a means of providing more excellence and capability transport services in order to build a sustainable transport –based future. Before implementation BRT system different obstructions must be overcome such as financial, political and having the required technical knowledge in place makes the implementation of it due to capital project must be feasible and successful.

As stated (Ashim, 2008)BRT system can be explained as an Exclusive (closed) BRT system in which the lane is restricted or dedicated only for buss while inclusive (opened) BRT system in which the lane is kept open for all existing bus operators. The benefit of dedicated infrastructure is distributed to all operators.

- As stated by (Chaurasia, 2014)Bus rapid transit (BRT) is a rapid mode of transportation which can be provided the quality of rail transit and in addition flexibility of bus and cost of bus to buy. It offers early advantages to overcome problems of public transport and incremental implementation in phases.
- Following are the most important features and elements of an efficient BRT system: (Chaurasia, 2014) (The federal transitAdministration(, 2010)

2.3. Features and Benefits of BRT system

(Wright L. , 2002)) Show that Bus Rapid Transit is a system that gives attention of priority for the BRTS through guarantee for the given buses with in the given runway. The Curitiba and Bogotá BRT have achieved this objective with the aid of the following design features: operating the buses along dedicated lanes, and introducing exclusive stations and off-board fare collection.

(Darshini M. & D, (2013) As explained the features of BRTS as follow exclusive travel ways, modern station, modern buses, rapid services, automated fare collection, ITS technologies and lower costs of transport must be fulfilled in every BRT system.

Table 1 communal and financial

class	explanation
financial	➢ abridged journey times ➢ extra reliable manufactured goods liberations ➢ enlarged financial efficiency ➢ enlarged service, enhanced work situation
community	➢ further fair right of entry all over the city ➢ abridged mishap and injuries ➢ better public conceit and intellect of society
ecological	➢ ecological abridged releases of air toxin ➢ Reduced sound
city appearance	➢ supplementary maintainable urban form, as well as densification along main corridors abridged cost of transport navy such as current, water and hygiene

(commmite, version 2.0)) (commmite, version 2.0)) Benefits of BRT system

Source ((Devarshi & Chaurasia, 2014)

Bus rapid transit (BRT) is a bus founded mass transit system that delivers fast, comfortable and Cost-effective urban mobility. Through the provision of elite right of way lanes and excellence in customer services which is essentially emulates the performance and amenity characteristics of a modern rail based transit system. (commmite, version 2.0)). Bus is an essential transport mode in providing mobility in the city (t, 2016).while the term BRT may vary from country to country but the same basic premise is followed. A high quality, car-competitive transit service at an affordable cost for simplicity the term BRT will be utilized in this context today, the BRT concept is becoming increasingly utilized by cities looking for cost effective transit solutions. As new experiments in BRT emerge, the state of the art in BRT will undoubtedly continue to evolve. Nevertheless, BRT's customer focus will likely remain its defining characteristic. (GTZ sources book, 2011)

As define by (Levinson H., S, ClingerJ., & Gast J., 2003)Bus Rapid Transit System (BRTS) is a flexible, rubber tiered rapid transit mode that contains stations, vehicles, services

patterns, Bus ways, and intelligent transportation system (ITS) elements into an integrated system with a strong positive image and identity.

The federal transit Administration (chrchr, 2015) stated that Bus Rapid Transit (BRT) as "a high quality bus-based transit system that delivers fast and efficient service that may include dedicated lanes ,bus ways, traffic signal priority, off board fare collection, elevated platforms, and enhanced stations." And the advantages of BRT include reductions in average travel time, enhance reliability, increase average travel speed, reductions in fuel consumption, emission, and improve customer experience.

2.4. SUSTAINABILITY ASSESSEMENT OF URBAN TRANSPORT

- (Honolulu, Hawaii November 2012) stated that sustainability assessment structure was the methodological guide for developing a sustainability assessment tool. The sustainability assessment devices accommodate five vehicle types. It was applied to transportation corridor to assess three vehicles mix scenario based on its demographic and transportation characteristics. This sustainability assessment is practical flexible and adaptable to different vehicle types and to future technological developments. (LutfiPrayogi & LutfiPrayogi, 2018) Explores that their private vehicle drivers shifting their mode of transport in to BRT system for same kind of trip and attempt to design an appropriate BRT passenger's modal shift evaluation which are passengers-friendly built environment qualities principles under transit-oriented development framework.

2.5. Types of BRT Station

From the document (Lloyd Wright, 2005) point of view Bus Stations are grouped in to three types; easy Stops, junction Stations and major road Stations or Terminals.

Station must have shelters for passengers to protect from sun shine and rain as shown in the figure including sufficient space and penning.

Figure 1 station of BRT
Source: from Internet

2.6. **Location of BRTS Stops**

(Lloyd Wright, 2005) A major part in humanizing bus transit effectiveness is end location. End places can be with reverence to a warning sign: nearside, far side, or mid-block. BRT systems with active signal priority and queue jumpers should place terminals at the far side, permitting for efficient use of these measures. It also clears the bus through the intersection with minimal delay. If the terminal was on the next to side, queue athletes would be not be used, and the bus would have to combine with queue traffic on the curbside lane for the stop. Consequently, the bus would be delayed by at least one signal cycle. Mid-block stops are not commonly used; however their location has no advantage and disadvantage in terms of signal priority and queue jumpers. Effective stop location helps to minimize travel time of passengers, which is essentially the goal of BRT. (Lloyd Wright, 2005)

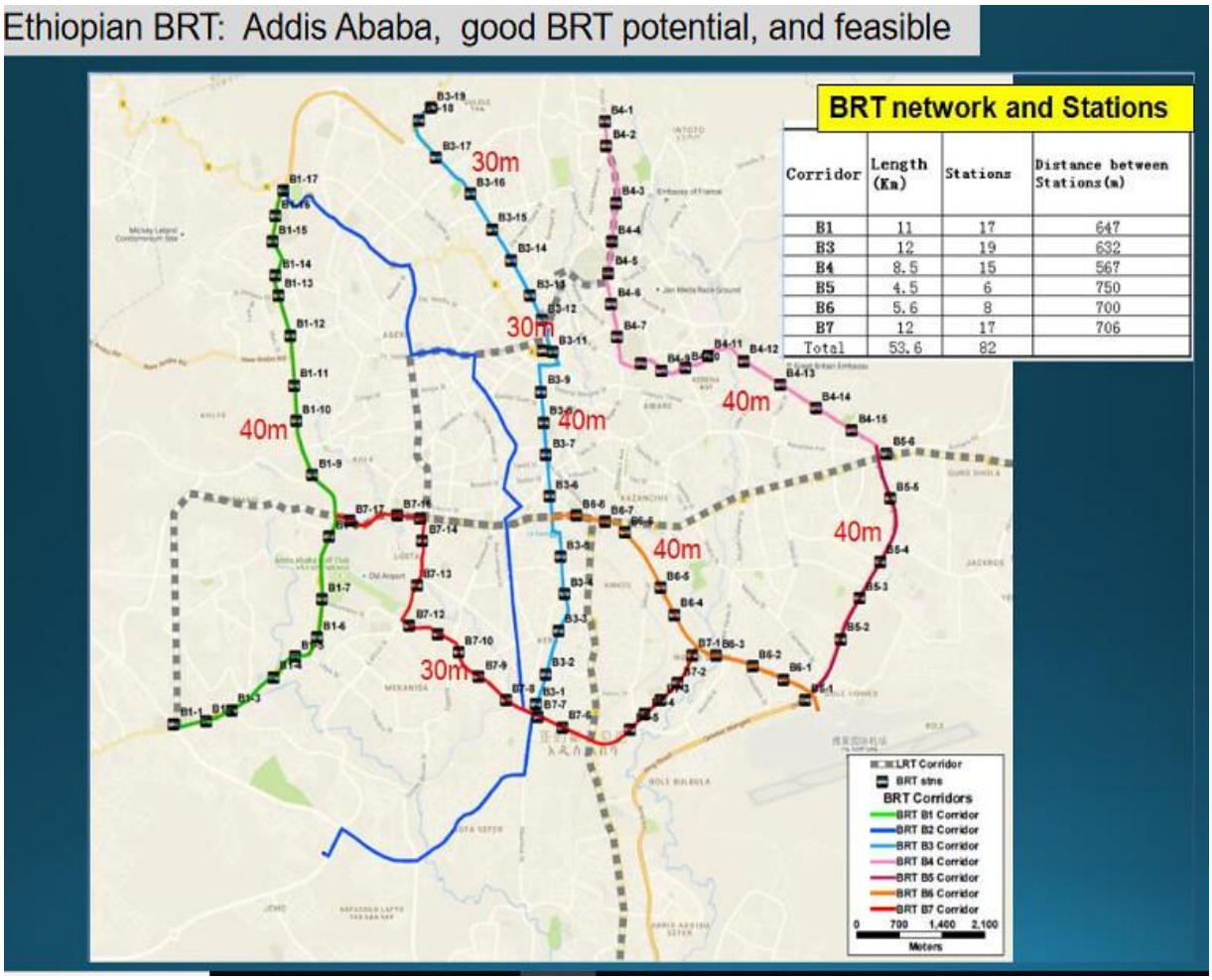


Figure 2 BRT network and station
Source: Addis Ababa city BRT FS Report

2.7. Bicycle facility

From Lloyd Wright (A, module 3b 2014) point of declaration the bicycle facility include bicycle lane, bicycle parking and bicycle locker are common. The provision of bicycle infrastructure serves a purpose similar to that of pedestrian access infrastructure. Namely, bicycles are an important feeder service providing client admission to the transportation system.

Most clients will believe the mass transport system a viable option if it is within certain time budget of their home. For instance, individuals may consider a time travel budget of 20 minutes is adequate in attainment at BRT station. Bicycles are capable of covering a distance five to ten times greater than walking in the same time period. Thus bicycles present the opportunity to increase ones effective customer catchment area by 25 to 100

times (since area is the related to the square of the distance traveled unfortunately the lack of adequate cycle ways and bicycle parking at stations means that many systems forgo this profitable opportunity.

Figure 3 bicycle parking by lock ring at BRT station
Source: Module 3b BRT Sustainable Transport

The bicycles are parking when the passengers arrive at bus station to travel with Bus rapid transit but bicycle must be available to bike from passenger's residential area to the BRT station at the same time from BRT station to the passenger's home. Unless otherwise public bicycle must be provided to the passengers to have bicycle without any fare and traveling with bicycle and then living it at anywhere but bicycles are collected by using GPS from where it was parking by passengers (A, module 3b 2014)

Figure 4 bicycle parking at BRT station
Source: Module 3b BRT Sustainable Transport

2.8. Pedestrian Facility

Addis Ababa city has 5 major arterial gate roads that radiate from the city center to different parts of the country. The five regional gate roads of the city and other arterial roads are linked to each other by the 8 lanes ring road that circumscribes the city. The Addis Ababa road network has increased from 2,200km in2005G.C as stated in her thesis (Meron, 2007) and then up to 2,675km as stated (Assegid, 2010)of that about 42.75%is paved asphalt or around 1136km and also the remaining 57.25% which is about 1521km gravel surfaced road, among the total area of city built up 10% is the road network areas Assegid (2010) as stated.

The pedestrian facility includes pedestrian walk way, pedestrian crossing facility, and sufficient space at Bus station during waiting for bus is the most important pedestrian facility that gives attention during public transport planning Assegid (2010).

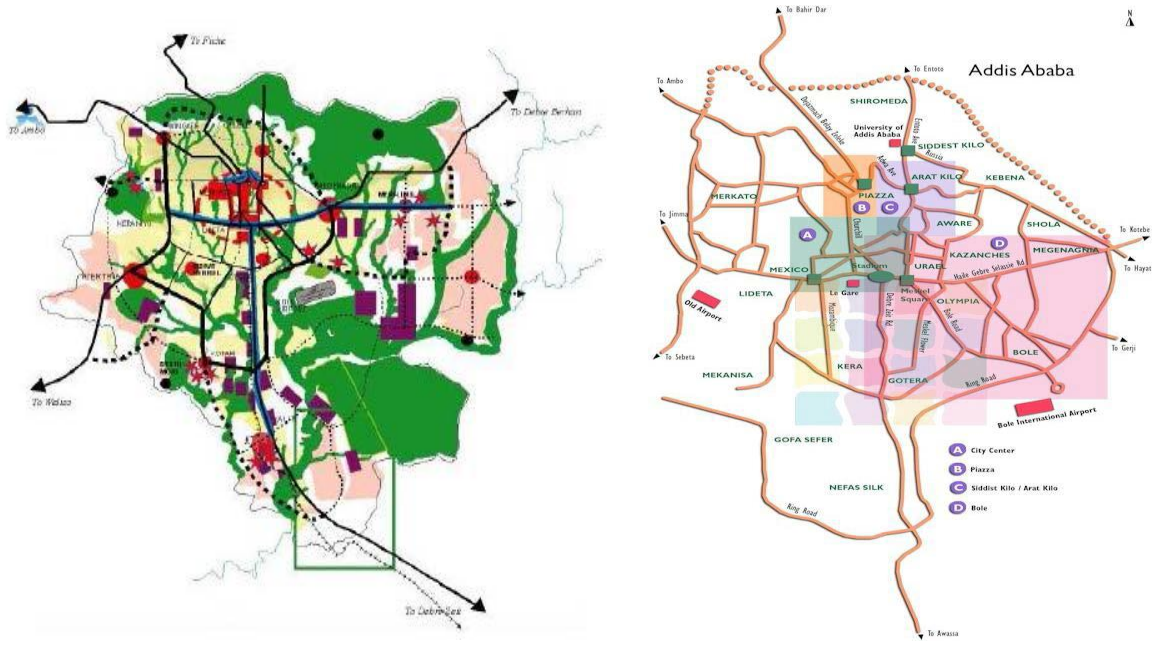


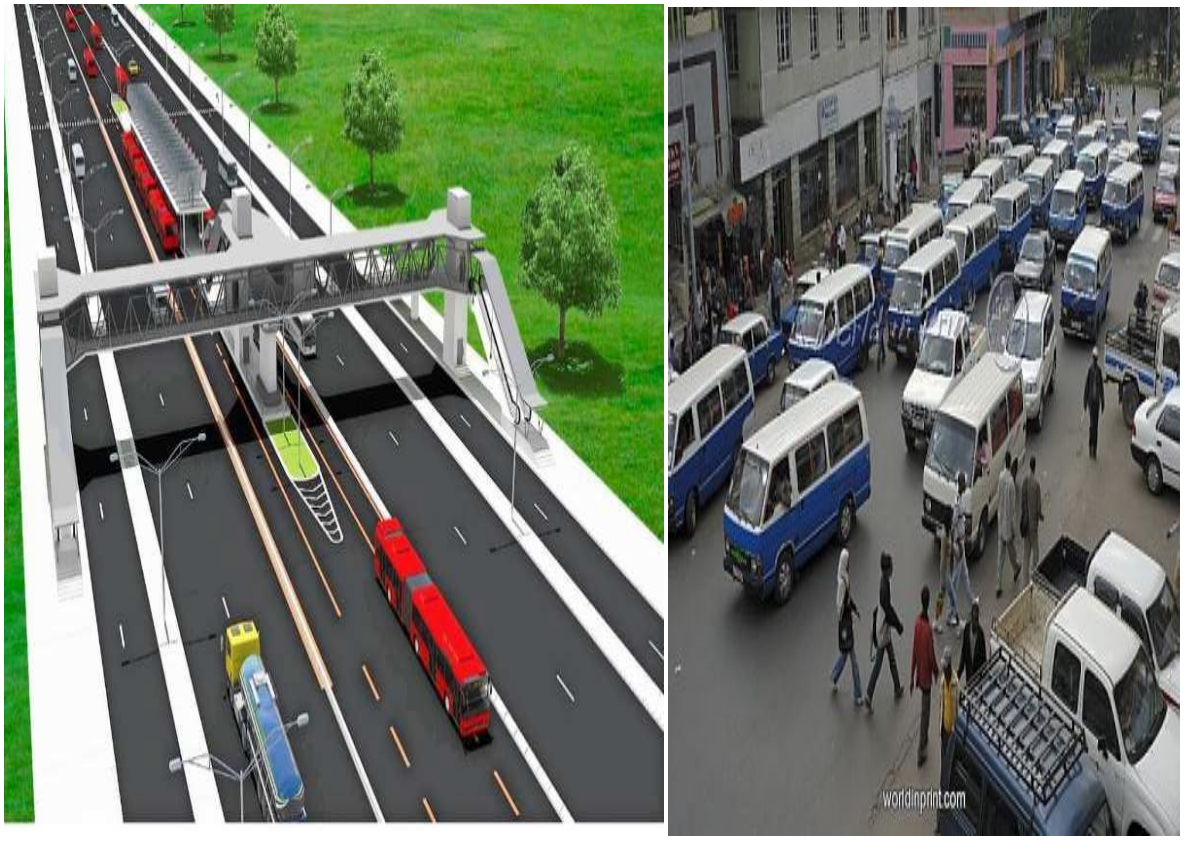
Figure 5 pedestrian facility of Addis Ababa city
Source: FantahunTesfaye (2012)

Table 2 Addis Ababa city road network and pedestrian walkway coverage as of 2010

Road hierarchy	Length of varying Width(km)	Length of 7m width (km)	Road condition	Pedestrian walkway		
I)Asphalt roads				Left side(km)	Right side(km)	Total
Arterial	344	552	Very good	73	58	131
Sub arterial	116	167	Very good	63	57	120
Collector	174	209	Good	55	55	110
Local	208	208	fair	13	13	26
Total	630	1136		204	183	387
II)Gravel Road		1521				
Total		2657				

Source: Assegid G. (2010) Urban Road Infrastructure

How much it is expensive either the pedestrian over pass or tunnel at grade which means under pass at grade for BRT routes are the most important issue to be keep the pedestrian safety as well as to attain the BRTS maximum level of service in the give route segment. So that at every bus station pedestrian passing either over pass or underpass that given traffic is critical cause during urban transport planning in every aspects as stated by **(Ishtiaque & warda, 2017)**.



Safe over passing unsafe pedestrian crossing facility

Figure 6 Safe over passing and unsafe pedestrian crossing facility
Source:Ishtiaque Ahmed,Noor-E-Alam & Faizuna Warda (2017)

As Lloyd Wright (module 3b) stated that if the pedestrian facilities such as walk way, pedestrian crossing are not convenient or not easy to travel to a BRT station, then the other qualities of the system become somewhat irrelevant. Without adequate access to stations customers will simply not utilize the system. The walking environment is a key determinant in whether the transit system is of use to the customer.

The development of dedicated pedestrian zones around a BRT station can be mutually synergistic for both the pedestrian and public transport systems. The BRT system helps to improve the requirement of costly car-based infrastructure in the city center. The dedicated pedestrian zones provide a concentration of customers that can feed directly into the BRT system. Curitiba, Brazil is a leading example of integrating dedicated pedestrian zones with its BRT system.

Figure 7 dedicated pedestrian walkway
Source: Lloyd Wright (module 3b) BRTS Sustainable Transport

2.9. BUS RAPID TRANSIT SYSTEM (BRTS) AND ITS BASIC ELEMENTS

Common bus rapid transit systems (BRTS) are a good possibility to the community of the city. It has been looking for new and innovative approaches to deal with growing metropolitan overcrowding and linked greenhouse gasses while providing competent and successful transport options. Adding more high ways is expensive and disruptive; and is not forever an environmentally noise way. However, light rail transit systems, of interest to many communities, needs a important preliminary assets investment, and possibly will not be an successful solution for all city transport troubles. Transit buses provided an essential transport service in urban areas, but are often viewed as low and unreliable. One inventive way is the utilization of buses rather than light and heavy rail in an integrated, well-defined system with design features similar to LRT (MTS, 2001).

BRT becomes popular now a day's around the world due to rapid population growth and demand of people for travel.

As developed by (Weinstock A., Hook W., M., & R, 2011) a representation of tiered score ranking by using the BRTS performance. The BRT standard permit BRT systems to be classified as gold, silver and bronze based on commuters travel time, LOS, speed, capacity, comfort, cost environmental impact and so on.

According to Institute of Transportation and development policy (Z, 2007)a total score of 85 and above BRT system classified as gold, a score of 70 to 84 as silver and a score of 50 to 69 as bronze.

Now a day, BRT is becoming increasingly utilized by cities looking for cost- effective transit solutions.BRT systems are designed with an objective to swiftly efficiently and cost – effectively more peoples rather than private vehicles. BRT tries to deal with the deficits of the previous public transport system by given that a rapid more superiority, secure and protected transit options. (Wright L. , 2007)

2.10. The basic components of BRTS

Those all are criteria to be the public transport measured with respect to service level wise classified as Golden, silver, bronze according to their order of excellence by providing the best service for passengers by improving those listed in the table below. According to (Kumar1, Vikranth, & Chaitanya, 2015)

Table 3 the basic components of BRTS are summarized as follow in the table.

No.	The basic components of BRTS as stated by (Kumar1, Vikranth, & Chaitanya, 2015)
1	Running ways,
2	ITS,
3	Fare collection,
4	Level boarding
5	Service and operational plan
6	Segregated bus ways
7	Rapid boarding and alighting
8	Clean ,secure and comfortable stations and terminals
9	Bus signal preference
10	Traffic management improvements
11	Dwell-time
12	Station

2.11. Running ways (guide ways are a BRT system)

It is the main and basic infrastructure that provided for BRT system excluding the general traffic for the purpose of rapid passing the road which contains protection or guide ways in the given road section at a time. it can be designed at the centre of the general traffic with two way right and left lane that is better to be exclusive which mean without interference of general traffic and pedestrians (Levinson H., Zimmerman S., ClingerJ, & Gast J., 2003)

2.12. Intelligent transportation systems purchase

Intelligent transportation system is managing the centre tracks of an overall activates of the whole buses and stations to improve the number of passengers waiting at station due to fluctuating of bus operator. Intelligent transportation system convey information to the bus at everywhere from passengers. It is important to give priority to the bus traffic signal and bus location can be informed to the passengers through mobile phone software explained by (Hineaugh, Wrght, & Hook, 2009 ,2007)

2.13. Fare collection

Paying a fare for BRTS in traditional method at the door by any means of payment either by cash or by fare card is time intense that can take about 5 second up to 9 second per each passenger which causes congestion, delay and it take long time because of high number of passengers' are waiting the bus in peak time of the day. The best way of fare collection is completely off-board fare collection that can be authenticate smart card at station, buy proof-of –payment ticket from machine by using coin or smart card, on any on board fare collection and interaction with bus operators, outstanding for high-ridership lines with stations as studied by (Devlin, february 2017)

Smart card and coin devices passage's without drives interaction

Figure 8 types of fare collection
Source: (Gang & Dong, 2012)

Fare collection for BRT is a combination of fare collection system of a ticketless system magnetic trip technology and smart cards (Gang & Dong, 2012)

Fare collection can be classified in to two off board fare collection and on board fare collection. Off-board fare collection is one of the necessary factors in reducing travel time and improving BRT passenger experience. On board fare collection is purchasing the tickets by the passengers while fare before boarding and validate it on the bus through rapid electronics readers at all doors as explained by (Carrigan, Wallerce, & Kodransky, 2019)

2.14. Level boarding

Level boarding is at bus station platform level with the bus floor to be comfortable to reduce boarding and alighting times for each passenger. Since any steps which seem easy to youngsters to climbing may be difficult to elders and disabled passengers with stroller or suitcases. So that removal of the vehicles to the platform gap important to passengers safety and comfort there for station platform must be at the same heig ht as bus floors, regardless of the given height.

BRT vehicle operate primary in fast and easily identifiable exclusive at-grade transit ways, grade separate ways.

Figure 9 level boarding
Source interent

2.15. Dwell-time

- Dwell-time is the time takes at bus station during stopping to load the passenger or to unload passenger that can be comprise up to the next bus travel time with conservative front- door of bus boarding. (Gupta K, A, V, & M, 2014)

2.16. Station

The BRT stations assortment from improved protections to large transit centers are smart and simply available. It must also suitable place and incorporated in to the city system. The BRT stations assortment from improved protections to large transit centers are smart and simply available. It must also suitable place and incorporated in to the city system.

The best practiced station is show as follow in figure 10.

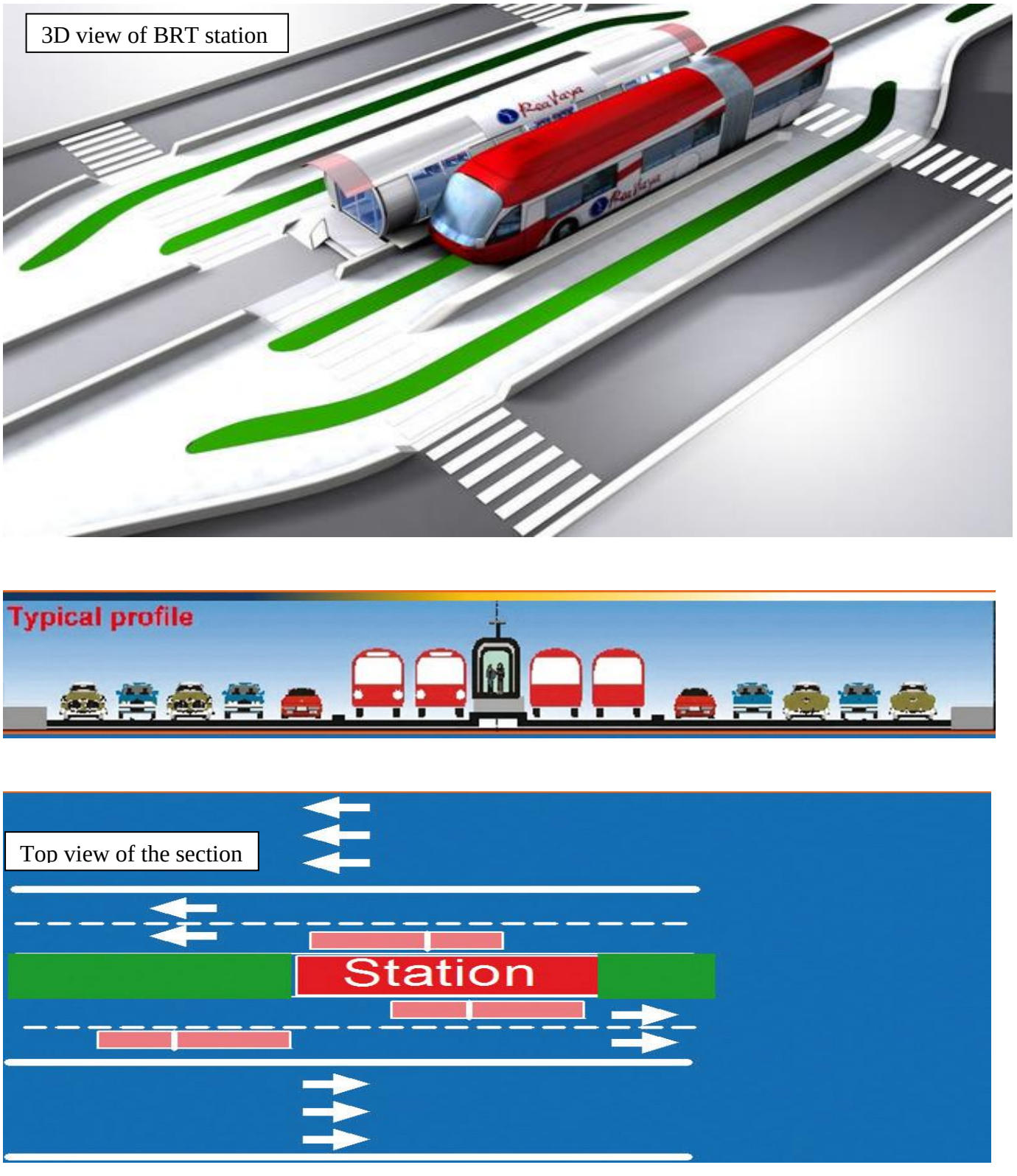


Figure 10 BRT station
Source Wright, 2017 as follow

2.17. Types of BRTS tariff

BRTS may charge either flat fare or zonal fare which mean distance based fee. In the world studies were conducted on the 31 high –end BRTS indicated that about 28 BRTS fee is flat which means no need of tariff difference between origin and destination of the BRT system the same toll through the route. The other one is zonal fare which means the fee depends on distance traveled by the passengers. BRTS fares are usually affordable by low income residents than private car operator's fee. ((Cervero, 2011)

In most countries in the world the about one US dollar is most probably enough an entire the whole day for BRTS fares.

Pre board fare collection and fare verification is popular around the world such as Latin America, Asia, United state of America, Europe and France are countries that on pre-paid ticketing with barrier free and proof of –purchase inspection for their BRT systems (Cervero R. , 2013).

2.18. Grading the BRTS according to their service quality standard

As stated by **(Breithaupt & Martins, 2014)**

1. Gold-quality standards which must be score above 85 points
2. Silver quality standards which must be score above 74-84 points
3. Bronze quality standards which must be score above 55-69 points

2.19. The followings are checking points allocate for each type of quality scale

2.19.1. Fundamental BRT components

Table 4 the fundamental BRT components

No.	The fundamental BRT component (14-23)	Allocated points
1	Dedicated right of way (runway)	8
2	The bus way alignment	8
3	off-board fare collection	8
4	platform-level boarding	7
5	intersection condition (level of service)	7

2.19.2. The service quality

Table 5 the service quality

No.	The service quality (24-30)	Allocated points
1	Multiple Route	4
2	Express, limited and local service	3
3	Control center	3
4	Located in top ten corridors	2
5	Demand profile	3
6	Hours of operation	2
7	Multi-corridor net work	2

2.19.3. Access and integration

Table 6 Access and integration

No.	Access and integration (44-49)	Allocated points
1	Universal access	3
2	integration with other public transport	3
3	pedestrian access	3
4	secured bicycle parking	3
5	Bicycle lane	2
6	bicycle sharing integration	1

2.19.4. Infrastructure

Table 7 infrastructure

No.	infrastructure (31-36)	Allocated points
1	Passing lanes at stations	4
2	minimizing bus emission	3
3	station set back from intersection	3
4	center stations	2
5	pavement quality	2
6	distance between stations	2
7	safe and comfortable stations	3
8	number of doors on bus	3
9	docking bays and sub-stops	1
10	sliding doors in BRT Station	1

2.19.5. Communications

Table 8 Communications

No.	Communications (pp 42-43)	Allocated points
1	Branding	3
2	passenger information	2

2.19.6. Access and integration

Table 9 Access and integration

No.	Access and integration (44-49)	Allocated points
1	Universal access	3
2	integration with other public transport	3
3	pedestrian access	3
4	secured bicycle parking	3
5	Bicycle lane	2
6	bicycle sharing integration	1

2.20. Point deduction

The main advantages of BRT in the city (as stated by Wright, 2007 as follow)

1. Economic advantages
    - Reduced travel time
    - More reliable product deliveries
    - Increase economic productivity
    - Increase employment
    - Improve work condition
2. Social advantages
    - More equitable access throughout the city
    - Reduce accidents and illness
    - Increase civic pride and sense of community
3. Environmental advantages
    - Reduce emission of pollutants related to human health such as CO, SOx, NOCx, CO2 and particulates
    - Reduced noise levels
4. Urban form advantage
    - extra sustainable metropolitan structure , including densification of major corridors
    - Reduce cost of conveying services such as current ,sanitation, and water

2.21. City transport forecast with respect to travel mode

The city transport can be planned in to three stages pre-analysis stage, scientifically analysis stage, and post analysis stage. (hanson, 1995).shown as follow

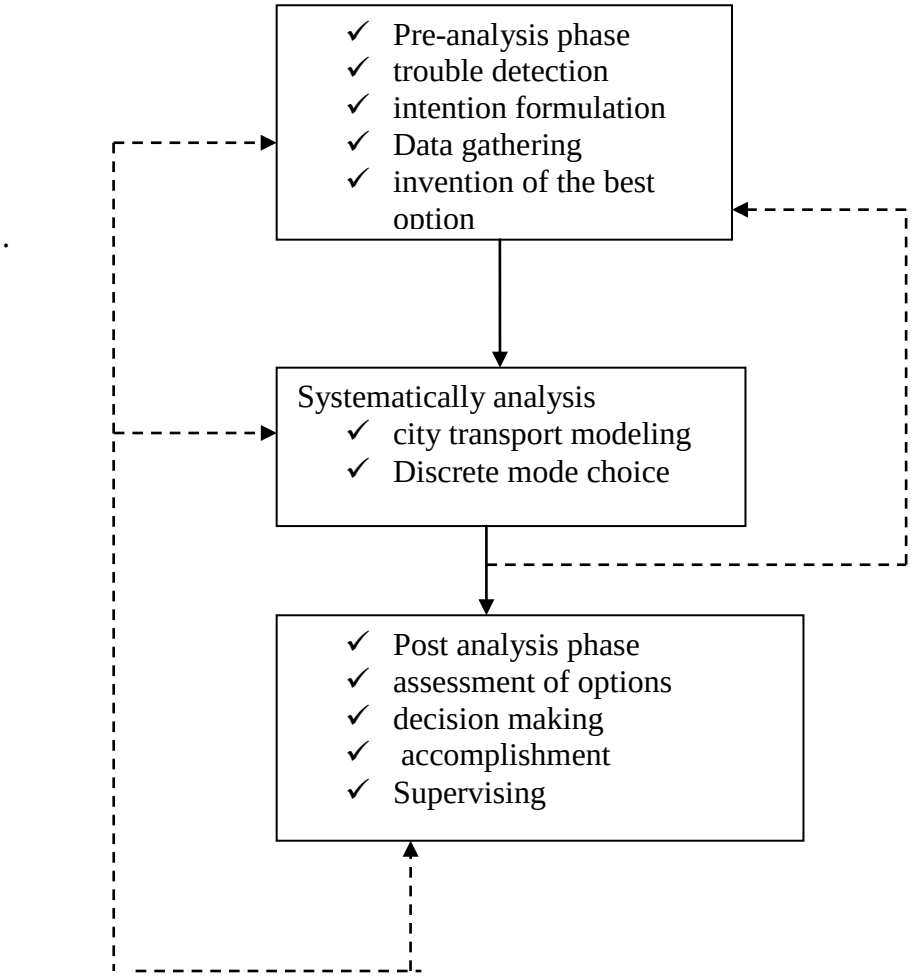


Figure 11 urban transport forecast with respect to travel mode

2.22. Performance evaluation of BRTS

As this study assessed from different literatures the performance of BRTS is measured by operating speed, levels comfort, safety, ecological pollution and equitable access to all population groups are the major measures of the performance of BRTS (Hildalgo & Graftieaux, 2008).

- ✓ BRTS is measured by fast in rapidity with less time which is called Operating speed that means without mixed traffic due to an introduction of tunnels, grade separation at intersection, BRTS with at-grade crossing (Hensher & Golob, 2008).

- ✓ Comfort the most criteria for passengers to shift their mode in to the comfortable one (Yazici, Levinson, Ilicali, Camkesen, & Kamga, 2013.).
- ✓ Safety is the critical issue in any transportation system in the world from different research point of view center –lane patterns, left turn exclusion and signalized mid-block pedestrian crossing s with protection islands considerably improve safety on corridors where BRT drives (Duduta, Hildalgo, Linda, & Santos, 2013).
- ✓ ecological pollution by considering the an indirect shock the net air quality pollution on BRTS is positive by avoiding cars from urban roads and changing in to low emission of carob in to atmosphere (Wöhrnschimmel, Zuk, Martinez-Villa, Cerón, Cárdenas, & Rojas-Brancho, 2008)
- ✓ BRTS must desire to include all population groups by low cost, more inexpensive mobility choice to serve downtown financial groups and economically advanced groups (Penalosa, 2002).

2.23. Mode choice or modal split

When we compare modes of transport classifying as public transport and private transport is more efficient road space user is public transport than private transport and provided social benefits when passengers travel together, less congestion on the road, less accident occurrence, low cost of transport, proper use of fuel and oil. But private transport is more flexible, comfortable, and convenient for passengers to travel and good access for use at any time and place. There foe mode choice is an important way in transport planning and policy making so that models that can be developed must be sensitive for passenger to travel feature which influences an individual mode choice as stated by (Alphone, 2008).

2.24. Feature that affect mode choice

Factors influencing mode choice are more and difficult to count all of them in transport modeling but there are about three major groups as declared by (Ortuzar, de, D, Willumsen, & G., 1999).

a. Travel behavior (which are very important)
   - ✓ Private cars availability, having driving license
   - ✓ Household structure (young couple, couples with children, retired, singles, etc) income decision made for example the need to use the car at work, take children to school, residential density.

b. Trip behavior (mode choice is strongly influenced)

- ✓ Time of the day during the travel which mean late is more difficult to accommodate by public transport
- ✓ Travel plan for example trip to work is easier to accommodate public transport relative to travel other purpose due to work is reliability.

c. Service behavior

- ✓ Quantitative factor such as travel time to transport stations by walking, travel time by vehicle, waiting time , costs such as fares, fuel cost and direct costs
- ✓ Qualitative factor which are comfort, convenience, reliability, safety and so on.

CHAPTER THREE

3.1. RESEARCH METHODOLOGY

The research approach can be reveled preference survey and stated preference survey according to the research procedure and methods of information gathering and analysis and interpretation.

It is based on the mode choice and modal split hypothesis from statistics data analysis way. However, the analysis of the study has a propensity to mainly tip on quantitative data in creating arguments.

3.2. Description of the study area

The research location is at Addis Ababa which is the capital city of Ethiopia. That is only 134 years old. It is the most active commercial city in the country generating as 65% of national internal revenue. It covers about 527 km^2 of the total coverage of the country. The population density is estimated to be near 5,165 individuals per square kilometer available. Administratively the city is divided in to 10 sub city and 116 districts (weredas) wraps about seven sections starting from Tor Hailoch –Mauritania (Length about 1.27km), Mauritania-karel (Length about 1.385km), karel-pushkin (Length about 1.385km), pushkin-Gotera, (Length about 1.3km), Gotera-wengelawit, (Length about 1.13km), wengelawit-welosefer, (Length about 1.54km), welosefer-bole (Length about 2.00km, Bole-Cameron, (Length about 0.26km). (korea exim, 2019)

Figure 12 BRT-B6 route maps
Source**:** BRT-B6 FS ground plan

3.4. Study Approach

This study is based on the case study methodology by assessing sustainability of BRTS-B_6 route in Addis Ababa with in optimum standard in to two parts

I. BRTS-B_6 route appraisal based on BRTS standard perspective by evaluating the feasibility study of the route to confirm system reliability, convenience, access, service quality, travel time, waiting time, travel speed, safety of passengers, comfort, ecological impact, equity, down economic passengers inclusive in cost, vehicle aesthetics, station length and fare collection way. Those all are criteria to rank BRTS as gold, Silver and bronze deepening on the quality of each element fulfill in a given BRTS route.

II. Analyzing the modal shift of the existing transport mode especially private vehicle drivers to identify how much of them drive to keep their social status who are not shift by any mean in to the new merging mode BRTS. On the other hand how much of private car drivers shift in to the new mode due to improvement of basic passengers interest such as reliability, convenience, access, service quality, travel time, waiting time, travel speed, safety, comfort, ecological impact, equity, cost of fuel , vehicle aesthetics, station length and fare collection way, parking space. And then based on the result of the analysis of the selected binary logistic model the conclusion is drown and finally the solution for the result is recommended for the best mass transport of the city.

3.5. Option of transport mode in BRT-B6 route

The access of options at the route for BRT-B6 route is private vehicle, taxi, sheger buses, Anbessa bus, the blue bus and higer bus. So that modes of transport which was considered in the analysis to develop the model are those all listed in the above but private car drivers are the most objectives of the study.

3.6. The necessary data needed for the analysis of the study

- ✓ Private information such as gender, gender, household income, vehicle availability, work condition and household size that can be provided information of their socio-economic behaviors of the passengers.
- ✓ Journey behavior such as travel time, mode type, travel cost, waiting time, and travel distance which shows their socio-economic history of private and journey behavior.

- ✓ BRTS behavior such as comfort, safety, consistency, expediency, convenience and speed.
- ✓ Stated preference (SP) information which means willingness of the passengers to shift in to the new BRTS from the existing transport mode which uses to make decision to choice characteristics of private passengers for hypothetical options.
- ✓ Revealed preference (RP) information which means unwillingness of the passengers to shift in to the new BRTS transport rather stay as existing transport mode
- ✓ Statistical Model selection which can confirm to the study base on the given data that can be analyzed by multiple regression model using SPSS.

3.8. RESEARCH DESIGN

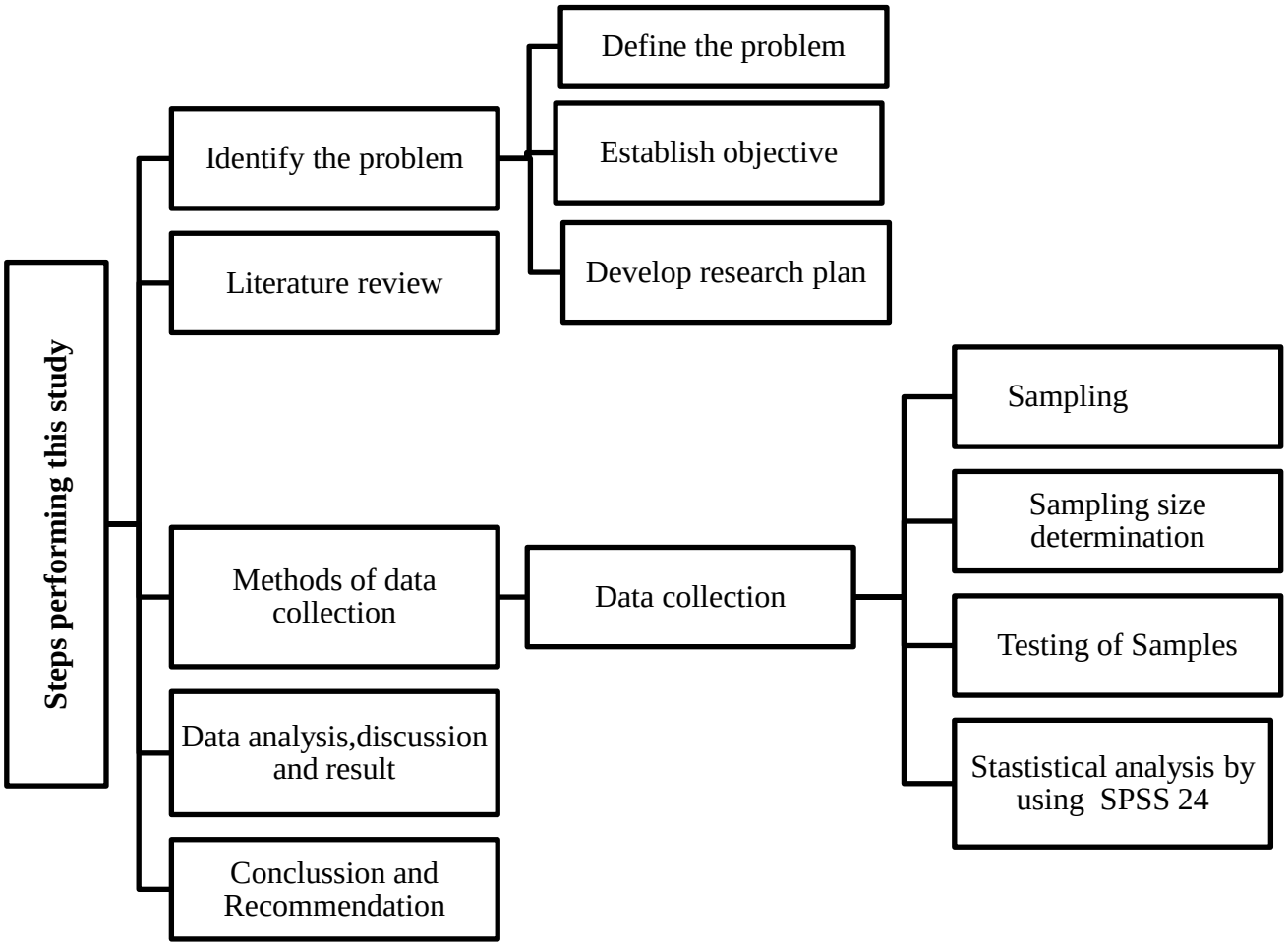


Figure 13 Research design
Source from the study

3.9. Data Types and Sources

Sources of data needed for conducting this research are primary data and Secondary data that were gathered accordingly. Primary data is collected directly from the field or from the data source. Those data was collected through face to face interview these stakeholders who works at AACATO were preferred due to their interaction with the surrounding. They may be face up to new ideas that have important sustainable assessment BRT due to their ordinary sense. The survey period was free from holidays and schools were open to representing normal traffic pattern.

3.10. Data Collection Techniques

As stated by Yin, R. (2003) perspective and approach the researcher have to choose data collection method. But the data or information collected by the researcher may be primary data or the researcher collects the data by himself or herself and secondary data or before now documented materials by others are being used as data source. In statistics data can be either quantitative (expressed in amount and size) or qualitative (expressed in percent or accordingly) there for in this thesis, both primary and secondary data are used.

3.11. Sample size Determination

Sampling was done randomly based on riders' presence in a particular area of the city at specific times however; the reference (Creswell, 2012)) developed the equation to determine the total sample size as follows:

$$n = \frac{z^2 * p(1-p)}{e2}$$

Where

The total population in the study area is greater than 100,000

- ✓ N= minimum sample size required for the study which

Z=1.96 (critical value) for the 95% the desired confidence level the amount of uncertainty that one can tolerate and researchers take 95% confidence level.

About 620 questionnaires were preparing for respondents. N represents sample size for commuters and privet car drivers.

- ✓ P=50% that indicates the proportion of people expected to have the basic understanding about the problem which means the modal shift to BRTS in this perspective.
- ✓ **ε**=5% that indicates a margin of error which can be tolerated

Then from the equation given $n=\frac{1.96^2*0.5(1-0.5)}{0.05^2}$

n=384

By adding the 5% of the total sample size to n=384which gives as that

N=384+ (0.05*384)

N=384+19

N=403

N=403 is the total number of samples must be needed for participants to responded the questionnaire survey but the sample size taken from secondary data were about 11496 population which is more accurate and precise.

3.12. Socio-economic factor

The secondary questionnaire survey data collected were household information such as household size, monthly household income and an individual job, sex, age, education level, household transport type are the most distinct in the survey.

3.13. Data quality control

Secondary data such as stated preference survey were properly arranged for research standards according to the study objectives. Sample size of the population also determined to fulfill what the study required at the end. During data collection period all the collected data were checked and identified for completeness' and uniformity. Deficient and incomplete data were rejected.

3.15. Data Extraction Methods

Secondary data has been about 11496 sample population that was collected by Addis Ababa city administration transport office (AACATO). Since the data was more than 390 items through the whole city of Addis Ababa item it needs filtering, sorting and data clearing by identifying the appropriate item for the study area according to its use and where the data is collected. Secondary data has been trying to cover both gender (male and female) and age group greater than 11 years old. The research approach in this thesis involves both quantitative and qualitative methods. Qualitative data from the secondary data were used to determine modal shift to BRT.

3.16. Data analysis

There are about a total of 11496 sample population stated preference survey which was taken from secondary data. Those data were filtered based on the importance to this study for the analysis of modal shift to know the attitude of passengers and their socio- economic group, age, sex, household income, family size, vehicle availability are more important factors for commuters to shift their mode of transport from the existing in to the new merging one know as BRTS. To generate the result from SPSS soft ware secondary data collected from city administration transport office data bank were registered in to Microsoft excel and exported in to SPSS soft ware for analysis. The collected data were analyzed in to two ways

The descriptive statistics method was used to analyze private car driver's weather shift in to the new mass transport system known as BRTS or not shift and to analyze different modes of transport system commuters' weather shift in to BRTS-B6 route.

The collected data were analyzed as three scenarios. The first phase is degree of commuter's pleasure / displeasure with current public transport system. It is analyzed as travel characteristics of the people and their awareness on the costs of commuting with public transport. The issue is why people travel on different means of transport and asking commuters attitude towards a latest and superior public transport system called BRTS.

The second phase was analyzing a new implementation of the proposed BRTS. Investigate the number of existing public transport system and private vehicles which will be exclusive out of the segregated lane of the route after implementation of this new BRT system.

By analyzing house hold survey data which can be endow with information about the commuter's socio-economic character and their travel behavior of a population gives advanced source of information for BRT -B6 route study.

3.17. Investigational of the study plan

The primary task is categorizing the basic factors about the travel behavior of passengers that can be based on major issues. Then following to investigate the importance and particular delivery of the new proposed BRT system and the by following the SPSS soft ware analyze the result up to end.

3.18. Multiple regression models

Multiple regressions are used to scaling and converting variables because there are various variables which cannot be use in their original forms. So that we have to have different approaches such logarithm, ratio, regression and so on. During data analysis of any model development we have to take care for data clearing to checking a data package for coding error. The multiple regression models are a location of method to investigate the straight-line association between above than one variable. It is used to calculate approximately $\boldsymbol{\beta}$ with*i*n the given formula as follow.

$$Y_1 = \boldsymbol{\beta_o} + \boldsymbol{\beta_1 X_{1j}} + \boldsymbol{\beta_2 X_{2j}} + \boldsymbol{\beta_3 X_{3j}} + \ldots\ldots\ldots + \boldsymbol{\beta_p X_{pf}} + \boldsymbol{\varepsilon_j}$$

From the above equation X implies that an independent variable while y is dependant variable. Then after j is number of observation in the row, $\boldsymbol{\beta}$ is coefficient of regression unknown in the equation which symbolizes the approximate of b. every $\boldsymbol{\beta}$ symbolizes the original unknown population constraints and b is an approximate of $\boldsymbol{\beta}$ while $\boldsymbol{\varepsilon_j}$ is error or residual of observation j.

The regration models can be developed in different way but the most popular approach is least square method in which ‘’b’’ is preferred for analysis to reduce the total of the square residuals (errors).

Multiple regression analysis examines the correlation among a dependent (response) variable and independent variables that means predictor and repressors’ which stated by equation as follow

$$y = b_0 + b_1 X_{1j} + b_2 X_{2j} + \ldots . b_p X_{pj} + \boldsymbol{\varepsilon_j}$$

When p=1 the model will become simple linear regration

Where,

y = dependent variable

$\mathbf{b_0}$ = intercept or constant

$\mathbf{b_j}$= slope or regression coefficient

$\mathbf{x_j}$ =independent variable

$\boldsymbol{\varepsilon_j}$ = random error term

3.19. R^2 (coefficient of determination)

Numerous measures of the goodness-off-fit to regression model of the statistics have been planned but the majority accepted one is $\mathbf{R^2}$. The square of the correlation coefficient among y and Y are $\mathbf{R^2}$. It is the proportion of the variation in Y that is accounted by the variation in the independent variables. $\mathbf{R^2}$ varies between zero (no linear relationship) and one (perfect linear relationship).

$\mathbf{R^2}$, formally known as the coefficient of determination, is defined as the sum of squares due to the regression divided by the adjusted total sum of squares of Y.

The formula of the coefficient of determination is given below.

$$SST = SSE + SSR$$

$$\mathbf{R^2} = \frac{\mathbf{SSE}}{\mathbf{SST}} = 1 - \frac{\mathbf{SSR}}{\mathbf{SST}}$$

Where SST=Total sum of squares
SSR=Residual sum of squares
SSE=Explained sum of squires

$\mathbf{R^2}$ is possible to highly accept the evaluation of how much best a regression model fits with the data. The adjusted $\mathbf{R^2}$ changes directly with the sample size of the population so that if N=P and adjusted $\mathbf{R^2}$=1 then adjusted $\mathbf{R^2}$ be approaches to sample size of the population and known as an adjusted $\mathbf{R^2}$ was reduces the impacts of sample size.

3.20. One-way analysis of variance (ANOVA)

In the multiple regression models one way analysis of variance is used to test whether significant table p-value must less than 0.05 or p-value< 0.05. One way analysis of variance (ANOVA) study the system ANOVA is an approach used to contrast the means of two and above variable group in which to check whether significant differences among the means of the given more than two unlike variable groups. The one way ANOVA is used to know by how much significant difference in mean of each another the independent more than two groups of variable in the set of data. One way analysis of variance (ANOVA) is checked through the ratio of variance among independent variable group and then comparing the significant difference among the groups which is taken.

The one way analysis of variance ANOVA is applied to check whether the modal shift is significant difference or has not significant difference among the given five factors which are

- Reliability of transport time on random delay and know time to arrive
- Short travel time for the given trip.
- comfort of passengers for the trip
- cost of public transport for tickets which is fare amount
- Safety of passengers due to traffic accident, pick pocketing and sexual harassment.

3.21. Description of problems

The mode choice was applied for this study to evaluate the outlooks of passengers towards the new public transport route that was proposed as BRTS-B_6 route and also its traits which mean distinguishing the outlook of passengers towards BRTS public transport. This research was aimed to character importance to check whether the new proposed BRTS public transport is in the study area attractive from commuter's opinion in order to achieve the sustainability of the proposed route.

3.22. Recognition the behaviors of passengers

The behaviors of the study contains the major issues on which alternative trip makers decision due to that the probability of not being case spirit to less convincing confirmed choice information. The auxiliary point of features is the superior of the analysis ability to be notice complex utility relationship. The objective of recognition is to distinguish the opinion of the people towards public transport which are behaviors of public transport from the commuter's significant attributes that is very important for passengers. Then pick the most important alternative from the features already set.

3.23. Predictable result

The analysis will be generating convenience standards on the major different travel behavior traits in which the statistical data has been examined in SPSS soft ware to invent the convenience equation for different modes especially for private cars and bicycle and then for the new mass transport BRTS . The second utilization of study data was distinguishing the persuaded unlike individuals and travel behaviors have on convenience rate of mode. Different theoretical circumstances were assisting to examine the features which describe shift in option of exact mode of travel and the tendency of passengers towards the new proposed route BRTS -B6. The analysis has been takes place by SPSS 24.0 version through multiple regression models.

CHAPTER FOUR

4.0. RESULTS AND DISCUTIONS

4.1. Introduction

The data collected from different sources were analyzed to meet the objectives of the research. The results obtained through data analysis were illustrated using graphs and tables followed by pertinent descriptions. Accordingly, in this chapter the results and discussions of modal shift were presented.

4.2. Performance of BRTS-B_6 and passenger's comfort for its sustainable implementation

1. Segregated running way types are: - mix flow lanes with queue jumpers, designated arterial lanes, at-grade exclusive lane, and grade-separated exclusive lane.
   Among those running ways type's grade-separated exclusive lane is best because the safest, fastest in speed, less congestion and risk with high investment cost for construction to implemented. Since the challenge in the city of Addis Ababa is delay and congestion the best solution will be grade-separated exclusive lane in the study area in our case.
2. The BRTS stations Types are: - basic shelter, enhanced shelter, designated station and intermodal transit center. Among those type intermodal transit center is the most comfortable for passengers during movement out of the bus including providing information but the most expensive construction and installation cost during implementation. Since the goal is urban transport improvement by attaining to the maximum passengers comfort intermodal transit center will covenant in the city of Addis Ababa to be implemented.
3. BRTS Vehicle configuration types are: - convectional standard, stylized standard, convectional articulated, stylized articulated and specialized BRT vehicles. Among those all specialized BRT vehicles is the most attractive aesthetics wise and comfortable for passengers but expensive cost wise. Since our country is low in capital convectional articulated will the most convenient to implemented as a city of Addis Ababa.
4. Fare collection types are: - on board pay, barrier free (self –service), proof of payment are the most common in fare collection systems. Among that Fare

collection type's proof of payment is the most convenient way which reduces dwell times for passengers.

The fare transaction media can be paying cash such as coins, bills, slips magnetic stripe media, smart card are the most common. The best fare transaction way is smart card which is quick and the most simple in every time and place.

5. Intelligent transportation systems include: - vehicle prioritzation, assist automation technology, electronic fare collection, operation management, passenger information, safety and protection issue and use of latest technology. So that ITS will be recommended to install for BRTS in the case of Addis Ababa BRTS-B6 route.

4.3. The socio-economic and commuters travel behavior of the sampled population

The study is based on primary data collection of questionnaires from 620 respondents in the study area. The socio-economic and demographic information were affect travel condition of the commuters in the city of Addis Ababa in urban transport. The socio-economic and demographic information collected in the questionnaires survey has direct relationship with the mobility of the people. The more sociable person has extensive socio-economic relations with which obtainable to it. The questionnaire survey can be grouped as

I. General socio- Demographic data characteristics analysis

- ✓ Gender
- ✓ Age group
- ✓ Work status
- ✓ Education level

II. General Socio-economic interaction respondents

- ✓ House hold characteristics
- ✓ House hold vehicle ownership
- ✓ House hold monthly income
- ✓ Mode choice by trip intention
- ✓ House hold vehicle availability
- ✓ Willingness to shift the mode in to BRT

4.4. Data Analysis and Interpretation

This chapter presents the data analyzed through a process of reviewing, cleansing, transforming and modeling data with the goal of discovering useful information, informing conclusions and supporting the conclusion of the thesis. The data analysis was made based on SPSS 24, using descriptive and inferential statics.

4.5. Socio Demographic Characteristics of Respondents

Regarding the socio demographic characteristics of respondents participated in the survey of secondary data from stated preference survey, the respondent's sex, age, residence, monthly income, Household Family Size and Distance from home was used for the sake of description the characteristics of the passengers.

4.6. The gender of respondents

Table 10 the sex of respondents

Gender	Frequency	Percent	Cumulative Percent
Female	7398	64.4%	64.4%
Male	4098	35.6%	35.6%
Total	11496	100.0	100.0%

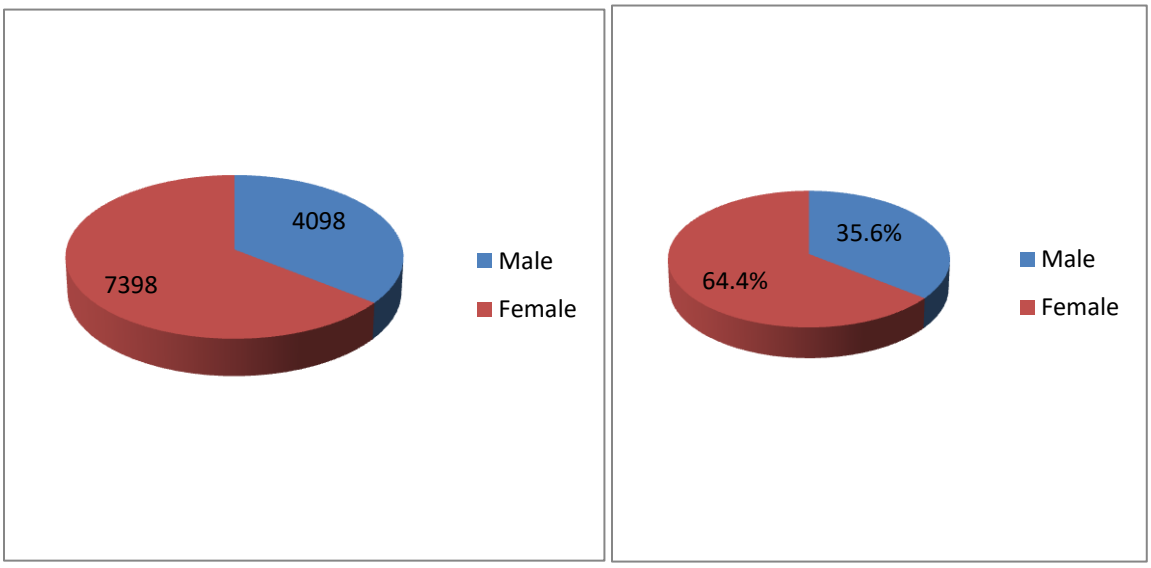


Figure 14 gender composition

Based on the result, 64.4% of the respondents were females while the remaining 35.6% of the respondents were males. This characteristic clearly shows the dominance of female participants in the survey.

4.7. Age of respondents

Table 11 Age of respondents

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	11496	11	97	37.06	13
N (listwise)	11496				

Regarding the sex of respondents, the minimum age of the survey was 11 years while the maximum age of the surveyed respondents were 97 years old with a standard deviation of 13 years. The mean age of the respondents was 37.06 years. This result indicates that various individuals with different age groups were participated in the survey which could be useful in understanding the varied interest of individuals across the ages.

4.8. Residence of respondents

The following graph shows the residence based on the sub cities has been shown in the following graph

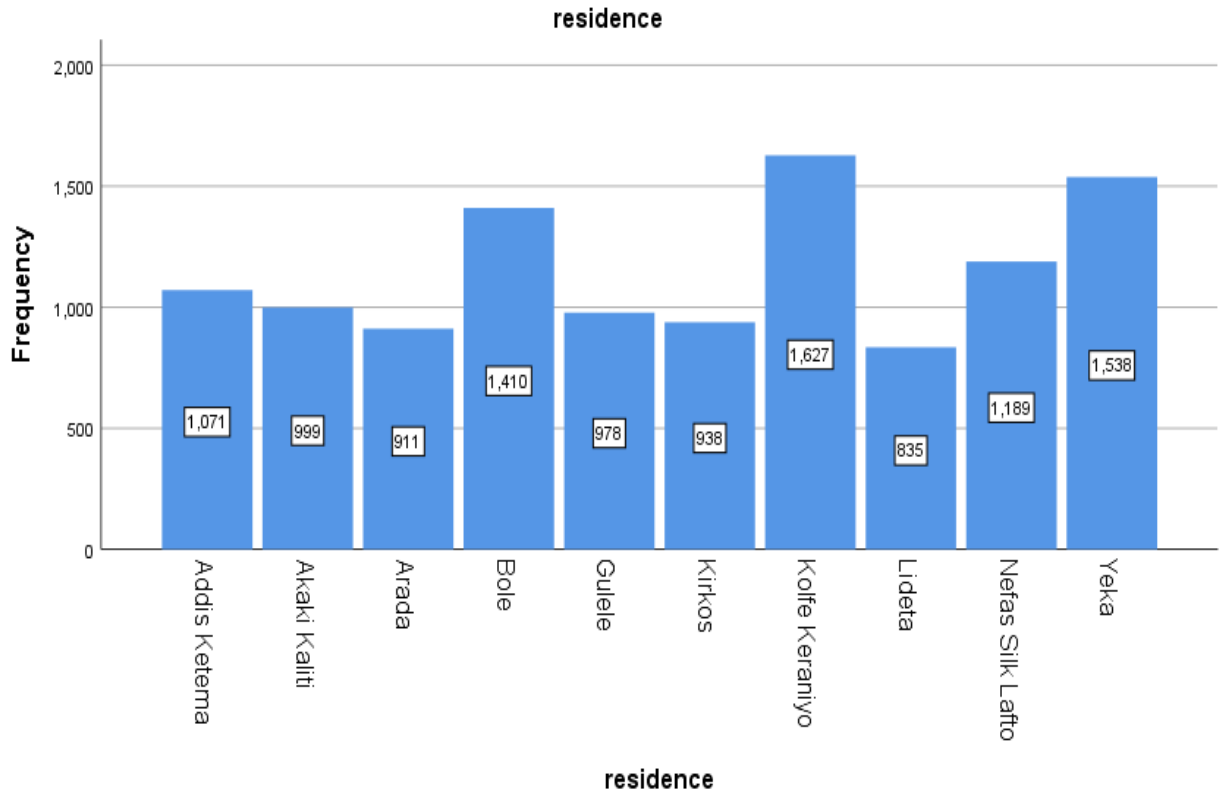


Figure 15 Residence

Regarding the residence of respondents, Kolfe Keraniyo, Yeka and Bole Sub Cities have the highest number of respondents respectively, Kirkos Sub City, Lideta and Arada sub cities have the lowest number of participants in relative to the other sub cities.

4.9. Monthly Income

For the choice of the mode of transportation, income level of users plays a significant role as presented in the literature review; therefore, the following income level of respondents has been presented using descriptive statics.

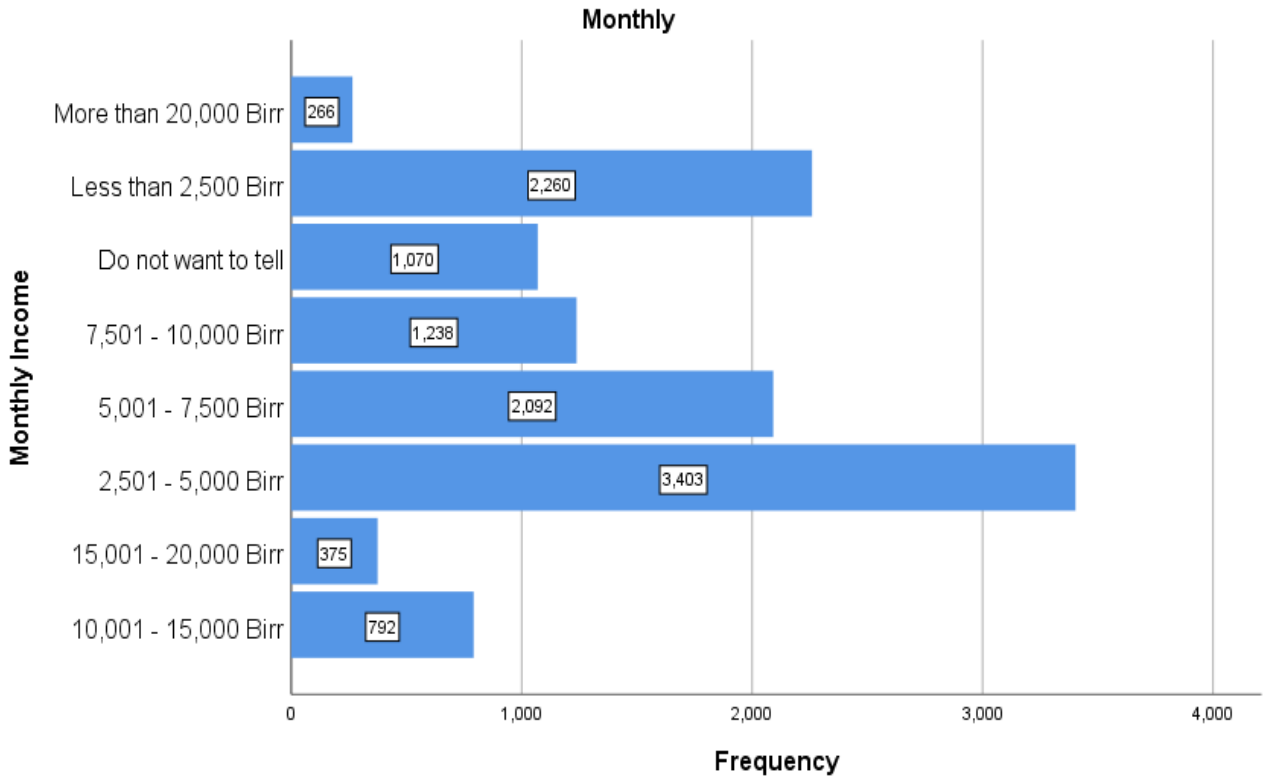


Figure 16 Monthly incomes

According to the results presented in the above table, respondents with a monthly income level of 2,501 - 5,000 Birr made up of the highest percentage followed by Less than 2,500 Birr and 5,001 - 7,500 Birr.

4.10. Household Family size

The last demographic variable discussed was household family size, with measured in a continuous scale, and presented as follow.

Table 12 Household Family size

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
HH Family Size	11496	1	17	3.67	1.656
Total number (N)	11496				

The minimum family size is 1 while the maximum is 17 in a given singe household from household survey data of 11496 populations.

Based on the results presented in the above table, the average household size of the respondents were 3.67 which is approximately the average household size was 4 persons with the minimum household size was 1 and the maximum household size was 17 persons.

Frequency of Use of Various Mode of Transportation Concurring to the script, Mode of transport may be a term utilized to recognize between distinctive ways of transportation or transporting individuals or products. The distinctive modes of transport are discussing, water, and air transport, which incorporate Rails or railroads, street and off-road transport. Other modes too exist, counting pipelines, cable transport, and space transport. Human-powered transport and animal-powered transport are now and then respected as their claim mode, but never drop into the other categories. In common, transportation is utilized for moving of individuals, creatures, and other merchandise from one put to another. These imply of transport, on the other hand, alludes to the (motorized) vehicles fundamental for transport concurring to the chosen mode (car, plane, transport, truck and rail). Each mode of transport incorporates a in a general sense diverse innovative arrangement, and a few require a isolated environment. Each mode has its claim framework, vehicles, and operations.

Regarding the mode of transportation used, the above table summarizes Private car, Bajaj, Minibus, Mid Bus [Higer and Isuzu], Bus [Sheger Anbessa PSETSE], Light Rail, Blue white Lada Taxi, Yellow Taxi, Digital Taxi, Bicycle, and Walking. Accordingly, regarding the use private car, the majority of the respondents 76.2% never used private car, while only 9.9% use private car Every day or (4-7 times a week).

Concerning the everyday usage of transportation mode, the above table shows Bajaj (7.9%), Minibus (31.6%), Mid Bus [Higer and Isuzu] (3.5%), Bus [Sheger Anbessa PSETSE] (7.9%), Light Rail (1.9%), Blue white Lada Taxi (0.5%), Yellow Taxi (0.2%), Digital Taxi (0.4%), Bicycle (0.3%) and Waking (48.0%).

4.11. Frequency of Use of Various Mode of Transportation

Table 13 Frequency of Use of Various Mode of Transportation

Mode		Frequency	Percentage
Private Car	Never	8759	76.2%
	Less than once a month	265	2.3%
	At least once a month	351	3.1%
	Once a week	464	4.0%
	2-3 times a week	514	4.5%
	Every day or (4-7 times a week)	1143	9.9%
Bajaj	Never	6654	57.9%
	Less than once a month	1152	10.0%
	At least once a month	908	7.9%
	Once a week	964	8.4%
	2-3 times a week	906	7.9%
	Every day or (4-7 times a week)	912	7.9%
Minibus	Never	1169	10.2%
	Less than once a month	600	5.2%
	At least once a month	1257	10.9%
	Once a week	2209	19.2%
	2-3 times a week	2629	22.9%
	Every day or (4-7 times a week)	3632	31.6%
Mid Bus [Higer and Isuzu]	Never	6335	55.1%
	Less than once a month	1182	10.3%
	At least once a month	1548	13.5%
	Once a week	1242	10.8%
	2-3 times a week	782	6.8%
	Every day or (4-7 times	407	3.5%

	a week)		
Bus [Sheger Anbessa PSETSE]	Never	4242	36.9%
	Less than once a month	1154	10.0%
	At least once a month	1929	16.8%
	Once a week	1831	15.9%
	2-3 times a week	1435	12.5%
	Every day or (4-7 times a week)	905	7.9%
Light Rail	Never	7042	61.3%
	Less than once a month	1619	14.1%
	At least once a month	1432	12.5%
	Once a week	786	6.8%
	2-3 times a week	394	3.4%
	Every day or (4-7 times a week)	223	1.9%
Blue white Lada Taxi	Never	8924	77.6%
	Less than once a month	1179	10.3%
	At least once a month	803	7.0%
	Once a week	393	3.4%
	2-3 times a week	145	1.3%
	Every day or (4-7 times a week)	52	0.5%
Yellow Taxi	Never	9984	86.8%
	Less than once a month	594	5.2%
	At least once a month	530	4.6%
	Once a week	261	2.3%
	2-3 times a week	99	0.9%
	Every day or (4-7 times a week)	28	0.2%

Digital Taxi	Never	9032	78.6%
	Less than once a month	882	7.7%
	At least once a month	858	7.5%
	Once a week	464	4.0%
	2-3 times a week	213	1.9%
	Every day or (4-7 times a week)	47	0.4%
Bicycle	Never	10781	93.8%
	Less than once a month	163	1.4%
	At least once a month	170	1.5%
	Once a week	228	2.0%
	2-3 times a week	121	1.1%
	Every day or (4-7 times a week)	33	0.3%
Walking	Never	1230	10.7%
	Less than once a month	257	2.2%
	At least once a month	683	5.9%
	Once a week	1560	13.6%
	2-3 times a week	2246	19.5%
	Every day or (4-7 times a week)	5520	48.0%

The most common one is walking which has high frequency than others. According to their frequency order Walking, Minibus, Bus, Bajaj, Mid Bus, Private Car, Light Rail, Blue white Lada Taxi, Yellow Taxi, Digital Taxi, Bicycle.

4.12. Frequency of Mode of Transportation Used

Table 14 Frequency of Mode of Transportation Used

Mode	Mean	Maximum	Minimum	Standard Deviation	Rank
Private Car	.8812	5.0000	.0000	1.7127	6
Bajaj	1.2216	5.0000	.0000	1.7097	4
Minibus	3.3418	5.0000	.0000	1.6153	2
Mid Bus [Higer and Isuzu]	1.1454	5.0000	.0000	1.5085	5
Bus [Sheger Anbessa PSETSE]	1.8067	5.0000	.0000	1.7048	3
Light Rail	.8292	5.0000	.0000	1.2651	7
Blue white Lada Taxi	.4179	5.0000	.0000	.9110	8
Yellow Taxi	.2586	5.0000	.0000	.7565	9
Digital Taxi	.4416	5.0000	.0000	.9707	10
Bicycle	.1597	5.0000	.0000	.6830	11
Walking	3.7306	5.0000	.0000	1.6414	1

Regarding the mode of transportation used with a mean of value of 3.7306 waking was found to be the frequent mode of transport used, followed by Minibus (Mean 3.3418, SD 1.6153). Therefore, Waking and Minibus were found to be the most frequently used mode of transportation.

On the contrary, Bicycle (mean .1597 and SD .6830), Yellow Taxi (mean .2586, SD .7565), and Blue white Lada Taxi (mean .4179, SD .9110) were found to be the least frequently used mode of transportation among the surveyed respondents respectively.

4.13. Analysis by multiple Regression model

Regression examination may be a factual estimation utilized for assessing the connections among factors. It empowers to decide the quality of the relationship between factors and the prescient control of the autonomous factors on the subordinate variable. In brief, relapse makes a difference an analyst get it to what degree alter the esteem of the subordinate variable causes the alter within the esteem of the independent variables, while other

autonomous factors are held unaltered. Regression investigation may be a way of measurably sorting out the factors that have certainly an affect. Whereas there are numerous sorts of relapse investigation, at their center they all look at the impact of one or more autonomous factors on a subordinate variable. The taking after portion too presents the relapse investigation of relapse.

After fitting a relapse demonstrate, check the remaining plots to begin with to be beyond any doubt simply have fair gauges. After that, it's time to translate the measurable yield. Straight relapse examination can produce a parcel of comes about, which I'll assist you explore. In this post, I cover deciphering the p-values and coefficients for the autonomous factors.

P-values and coefficients in relapse investigation work together to tell which connections in your demonstrate are factually critical and the nature of those connections: The coefficients portray the scientific relationship between each free variable and the subordinate variable. The p-values for the coefficients show whether these connections are measurably significant. The sign of a relapse coefficient tells whether there's a positive or negative relationship between each autonomous variable the subordinate variable. A positive coefficient demonstrates that as the esteem of the free variable increments, the cruel of the subordinate variable also tends to extend. A negative coefficient recommends that as the autonomous variable increments, the subordinate variable tends to decrease.

The coefficient value means how much the cruel of the subordinate variable changes given a one-unit move within the autonomous variable while holding other factors within the show steady. This property of holding the other factors steady is pivotal since it permits to evaluate the impact of each variable in separation from the others.

4.14. Correlation among independent variables

Correlation matrix indicates the linearity of coherence among independent variables.

- ✓ If the correlation is negative one it shows completely negative linear correlation among the independent variables.
- ✓ If the correlation is zero it shows no linear correlation among the independent variables.
- ✓ If the correlation is positive one it shows completely positive linear correlation among the independent variables.

Table 15 Correlation b/n independent variable

Control Variables			Reliability	Travel time	Comfort	Cost	Safety
Modal shift for BRT	Reliability	Correlation	1	0.872	0.807	0.482	0.723
	Travel time	Correlation	0.872	1	0.809	0.528	0.722
	Comfort	Correlation	0.807	0.809	1	0.546	0.798
	Cost	Correlation	0.482	0.528	0.546	1	0.546
	Safety	Correlation	0.723	0.722	0.798	0.546	1

- ✓ Correlation result must be from 1 up to -1
- ✓ If it is positive 1 perfect correlation
- ✓ From 0.75 up to +1 high degree correlation
- ✓ From 0.5 up to 0.75 moderate
- ✓ From 0.25 up to 0.5 low degree
- ✓ From 0 up to 0.25 no correlation
- ✓ Correlation is not belongs that one variable affect the other variable.
- ✓ Negative correlation indicates no relation among variable.

4.15. Linearity Test

The linearity of affiliations between the subordinate and free factors can be tried by looking at the P-P plot for the show. The closer the dabs mislead the corner to corner line, the closer to typical the residuals are distributed. As delineated within the underneath chart, the visual assessments of the p-p plot uncovered that there exist direct relationship between the subordinate and free factors. The concept of linearity can be expanded to direct administrators. Vital illustrations of direct administrators incorporate the subsidiary considered as a differential administrator, and other administrators developed from it, such as Del and the Laplacian. When a differential condition can be communicated in direct frame, it can for the most part be unraveled by breaking the condition up into little pieces,

tackling each of those pieces, and summing the solutions. Linear polynomial math is the department of arithmetic concerned with the considering a vectors, vector spaces (too called 'linear spaces'), straight changes (too called 'linear maps'), and frameworks of straight equations.

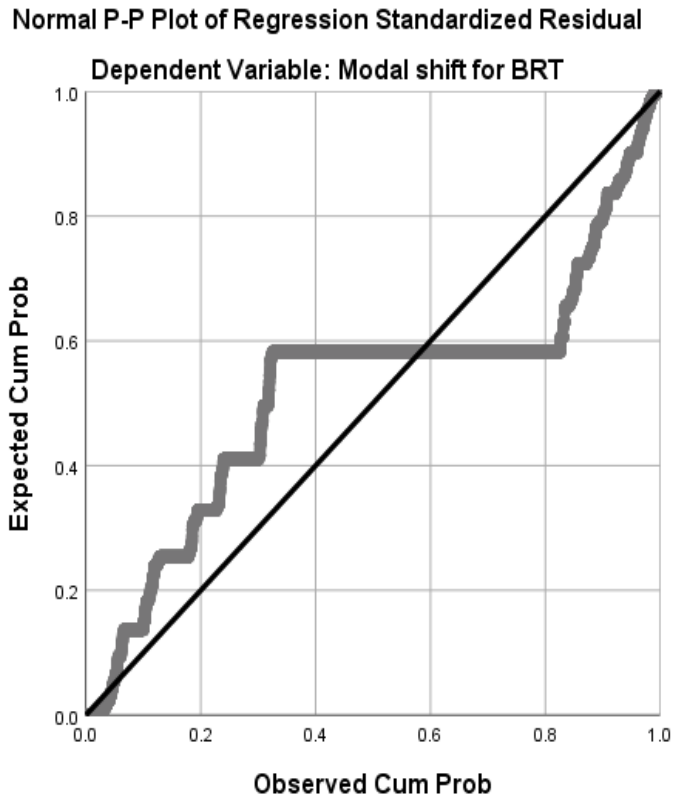


Figure 17 p-p plot of Regression Standardized Residual

4.16. Homoscedasticity Test

The suspicion of homoscedasticity alludes to break even with change of mistakes over all levels of the autonomous factors (Osborne & Waters, 2002). This infers it requires indeed dispersion of leftover terms or homogeneity of mistake terms all through the information. Homoscedasticity can be checked by visual examination of a plot of the standardized residuals by the relapse standardized anticipated esteem (Osborne & Waters, 2002). In the event that the mistake terms are dispersed haphazardly with no certain design, the issue isn't hindering for examination. The scatter plot in Fig 21 appears that the standardized residuals in this investigate are dispersed.

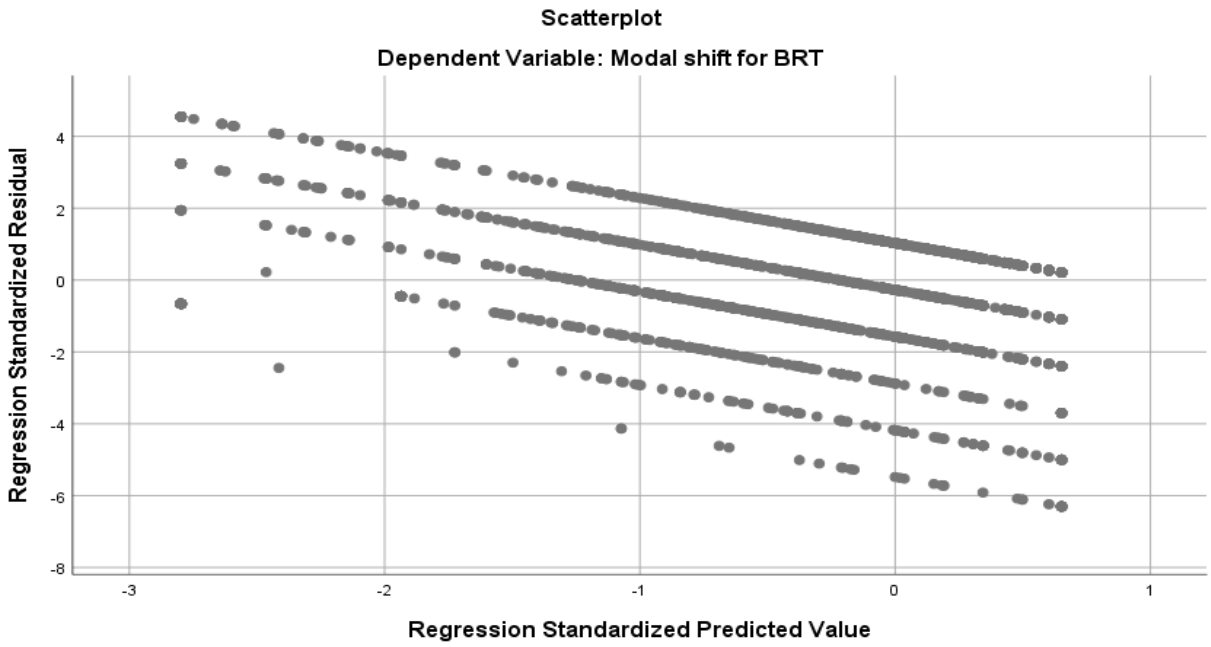


Figure 18 Scatter plot of standardized residuals vs standardized fitter value

- ✓ Having the same scatter to exist a set of data (a set of data having a variance of zero).
- ✓ It described as condition where the standard deviations are equal for all points.
- ✓ The point must be about the same distance from the line as shown above.
- ✓ The scattered plot Test shows that homoscedasticity (equability of variances) of our data, scatter plot of standardized residuals versus standardized fitted values which are analyzed.

4.17. Auto Correlation (Durbin Watson Test)

Autocorrelation or autonomy of blunders alludes to the suspicion that blunders are autonomous of one another, inferring that subjects are reacting freely Stevens (2009). Durbin-Watson measurement can be utilized to test the presumption that our residuals are autonomous (or uncorrelated). This measurement can shift from 0.2 to 0. 4. For this suspicion to be met, the Durbin-Watson esteem has to be near to 2 (Field, 2006). Values underneath 1 and over 3 are tricky and causes for concern. To check this presumption we got to see at the Demonstrate Outline box displayed underneath.

Table 16 Durbin Watson statistics

Model Summary	
Std. Error of the Estimate	Durbin-Watson
.768	1.450
a. Predictors: (Constant), Safety, Cost, Reliability, Comfort, Travel speed	
b. Dependent Variable: Modal shift for BRT	

Table 16 above reveals that errors are responding independently, and autocorrelation is not a concern with Durbin-Watson value of 1.450. Therefore, it is possible to say the auto-correlation test has been met.

4.18. Normality Test

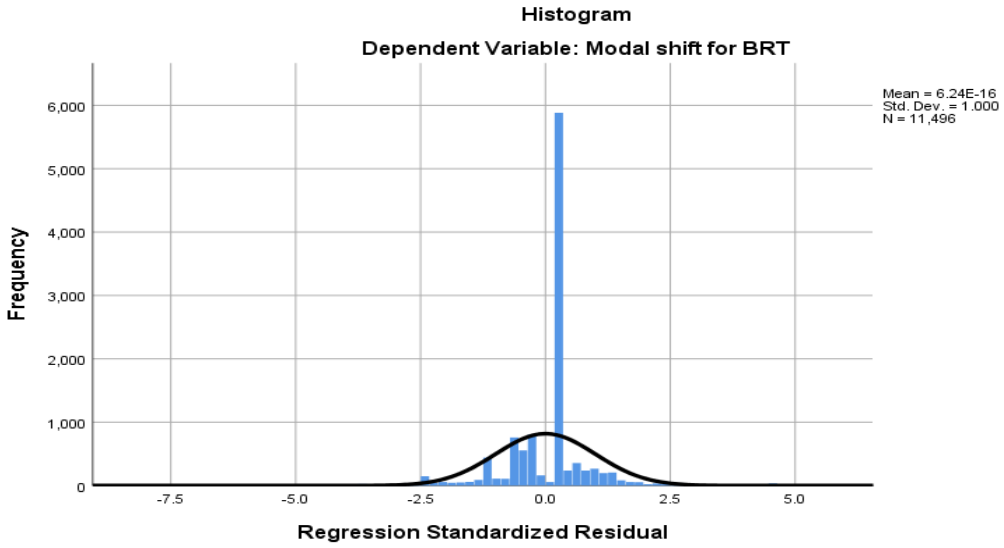


Figure 19 Normality Test

Histogram is a bar graph like representation of data that buckets a range of out comes in to a columns along the x- axis. The y- axis represents the frequency of occurrences. The purpose of histogram is graphically summarizing the distribution of a univariate data set.

Different relapses require the free factors to be regularly disseminated. This implies that blunders are ordinarily disseminated, which a plot of the values of the residuals will inexact a typical bend (Keith, 2006).

Frequency dispersion comes in numerous distinctive shapes and sizes. Subsequently, it is very imperative, to have a few common depiction for common sorts of disseminations. In an

perfect world our information would be dispersed symmetrically around the center of all scores. As such, on the off chance that we draw a vertical line through the center of the conveyance at that point it ought to see the same on both sides. Usually known as a typical dispersion and is characterized by bell-shaped bend. This shape fundamentally infers that the lion's share of scores lie around the center of the conveyance (Field, 2006). The ordinary dispersion chart was appeared on Fig 19 underneath and uncovered that the suspicion of ordinariness has been met.

4.19. Multiple Regression Model Results

Table 17 model summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.783[a]	.613	.613	.768
a. Predictors: (Constant), Safety, Cost, Reliability, Comfort, Travel speed				
b. Dependent Variable: Modal shift for BRT				

Based on the model summary of the predictor variables presented above (Safety, Cost, Reliability, Comfort, Travel time), their **correlation coefficient** with the dependent variable (Modal shift for BRT) is 0.783 which was between 1 and -1 indicates the presence of high correlation between the dependent and the independent variables as a whole. The correlation coefficient must be between 1 and -1 and also if correlation coefficient is one it is a perfect positive linear relationship while negative a perfect negative linear relationship but if it become zero no linear relationship. Coefficient of determination (R^2) was about 0.613 while adjusted Coefficient of determination (R^2) the same and equal with Coefficient of determination (R^2) which was 0.613 as shown from table 16.the standard error of estimated was 0.768. Since $\mathbf{R^2}$ varies between zero and one (perfect linear relationship) the value 0.613 found between 0 and 1 which was satisfied.

The independent variables (namely; Safety, Cost, Reliability, Comfort, Travel time) explain 61.3% variability on the dependent variable (Modal shift for BRT) since R square value is 0.613

Table 18 model fitting information

Model	Model Fitting Criteria -2 Log Likelihood	Likelihood Ratio Tests		
		Chi-Square	df	Sig.
Intercept Only	15390.759			
Final	3626.041	11764.718	100	.000

Significant error for model fitting became zero and significant level df for the model is 100%

Table 19 Likelihood Ratio Tests

Effect	Model Fitting Criteria -2 Log Likelihood of Reduced Model	Likelihood Ratio Tests		
		Chi-Square	df	Sig.
Intercept	3626.041[a]	.000	0	.
Reliability	72728.114[b]	69102.073	20	.000
Travel time	32676.423[b]	29050.383	20	.000
Comfort	18653.890[c]	15027.849	20	.000
Cost	19369.938[b]	15743.897	20	.000
Safety	58610.849[b]	54984.808	20	.000

4.20. The one -way analysis of variance (ANOVA) Reliability

Table 20 Variation in Modal shift for BRT b/n reliability (one way-ANOVA)

Modal shift for BRT	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	9506.301	4	2376.575	3414.999	.000
Within Groups	7996.848	11491	.696		
Total	17503.150	11495			

The variation in modal shift due to Reliability of transport time on random delay and know The time to arrive of BRTS from one way analysis of variance (ANOVA) in table 19 above Output indicate that f(4,11491)=3414.999 and P=0.000 which was very much less than ($\acute{\alpha}$=0.05). So that the outcome indicates significant confirmation To reject the null hypothesis (Ho)and then deducing that the difference of reliability has very much significant variation among Modal shift for BRT.

Travel time

Table 21 variation in Modal shift for BRT b/n Travel time (One way-ANOVA result)

Modal shift for BRT	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	9439.382	4	2359.846	3362.818	.000
Within Groups	8063.767	11491	.702		
Total	17503.150	11495			

The variation in modal shift due to Short travel time for the specific trip of BRTS from the output of one way analysis of variance (ANOVA) in table 20 above indicate that f(4,11491)=3362.818 and P=0.000 which was too much less than ($\acute{\alpha}$=0.05). So that the outcome indicates significant confirmation To reject the null hypothesis (Ho) and then deduce that the difference of Travel time has so much significant variation among modal shift for BRT.

Comfort

Table 22 Variation in Modal shift for BRT b/n Comfort (one way -ANOVA result)

Modal shift for BRT	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	9970.879	4	2492.720	3802.816	.000
Within Groups	7532.271	11491	.655		
Total	17503.150	11495			

The variation in modal shift due to comfort of passengers for the trip of BRTS from one way analysis of variance (ANOVA) in table 21 above output indicate that f(4,11491)=3802.816 and P=0.000 which was too much less than (α=0.05). So that the outcome indicates significant confirmation To reject the null hypothesis (Ho) and then deduce that the difference of Comfort has very much significant variation among modal shift for BRT.

Cost of transport

Table 23 Variation in Modal shift for BRT b/n Cost (one way- ANOVA result)

Modal shift for BRT	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	8013.883	4	2003.471	2426.097	.000
Within Groups	9489.267	11491	.826		
Total	17503.150	11495			

The variation in modal shift due to cost of public transport for tickets which is fare amount of BRTS from one way analysis of variance (ANOVA) in table 22 above output indicate that f(4,11491)=2426.097 and P=0.000 which was too much less than (α=0.05). So that the outcome indicates significant confirmation To reject the null hypothesis (Ho) and then deduce that the difference of cost has very much significant variation among modal shift for BRT.

Safety

Table 24 variation in Modal shift for BRT b/n safety (one way- ANOVA result)

Modal shift for BRT	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	10096.988	4	2524.247	3916.485	.000
Within Groups	7406.162	11491	.645		
Total	17503.150	11495			

The variation in modal shift due to Safety of passengers due to traffic accident, pick pocketing and sexual harassment of BRTS from one way analysis of variance (ANOVA) in table 23 above output indicate that f(4,11491)=3916.485 and P=0.000 which was too much less than (ǎ=0.05). So that the outcome indicates significant confirmation to reject the null hypothesis (Ho) and then deduce that the difference of Safety has very much significant variation among modal shift for BRT.

4.21. The one -way analysis of variance (ANOVA) output from multiple regression

ANOVA is the easiest for single way or single factor that outcome variable is comparing and the factor variable is classified variable being used to describe the group of factors. Postulation of ANOVA are about three listed as follow independence, normality, homogeneity of variances or homoscedasticty. ANOVA is applicable in statistics during the reasons which average independent variables have two and above groups which is used to decide whether there is some statistically important variation among the average of the independent groups. Events to examine the one way examination of variance is examined and contrast average one way ANOVA outcome as follow in the table below shown.

Table 25 ANOVA Results

ANOVA						
Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	10726.725	5	2145.345	3637.613	.000
	Residual	6776.425	11490	.590		
	Total	17503.150	11495			
a. Dependent Variable: Modal shift for BRT						
b. Predictors: (Constant), Safety, Cost, Reliability, Comfort, Travel speed						

The ANOVA table above indicates the existence of a significant regression model which predict the dependent variable based on the models independent variable which are F-test and the significance interval p value (F statistics 3637.613, P value <0.01).

Table 26 Coefficients

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.675	.027		24.560	.000
	Reliability	.155	.019	.150	7.987	.000
	Travel time	.048	.019	.047	2.488	.013
	Comfort	.167	.019	.163	8.885	.000
	Cost	.149	.009	.163	16.971	.000
	Safety	.314	.015	.310	20.308	.000
a. Dependent Variable: Modal shift for BRT						

Based on the coefficient table the following regression formula (model) is constructed in an effort to predict Modal for BRT. Safety, Cost, Reliability, Comfort, and Travel time determine the level of BRT modal shift as follow.

Modal shift for BRT = .675 + .155 Reliability + .048 Travel speed + .167 Comfort +.149 Cost + .314 Safety

For the modal shift to BRT, Reliability causes the most modal shift than the other independent variables while travel time exerts the lowest pressure on modal shift.

CHAPTER FIVE

5. 0. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

The study examined the sustainability assessment of exclusive BRT-B6 route in the case of Addis Ababa City which includes pedestrian walk way facility and non-motorized vehicle encouragement in the study area.

In the new BRTS implementation passenger's comfort is the main issue by providing payment machine and card for passengers at each station, shelter at station, level boarding, ITS and bicycle parking at each station and bicycle locker at each station must be provided for passengers.

Pedestrian facilities such as walk way, cross way, exclusive biking lane must be provided along the new route to be sustainable urban transport project.

Based on the findings of this study there are major conclusions are drawn with respect to the study route described as follow.

The study shows that an important relationship among modal shift to the new system and private car drivers in the study area. The modern mass transport system attracts the most private care drivers if the mode is comfortable, attractive aesthetics wise, reliable, identified station and can solve the problem of parking for private care.

The result shows from data analysis that private care drivers can be shift to the new merged mass transport system in the given study area.

The multiple linear regression models were developed to predict with the modal shift to BRTS from different modes of transport. Through the entire variables were found to statically significant prediction on the modal shift at 95%of the confidence interval.

Turn by turn about six regression models were developed with that of modal shift from different mode of transport to the new modern BRT system as the dependent variable and number of cars in the household, cost of private cars such as fuel cost, type fuel taken by private care, enough information about BRTS, implementation period of BRT-B6 and open to operation and requirement of BRT system fulfilled to attract to from other modes of transport are taken as independent variables.

The adjusted coefficient of determination ($R^2_{adj)}$ is about 0.865 which means that 86.5% from the total mode shift to the new mass transport mode called BRTS in the study area.

Based on this study the following conclusions are drawn:

- This study has assessed the frequency of use of Private car, Bajaj, Minibus, Mid Bus [Higer and Isuzu], Bus [Sheger Anbessa PSETSE], Light Rail, Blue white Lada Taxi, Yellow Taxi, Digital Taxi, Bicycle, and Walking. Based on the result, private car, the majority of Addis Ababa Residents (76.2%) never used private car, while only 9.9% use private car every day or (4-7 times a week).
- The results of for the frequency of use of Bajaj (7.9%), Minibus (31.6%), Mid Bus [Higer and Isuzu] (3.5%), Bus [Sheger Anbessa PSETSE] (7.9%), Light Rail (1.9%), Blue white Lada Taxi (0.5%), Yellow Taxi (0.2%), Digital Taxi (0.4%), Bicycle (0.3%) and Waking (48.0%).
- Regarding the mode of transportation used with a mean of value of 3.7306 waking was found to be the frequent mode of transport used, followed by Minibus (Mean 3.3418, SD 1.6153). Therefore, Waking and Minibus were found to be the most frequently used mode of transportation.
- Quite the reverse, Bicycle (mean .1597 and SD .6830), Yellow Taxi (mean .2586, SD .7565), and Blue white Lada Taxi (mean .4179, SD .9110) were found to be the smallest frequently used mode of transportation among the surveyed respondents respectively.
- Based on the regression results, Safety, Cost, Reliability, Comfort, Travel speed) explain 61.3% variability on the dependent variable (Modal shift for BRT). Reliability causes modal shift more than the other independent variables while travel speed exerts the lowest pressure on modal shift.
- The one way analysis of variance (ANOVA) output show that the significant p-value is zero (0) for independent variables which were reliability, travel time , comfort, cost ,safety.

5.2. Recommendations

From the following outcomes of the above analysis the finding measures are needed to be taken to deal with considerations in an attempt to assess sustainability of the project in study area. There for measures that are recommended to predict in the future that can be factors for the BRT-B_6 route in Addis Ababa city are listed as follow.

- Pedestrian Infrastructure Facilities: - sufficient walk way for pedestrian must be provided along the running way and proper crossway for pedestrian crossing in proper distance must be provided for BRTS-B6 route.
- Non-Motorized Transport (NMT) Facilities: - exclusive bicycle lane must be provided along the BRT- B6 route and simply bicycle parking space or bicycle parking by lock ring at BRT station will recommended to provide.
- Usage of Intelligent Transport System: -BRTS –B6 route must be install ITS technologies such as transit signal priority real time passenger information and advanced communication digital display systems for faster and more convenient trip.
- Travel Speed due to exclusiveness of general traffic and BRT Along the proposed Corridors has been ultimate by prior zing for BRTS.
- Availability of Parking Spaces at station and depot must considered by focus ting for maximum design period.
- Safety of Road with respect to general traffic and BRT at intersection must be considered to be sustainable project.
- Grade separation at intersection to reduce delay, accident, congestion for BRT is the basic one to avoided delay for general traffic to be sustainable project.
- Electronics Fare collection mechanism must be considered to make the commuter modernizing and to provided Addis Ababa BRT company safe fare collection system.
- The government will be approving enforcement law to discourage privet cars driving in the city through taxation and different service payments.

Those the above listed measures are encourage private car drivers, small bus, minibus and taxi user’s modal shifts towards BRTS.

5.3. Future research direction

There are more different potential research topics that can be related to this study which are listed as follow.

Unbalanced work place, market place, education and health center location has significant impact on the resident's distribution and their activities, land use, land value, tendency of mobility, travel pattern in Addis Ababa city. So that we have to integrate land use and proper transport pattern in the study area.

- **Further BRTS in Addis Ababa city related studies in the feature**

- ✓ Since BRTS is new transport system in our country traffic volume modeling in the study area can be studied in the future.
- ✓ The BRTS-B6 route corridor potential displacement impacts on the residents around the project can be studied in the future.
- ✓ The impact of Land value at BRTS-B6 route station due to market attraction for trade and social services can be studied in the future.
- ✓ The impact of land value escalation at BRTS-B6 route station due to market attraction for trade and social services can be studied in the future.

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Appendices

Appendix I
Correlation matrix among independent variables

	Reliablity	Travel time	Comfort	Cost	Safety	age	HH Family Size	Private Car	Bajaj	Minibus	Mid Bus [Higer and Isuzu]	Bus [Sheger Anbessa PSETSE]	Light Rail	Blue white Lada Taxi	Yellow Taxi	Digital Taxi	Bicycle	Walking	Modal shift for BRT
Reliablity	1	.941**	.914**	.738**	.877**	-0.012	0.000	.048**	.048**	-.022**	.016*	-.047**	-.054**	-.032**	-0.006	-.028**	-.027**	.033**	.736**
Travel time	.941**	1	.914**	.760**	.876**	-.018*	-0.009	.049**	.044**	-.023**	.016*	-.046**	-.049**	-.034**	-0.010	-.034**	-.029**	.027**	.733**
Comfort	.914**	.914**	1	.774**	.913**	-0.008	-0.014	.039**	.027**	-.029**	-0.009	-.059**	-.064**	-.051**	-.022**	-.043**	-.044**	.033**	.752**
Cost	.738**	.760**	.774**	1	.775**	-0.001	-.038**	.025**	.047**	-.035**	.028**	-.056**	-.048**	-.037**	0.006	-.052**	-.019*	0.013	.676**
Safety	.877**	.876**	.913**	.775**	1	-.015*	-0.005	.025**	.033**	-.020*	-.023**	-.065**	-.070**	-.056**	-.033**	-.043**	-.057**	.048**	.758**
age	-0.012	-.018*	-0.008	-0.001	-.015*	1	.062**	.046**	-.110**	-.150**	.031**	.048**	.019*	0.010	.020*	-0.013	-.025**	-.038**	-0.002
HH Family Size	0.000	-0.009	-0.014	-.038**	-0.005	.062**	1	.054**	-0.015	.043**	-.036**	-.027**	.022**	0.013	-.016*	-0.001	-.051**	.059**	-.028**
Private Car	.048**	.049**	.039**	.025**	.025**	.046**	.054**	1	-.082**	-.323**	-.161**	-.248**	-.049**	.111**	.186**	.226**	.108**	-.134**	.050**
Bajaj	.048**	.044**	.027**	.047**	.033**	-.110**	-0.015	-.082**	1	.116**	.125**	.080**	.036**	.073**	.078**	.026**	.111**	.099**	.030**
Minibus	-.022**	-.023**	-.029**	-.035**	-.020*	-.150**	.043**	-.323**	.116**	1	.158**	.243**	.151**	.058**	-0.008	0.009	-0.009	.270**	-.047**
Mid Bus [Higer and Isuzu]	.016*	.016*	-0.009	.028**	-.023**	.031**	-.036**	-.161**	.125**	.158**	1	.476**	.348**	.180**	.147**	.065**	.153**	-0.003	.025**
Bus [Sheger Anbessa PSETSE]	-.047**	-.046**	-.059**	-.056**	-.065**	.048**	-.027**	-.248**	.080**	.243**	.476**	1	.299**	.092**	.051**	0.009	.084**	.069**	-.040**
Light Rail	-.054**	-.049**	-.064**	-.048**	-.070**	.019*	.022**	-.049**	.036**	.151**	.348**	.299**	1	.221**	.211**	.153**	.218**	.071**	-.034**
Blue white Lada Taxi	-.032**	-.034**	-.051**	-.037**	-.056**	0.010	0.013	.111**	.073**	.058**	.180**	.092**	.221**	1	.521**	.437**	.346**	-.023**	-.029**
Yellow Taxi	-0.006	-0.010	-.022**	0.006	-.033**	.020*	-.016*	.186**	.078**	-0.008	.147**	.051**	.211**	.521**	1	.581**	.430**	-.042**	.019*
Digital Taxi	-.028**	-.034**	-.043**	-.052**	-.043**	-0.013	-0.001	.226**	.026**	0.009	.065**	0.009	.153**	.437**	.581**	1	.329**	-.039**	0.002
Bicycle	-.027**	-.029**	-.044**	-.019*	-.057**	-.025**	-.051**	.108**	.111**	-0.009	.153**	.084**	.218**	.346**	.430**	.329**	1	-.040**	-0.014
Walking	.033**	.027**	.033**	0.013	.048**	-.038**	.059**	-.134**	.099**	.270**	-0.003	.069**	.071**	-.023**	-.042**	-.039**	-.040**	1	-0.013
Modal shift for BRT	.736**	.733**	.752**	.676**	.758**	-0.002	-.028**	.050**	.030**	-.047**	.025**	-.040**	-.034**	-.029**	.019*	0.002	-0.014	-0.013	1

****. Correlation is significant at the 0.01 level (1-tailed).**

***. Correlation is significant at the 0.05 level (1-tailed).**

c. Cannot be computed because at least one of the variables is constant.

Appendix II

Parameter Estimates

Modal shift for BRT[a]		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
0	Intercept	-5.468	0.198	762.88	1	0			
	[Reliablity=1]	-6.148	84.451	0.005	1	0.942	0.002	2.79E-75	1.64E+69
	[Reliablity=2]	0.93	1.507	0.381	1	0.537	2.534	0.132	48.553
	[Reliablity=3]	0.599	0.96	0.39	1	0.532	1.821	0.277	11.952
	[Reliablity=4]	0.063	0.662	0.009	1	0.924	1.065	0.291	3.9
	[Reliablity=5]	0[b]	.	.	0	.	.	.	.
	[Travel time=1]	-5.954	29.624	0.04	1	0.841	0.003	1.58E-28	4.266E+22
	[Travel time=2]	0.375	1.214	0.096	1	0.757	1.455	0.135	15.707
	[Travel time=3]	-1.253	1.041	1.449	1	0.229	0.286	0.037	2.197
	[Travel time=4]	-0.355	0.614	0.334	1	0.563	0.701	0.211	2.335
	[Travel time=5]	0[b]	.	.	0	.	.	.	.
	[Comfort=1]	-19.827	0	.	1	.	2.45E-09	2.45E-09	2.45E-09
	[Comfort=2]	-0.347	1.555	0.05	1	0.824	0.707	0.034	14.888
	[Comfort=3]	0.2	0.858	0.054	1	0.816	1.221	0.227	6.562
	[Comfort=4]	0.88	0.539	2.661	1	0.103	2.41	0.838	6.934
	[Comfort=5]	0[b]	.	.	0	.	.	.	.
	[Cost=1]	1.173	0.577	4.136	1	0.042	3.231	1.044	10.007
	[Cost=2]	0.811	0.835	0.944	1	0.331	2.25	0.438	11.549
	[Cost=3]	0.933	0.55	2.877	1	0.09	2.543	0.865	7.475
	[Cost=4]	1.019	0.546	3.484	1	0.062	2.77	0.95	8.072
	[Cost=5]	0[b]	.	.	0	.	.	.	.
	[Safety=1]	2.168	1.486	2.127	1	0.145	8.737	0.475	160.812
	[Safety=2]	0.898	1.136	0.626	1	0.429	2.455	0.265	22.737
	[Safety=3]	1.243	0.683	3.316	1	0.069	3.466	0.91	13.207
	[Safety=4]	-0.137	0.634	0.047	1	0.829	0.872	0.252	3.023
	[Safety=5]	0[b]	.	.	0	.	.	.	.
1	Intercept	-5.19	0.17	931.511	1	0			
	[Reliablity=1]	1.344	1.013	1.762	1	0.184	3.836	0.527	27.921

	[Reliablity=2]	-6.409	6.401	1.002	1	0.317	0.002	5.86E-09	463.096
	[Reliablity=3]	1.003	0.454	4.87	1	0.027	2.726	1.119	6.642
	[Reliablity=4]	0.417	0.389	1.152	1	0.283	1.518	0.708	3.253
	[Reliablity=5]	0[b]	.	.	0	.	.	.	.
	[Travel time=1]	1.711	0.953	3.223	1	0.073	5.534	0.855	35.829
	[Travel time=2]	-2.596	1.32	3.866	1	0.049	0.075	0.006	0.992
	[Travel time=3]	0.107	0.427	0.063	1	0.801	1.113	0.482	2.573
	[Travel time=4]	-0.242	0.379	0.41	1	0.522	0.785	0.373	1.649
	[Travel time=5]	0[b]	.	.	0	.	.	.	.
	[Comfort=1]	-0.071	0.749	0.009	1	0.924	0.931	0.215	4.044
	[Comfort=2]	-1.501	1.068	1.978	1	0.16	0.223	0.027	1.806
	[Comfort=3]	0.505	0.381	1.755	1	0.185	1.657	0.785	3.501
	[Comfort=4]	0.528	0.332	2.536	1	0.111	1.696	0.885	3.25
	[Comfort=5]	0[b]	.	.	0	.	.	.	.
	[Cost=1]	2.573	0.284	81.962	1	0	13.109	7.51	22.884
	[Cost=2]	1.907	0.43	19.678	1	0	6.735	2.9	15.644
	[Cost=3]	2.086	0.3	48.473	1	0	8.05	4.475	14.481
	[Cost=4]	1.316	0.382	11.856	1	0.001	3.73	1.763	7.89
	[Cost=5]	0[b]	.	.	0	.	.	.	.
	[Safety=1]	2.243	0.568	15.606	1	0	9.419	3.096	28.656
	[Safety=2]	1.733	0.464	13.935	1	0	5.659	2.278	14.06
	[Safety=3]	-0.019	0.428	0.002	1	0.965	0.982	0.425	2.269
	[Safety=4]	-0.115	0.368	0.098	1	0.754	0.891	0.433	1.833
	[Safety=5]	0[b]	.	.	0	.	.	.	.
2	Intercept	-5.528	0.193	824.101	1	0			
	[Reliablity=1]	-0.335	0.924	0.131	1	0.717	0.715	0.117	4.378
	[Reliablity=2]	0.921	0.438	4.421	1	0.036	2.512	1.064	5.93
	[Reliablity=3]	-0.399	0.35	1.298	1	0.255	0.671	0.338	1.333
	[Reliablity=4]	0.096	0.259	0.137	1	0.711	1.101	0.663	1.827
	[Reliablity=5]	0[b]	.	.	0	.	.	.	.
	[Travel time=1]	-1.192	0.737	2.614	1	0.106	0.304	0.072	1.288
	[Travel time=2]	0.545	0.463	1.391	1	0.238	1.725	0.697	4.272
	[Travel time=3]	0.331	0.341	0.943	1	0.332	1.393	0.713	2.72

	[Travel time=4]	0.576	0.266	4.692	1	0.03	1.779	1.056	2.997
	[Travel time=5]	0[b]	.	.	0	.	.	.	.
	[Comfort=1]	-2.621	1.557	2.834	1	0.092	0.073	0.003	1.538
	[Comfort=2]	1.002	0.445	5.066	1	0.024	2.722	1.138	6.512
	[Comfort=3]	0.408	0.348	1.374	1	0.241	1.503	0.76	2.972
	[Comfort=4]	1.03	0.28	13.527	1	0	2.8	1.618	4.847
	[Comfort=5]	0[b]	.	.	0	.	.	.	.
	[Cost=1]	1.117	0.431	6.71	1	0.01	3.054	1.312	7.11
	[Cost=2]	2.641	0.328	65.001	1	0	14.031	7.383	26.665
	[Cost=3]	1.785	0.312	32.665	1	0	5.959	3.231	10.99
	[Cost=4]	0.873	0.346	6.354	1	0.012	2.394	1.214	4.72
	[Cost=5]	0[b]	.	.	0	.	.	.	.
	[Safety=1]	1.729	0.781	4.897	1	0.027	5.634	1.219	26.051
	[Safety=2]	2.895	0.372	60.417	1	0	18.086	8.715	37.53
	[Safety=3]	2.615	0.296	78.05	1	0	13.668	7.651	24.415
	[Safety=4]	0.891	0.303	8.615	1	0.003	2.437	1.344	4.418
	[Safety=5]	0[b]	.	.	0	.	.	.	.
3	Intercept	-3.684	0.079	2191.59	1	0			
	[Reliablity=1]	-0.006	0.584	0	1	0.991	0.994	0.316	3.121
	[Reliablity=2]	-0.819	0.39	4.415	1	0.036	0.441	0.205	0.946
	[Reliablity=3]	0.633	0.197	10.29	1	0.001	1.884	1.279	2.774
	[Reliablity=4]	-0.019	0.16	0.014	1	0.907	0.981	0.717	1.344
	[Reliablity=5]	0[b]	.	.	0	.	.	.	.
	[Travel time=1]	2.03	0.494	16.863	1	0	7.615	2.89	20.069
	[Travel time=2]	-0.24	0.337	0.507	1	0.477	0.787	0.406	1.524
	[Travel time=3]	0.724	0.19	14.521	1	0	2.063	1.422	2.994
	[Travel time=4]	0.446	0.153	8.558	1	0.003	1.562	1.159	2.107
	[Travel time=5]	0[b]	.	.	0	.	.	.	.
	[Comfort=1]	-2.344	0.644	13.231	1	0	0.096	0.027	0.339
	[Comfort=2]	-0.338	0.342	0.981	1	0.322	0.713	0.365	1.392
	[Comfort=3]	0.967	0.179	29.338	1	0	2.631	1.854	3.734
	[Comfort=4]	0.513	0.153	11.305	1	0.001	1.67	1.239	2.253
	[Comfort=5]	0[b]	.	.	0	.	.	.	.
	[Cost=1]	0.941	0.211	19.806	1	0	2.563	1.693	3.879
	[Cost=2]	2.034	0.189	115.62	1	0	7.643	5.276	11.074
	[Cost=3]	1.892	0.144	173.344	1	0	6.635	5.006	8.793
	[Cost=4]	0.853	0.166	26.274	1	0	2.347	1.694	3.252
	[Cost=5]	0[b]	.	.	0	.	.	.	.

	[Safety=1]	1.755	0.543	10.446	1	0.001	5.781	1.995	16.753
	[Safety=2]	1.536	0.284	29.158	1	0	4.644	2.66	8.108
	[Safety=3]	2.456	0.164	222.88	1	0	11.652	8.441	16.085
	[Safety=4]	0.963	0.152	40.039	1	0	2.62	1.944	3.531
	[Safety=5]	0[b]	.	.	0	.	.	.	.
4	Intercept	-2.548	0.047	2972.7	1	0			
	[Reliablity=1]	0.922	0.479	3.697	1	0.055	2.514	0.982	6.433
	[Reliablity=2]	-0.556	0.334	2.769	1	0.096	0.574	0.298	1.104
	[Reliablity=3]	-0.489	0.193	6.401	1	0.011	0.613	0.42	0.896
	[Reliablity=4]	-0.406	0.131	9.559	1	0.002	0.666	0.515	0.862
	[Reliablity=5]	0[b]	.	.	0	.	.	.	.
	[Travel time=1]	1.191	0.435	7.513	1	0.006	3.29	1.404	7.711
	[Travel time=2]	0.391	0.302	1.68	1	0.195	1.478	0.819	2.669
	[Travel time=3]	0.24	0.175	1.89	1	0.169	1.271	0.903	1.79
	[Travel time=4]	0.699	0.117	35.621	1	0	2.012	1.599	2.531
	[Travel time=5]	0[b]	.	.	0	.	.	.	.
	[Comfort=1]	-2.575	0.549	22.008	1	0	0.076	0.026	0.223
	[Comfort=2]	0.755	0.3	6.314	1	0.012	2.127	1.181	3.833
	[Comfort=3]	0.973	0.161	36.343	1	0	2.647	1.929	3.632
	[Comfort=4]	0.978	0.117	70.431	1	0	2.66	2.116	3.342
	[Comfort=5]	0[b]	.	.	0	.	.	.	.
	[Cost=1]	0.297	0.175	2.896	1	0.089	1.346	0.956	1.896
	[Cost=2]	1.299	0.164	62.774	1	0	3.666	2.658	5.055
	[Cost=3]	1.239	0.114	117.307	1	0	3.451	2.758	4.318
	[Cost=4]	0.789	0.121	42.27	1	0	2.201	1.735	2.791
	[Cost=5]	0[b]	.	.	0	.	.	.	.
	[Safety=1]	2.82	0.427	43.629	1	0	16.782	7.268	38.752
	[Safety=2]	1.342	0.261	26.502	1	0	3.828	2.296	6.381
	[Safety=3]	1.517	0.159	90.562	1	0	4.561	3.337	6.234
	[Safety=4]	0.712	0.12	34.912	1	0	2.038	1.609	2.581
	[Safety=5]	0[b]	.	.	0	.	.	.	.

a. The reference category is: 5.

b. This parameter is set to zero because it is redundant.

Appendix III

Code book

Private Car

			Frequency	Percent	Valid Percent	Cumulative Percent
Valid	2-3 times a week	4	514	4.5	4.5	4.5
	At least once a month	2	351	3.1	3.1	7.5
	Every day or (4-7 times a week)	5	1143	9.9	9.9	17.5
	Less than once a month	1	265	2.3	2.3	19.8
	Never	0	8759	76.2	76.2	96.0
	Once a week	3	464	4.0	4.0	100.0
	Total		11496	100.0	100.0	

Appendix IV

HOUSEHOLD SURVEY IN ADDIS ABABA

Appendices

Content of Household Surveys

HOUSEHOLD SURVEY IN ADDIS ABABA

Our goal is to get to know what people living in the city are thinking about the current situation in traffic and traffic infrastructure. In order to better understand the situation in the area concerned we will like to get information on the trips that are generated in households based on the previous day.

Trip diary interviews must be made regarding* Mondays, *Tuesday, Wednesdays or Thursdays.

A. Person called/visited

A0. Gender of the household Head:	**Male:** ☐ **Female:** ☐
A1. Gender of respondent:	**Male:** ☐ **Female:** ☐
A2. Age of the respondent (in completed years)	☐☐

B. Place of residence

B1. Sub-City	B2. Woreda	B3. Locality

1. What are most important factors for you when travelling in Addis Ababa?

	1 Less important	2	3	4	5 Most important
Reliable transport time (no random delays – you know what time you will arrive)	❑	❑	❑	❑	❑
Short travel time	❑	❑	❑	❑	❑
Easy and comfortable trip	❑	❑	❑	❑	❑
A healthy way of travelling (help you get fit)	❑	❑	❑	❑	❑
Way of travelling that is good for the environment (ex: limited pollution)	❑	❑	❑	❑	❑
I can do other things during the trip (reading etc,)	❑	❑	❑	❑	❑
Cost of public transport tickets	❑	❑	❑	❑	❑
A high level of traffic safety (few traffic accidents)	❑	❑	❑	❑	❑
Personal Safety (pickpocketing & sexual harassment)	❑	❑	❑	❑	❑

Are any other things important to you?

_____

_____

_____

2. How often do you use following mode of transport when travelling within Addis Ababa?

	Never	Less than once a month	At least once a month	Once a week	2-3 times a week	Every day or (4-7 times a week)
Private car	❑	❑	❑	❑	❑	❑
Bajaj	❑	❑	❑	❑	❑	❑
Minibus (like the blue & white ones)	❑	❑	❑	❑	❑	❑
MidiBus (like Higer and Isuzu)	❑	❑	❑	❑	❑	❑
Bus (like Sheger, Anbessa, public service bus)	❑	❑	❑	❑	❑	❑
Light Rail	❑	❑	❑	❑	❑	❑
Blue/white Lada Taxi	❑	❑	❑	❑	❑	❑

Yellow Taxi	❑	❑	❑	❑	❑	❑
RIDE taxi						
Bicycle	❑	❑	❑	❑	❑	❑
Walking	❑	❑	❑	❑	❑	❑

Any comments?

_____

_____

_____

3. What is important for you in improving the traffic situation in Addis Ababa?

	1 Less important	2	3	4	5 Most important	Not Important /applicable
Improving conditions for private car transport	❑	❑	❑	❑	❑	❑
Improving conditions for bus transport	❑	❑	❑	❑	❑	❑
Improving conditions for light rail transport	❑	❑	❑	❑	❑	❑
Improving conditions for bicycle transport	❑	❑	❑	❑	❑	❑
Improving conditions for pedestrians Improving cost of public transport	❑	❑	❑	❑	❑	❑

Any other ways you can suggest?

_____

_____

4. What is important for you in improving conditions for private car transport?

	1 Less important	2	3	4	5 Most important	Not Important/applicable
Less import tax on cars	❑	❑	❑	❑	❑	❑
Restriction on import of old cars	❑	❑	❑	❑	❑	❑
More parking facilities	❑	❑	❑	❑	❑	❑
Cheaper parking facilities	❑	❑	❑	❑	❑	❑
More roads	❑	❑	❑	❑	❑	❑
Wider roads	❑	❑	❑	❑	❑	❑
Better quality of road surfaces	❑	❑	❑	❑	❑	❑
Designated parking lots at selected light rail stations	❑	❑	❑	❑	❑	❑

Any other ways you can suggest?

_____

_____

5. What is important for you in improving conditions for public transport?

	1 Less important	2	3	4	5 Most important	Not Important/ applicable
Increasing the number of lines and routes	❑	❑	❑	❑	❑	❑
Increasing the number of departures on the existing routes	❑	❑	❑	❑	❑	❑
Increasing reliability (more accurate arrival at the station)	❑	❑	❑	❑	❑	❑
Improved capacity of light rail trains	❑	❑	❑	❑	❑	❑
Lower price on tickets	❑	❑	❑	❑	❑	❑
Improving travel conditions for women	❑	❑	❑	❑	❑	❑
Improving travel conditions for children/young persons	❑	❑	❑	❑	❑	❑
Improving travel conditions for elderly people	❑	❑	❑	❑	❑	❑
Improving travel conditions for people with physical disabilities	❑	❑	❑	❑	❑	❑
An online or mobile public transport planner	❑	❑	❑	❑	❑	❑
A simpler ticket system with one common ticket for all modes	❑	❑	❑	❑	❑	❑
Introduction of dedicated bus lanes	❑	❑	❑	❑	❑	❑
Road surface improvements for a more comfortable and safe ride	❑	❑	❑	❑	❑	❑
Any other ways you can suggest? _____ _____						

6. Cycling in Addis Ababa

	Yes	**No**
6.1. Can you ride a bike? (*If "No," skip to 6.3*)	❑	❑
6.2. Have you ever used bike as a transport option in AA?	❑	❑
6.3. Would you be interested to use it as a transport option with the right infrastructure? (*whether you currently can or can't ride a bike*)	❑	❑

7. What is important for you in improving conditions for bicycle transport?

	1 Less important	2	3	4	5 Most important	Not Important/ applicable
Separate bicycle tracks	❑	❑	❑	❑	❑	❑
Training Grounds	❑	❑	❑	❑	❑	❑
Bicycle parking facilities	❑	❑	❑	❑	❑	❑
Improved maintenance of roads	❑	❑	❑	❑	❑	❑
Improved maintenance of bicycle tracks	❑	❑	❑	❑	❑	❑
Fewer stops at road intersections	❑	❑	❑	❑	❑	❑
Information for cyclists	❑	❑	❑	❑	❑	❑
Better possibilities for bath and clothes change at my work or education	❑	❑	❑	❑	❑	❑
City bikes in the cities (bikes for everybody to use and share for a small fee)	❑	❑	❑	❑	❑	❑
Any other ways you can suggest? _____ _____						

7. What is important for you in improving conditions for walking in Addis Ababa?

	1 Less important	2	3	4	5 Most important	Not Important/ applicable
More sidewalks	❑	❑	❑	❑	❑	❑
Wider sidewalks	❑	❑	❑	❑	❑	❑
Better quality / more even paving on sidewalks	❑	❑	❑	❑	❑	❑
Sidewalks not cluttered by sellers/market shops	❑	❑	❑	❑	❑	❑
More zebra crossings	❑	❑	❑	❑	❑	❑
Signalised pedestrian crossings	❑	❑	❑	❑	❑	❑
Pedestrian crossings in tunnels	❑	❑	❑	❑	❑	❑
Pedestrian crossings in tunnels including the presence of lighting and shops	❑	❑	❑	❑	❑	❑
Pedestrian crossings on bridges						
Pedestrian crossings on bridges including the presence of elevator or escalator to	❑	❑	❑	❑	❑	❑

access and go down the bridge						
More crossings of the light rail lines	❑	❑	❑	❑	❑	❑
Controlled and wider crossings of the light rail lines	❑	❑	❑	❑	❑	❑
Lower kerb stones and ramps at intersections	❑	❑	❑	❑	❑	❑
Lighting for pedestrians on streets, paths or walkways	❑	❑	❑	❑	❑	❑
Any other ways you can suggest? _____ _____						

8a1. In general, how personal safe do you feel when using the following transport modes in regard to pickpocketing? (*Skip to next mode of transport if the response for Q2 is "Never"*)

	1 Very Unsafe	2	3	4	5 Very Safe
Private car	❑	❑	❑	❑	❑
Bajaj	❑	❑	❑	❑	❑
Minibus (like the blue & white ones)	❑	❑	❑	❑	❑
MidiBus (like Higer and Isuzu)	❑	❑	❑	❑	❑
Bus (like Sheger, Anbessa, PSETSE)	❑	❑	❑	❑	❑
Light rail	❑	❑	❑	❑	❑
Blue/white Lada Taxi	❑	❑	❑	❑	❑
Yellow Taxi	❑	❑	❑	❑	❑
RIDE Taxi service	❑	❑	❑	❑	❑
Bicycle	❑	❑	❑	❑	❑
Walking	❑	❑	❑	❑	❑
Any other ways you feel? _____ _____					

8a2. In general, how personal safe do you feel when using the following transport modes in regard to sexual harassment/gender-based violence? (*Skip to next mode of transport if the response for Q2 is "Never"*)

	1 Very Unsafe	2	3	4	5 Very Safe
Private car	❑	❑	❑	❑	❑
Bajaj	❑	❑	❑	❑	❑
Minibus (like the blue & white ones)	❑	❑	❑	❑	❑
MidiBus (like Higer and Isuzu)	❑	❑	❑	❑	❑
Bus (like Sheger, Anbessa, PSETSE)	❑	❑	❑	❑	❑
Light rail	❑	❑	❑	❑	❑
Blue/white Lada Taxi	❑	❑	❑	❑	❑
Yellow Taxi	❑	❑	❑	❑	❑
RIDE Taxi service	❑	❑	❑	❑	❑
Bicycle	❑	❑	❑	❑	❑
Walking	❑	❑	❑	❑	❑

Any other ways you feel?

_____

_____

8b. In general, how safe do you feel when using the following transport modes (Taking traffic safety into account)**? (*Skip to next mode of transport if the response for Q2 is "Never"*)**

	1 Very Unsafe	2	3	4	5 Very Safe
Private car	❑	❑	❑	❑	❑
Bajaj	❑	❑	❑	❑	❑
Minibus (like the blue & white ones)	❑	❑	❑	❑	❑
Midi-Bus (like Higer and Isuzu)	❑	❑	❑	❑	❑
Bus (like Sheger, Anbessa, PSETSE)	❑	❑	❑	❑	❑
Light rail	❑	❑	❑	❑	❑
Blue/white Lada Taxi	❑	❑	❑	❑	❑

Yellow Taxi	❑	❑	❑	❑	❑
RIDE Taxi service	❑	❑	❑	❑	❑
Bicycle	❑	❑	❑	❑	❑
Walking	❑	❑	❑	❑	❑
Crossing the streets on foot	❑	❑	❑	❑	❑

Any other ways you feel?

_____

_____

9. How often do you use public transport (light railway, bus, minibus, bajaj)?

	Never	Less than once a month	At least once a month	Once a week	2-3 times a week	Every day or (4-7 times a week)
Trips between home and work (formal or informal)	❑	❑	❑	❑	❑	❑
Trips between home and daycare/kindergarten/school/education	❑	❑	❑	❑	❑	❑
Trips between home and health facilities	❑	❑	❑	❑	❑	❑
Trips for social gatherings (visits and the like)	❑	❑	❑	❑	❑	❑
Business trips (like meetings)	❑	❑	❑	❑	❑	❑
Trips going shopping	❑	❑	❑	❑	❑	❑
Recreation / Entertainment	❑	❑	❑	❑	❑	❑
Church/ Mosque	❑	❑	❑	❑	❑	❑

10a. What is your experience using Light Rail? (*Skip to question 10b if the response for Light Rail in Q2 is "Never"*)

	1 Low	2	3 Medium	4	5 High	Do not know
Waiting time getting a ride	❑	❑	❑	❑	❑	❑
Quality of the vehicles	❑	❑	❑	❑	❑	❑
Quality of stations	❑	❑	❑	❑	❑	❑

Ease of access to stations	❑	❑	❑	❑	❑	❑
Quality of the drivers & assistants	❑	❑	❑	❑	❑	❑

10b. What is your experience using Buses (Sheger/Anbessa/Blue bus)? (*Skip to question 10c if the response for buses in Q2 is "Never"*)

	1 Low	2	3 Medium	4	5 High	Do not know
Waiting time getting a Bus	❑	❑	❑	❑	❑	❑
Quality of Buses (the vehicles)	❑	❑	❑	❑	❑	❑
Quality of stops/stations	❑	❑	❑	❑	❑	❑
Quality of the drivers & assistants	❑	❑	❑	❑	❑	❑

10c. What is your experience using minibuses (like the blue & white ones)? (*Skip to question 10d if the response for mini buses in Q2 is "Never"*)

		1 Low	2	3 Medium	4	5 High	Do not know
Waiting time getting a Bus		❑	❑	❑	❑	❑	❑
Quality of Buses (the vehicles)		❑	❑	❑	❑	❑	❑
Quality of stops/stations		❑	❑	❑	❑	❑	❑
Quality of the drivers & assistants		❑	❑	❑	❑	❑	❑

10d. What is your experience using MidiBuses (Higer, Isuzu)? -(*Skip to question 10e if the response for Midi-buses in Q2 is "Never"*)

		1 Low	2	3 Medium	4	5 High	Do not know
Waiting time getting a Bus		❑	❑	❑	❑	❑	❑
Quality of Buses (the vehicles)		❑	❑	❑	❑	❑	❑
Quality of stops/stations		❑	❑	❑	❑	❑	❑
Quality of the drivers & assistants		❑	❑	❑	❑	❑	❑

10e. What is your experience using Bajaj? -(*Skip to question 10e if the response for bajajy in Q2 is "Never"*)

	1 Low	2	3 Medium	4	5 High	Do not know
Waiting time getting a ride	❑	❑	❑	❑	❑	❑

Quality of the vehicles	❑	❑	❑	❑	❑	❑
Quality of stops/stations	❑	❑	❑	❑	❑	❑
Quality of the drivers & assistants	❑	❑	❑	❑	❑	❑

11. How often do you use taxi? -(*Skip to question 12a if the response for taxi in Q2 is "Never"*)

	Never	Less than once a month	At least once a month	2-3 times a week	Once a week	Every day or (4-7 times a week)
Trips between home and work (formal or informal)	❑	❑	❑	❑	❑	❑
Trips between home and daycare/kindergarten/school/education	❑	❑	❑	❑	❑	❑
Trips between home and health facilities	❑	❑	❑	❑	❑	❑
Trips for social gatherings (visits and the like)	❑	❑	❑	❑	❑	❑
Business trips (like meetings)	❑	❑	❑	❑	❑	❑
Trips going shopping	❑	❑	❑	❑	❑	❑
Recreation / Entertainment	❑	❑	❑	❑	❑	❑
Church/ Mosque	❑	❑	❑	❑	❑	❑

12a. What is your experience using blue/white Lada taxis? -(*Skip to question 12b if the response for* blue/white Lada taxis *in Q2 is "Never"*)

	1 Low	2	3 Medium	4	5 High	Do not know
Waiting time getting a taxi	❑	❑	❑	❑	❑	❑
Quality of taxis (the vehicles)	❑	❑	❑	❑	❑	❑
Quality of the drivers & assistants	❑	❑	❑	❑	❑	❑

12b. What is your experience using yellow taxis? -(*Skip to question 10c if the response for yellow taxi in Q2 is "Never"*)

	1 Low	2	3 Medium	4	5 High	Do not know
Waiting time getting a taxi	❑	❑	❑	❑	❑	❑
Quality of taxis (the vehicles)	❑	❑	❑	❑	❑	❑
Quality of the drivers & assistants	❑	❑	❑	❑	❑	❑

12c. What is your experience using RIDE taxis? -(*Skip to question 13 if the response for RIDE taxi in Q2 is "Never"*)

	1 Low	2	3 Medium	4	5 High	Do not know
Waiting time getting a taxi	❑	❑	❑	❑	❑	❑
Quality of taxis (the vehicles)	❑	❑	❑	❑	❑	❑
Quality of the drivers & assistants	❑	❑	❑	❑	❑	❑

13. What form of public transport is the closest to your household? (Multiple response allowed)

- ❑ Bajaj
- ❑ Minibus
- ❑ MidiBus
- ❑ Bus
- ❑ Light Rail (LRT)

14. What is the distance from your household to the nearest public transport?

- ❑ 1-3 min of walking (<250 m)
- ❑ 4-6 min of walking (250-500 m)
- ❑ 7-10 min of walking (500-800 m)
- ❑ More than 10 min of walking (more than 800 m)

15. What is the total monthly income (before tax) of all members of your household together?

- ❑ Less than or equal to 2,500 Birr
- ❑ 2,501 - 5,000 Birr
- ❑ 5,001 - 7,500 Birr
- ❑ 7,501 - 10,000 Birr
- ❑ 10,001 - 15,000 Birr
- ❑ 15,001 - 20,000 Birr

❑ More than 20,000 Birr

❑ Do not want to tell

16. With an improved service quality, how much are you willing to pay for a typical short trip (up to 2.5 km) using these modes?

Mode Type	Willingness to pay					
	Up to 2 Birr	2-4 Birr	4-6 Birr	6-8 Birr	Greater than 8 Birr	Not Willing to use/ Pay
Sheger						
Anbessa						
MidiBus (Higer/ Isuzu)						
Mini-bus						

17. Now we like to know something about your household and the transport of your household

Gender of person being the primary source of economic support for the household?	Female Male Both, equally
How many household members stayed in the household yesterday morning at 5:00?	
How many cars do your household (either owned by you or in other ways available for you like a company car) have?	
How many motorcycles/scooters/mopeds do your household have?	
How many bicycles do your household have?	

18. Members of Household

	Name (just for your own later reference)	Age	Sex	Employment/ Education	Does the Person have a driver's license
			□ Male □ Female	□ Permanently employed □ Occasionally employed □ Unemployed □ Pensioner □ Student □ Pupil	□ Yes □ No
Person 1 (respondent)					
Person 2					

Person 3					
Person 4					
Person 5					
Person 6					
Person 7					
Person 8					
Person 9					
…					

19. Global/Geographic Positioning

S. No.	**Positioning**	**Coordinate**
19.1	Northing	
19.2	Easting	

Trip Diary of all household members aged 4 years or above

Trips made latest Monday, Tuesday, Wednesday or Thursday between 05:00 and 04:59 the following day.

D0. What is the trip diary respondent's line number from the list above?

D1. Where were you at 05:00 latest Monday, Tuesday, Wednesday or Thursday?

- ❑ Home
- ❑ Work (formal or informal)
- ❑ Daycare, kindergarten, school or education
- ❑ Heath facilities
- ❑ At a social gathering (visit or the like)
- ❑ Business meeting
- ❑ Shopping
- ❑ Recreation/entertainment/ Religious place
- ❑ Other

D2. Did you make any trips between 05:00 that day and the day after at 04:59?

- ❑ Yes
- ❑ No (if so, ask the next eligible household member- age 4 years or above)

D3. What was the next location you were going to?

- ❑ Home
- ❑ Work
- ❑ Daycare, kindergarten, school or education
- ❑ Heath facilities
- ❑ A social gathering (visit or the like)
- ❑ Driving/following other household member to daycare/school/college/work etc.
- ❑ Business meeting
- ❑ Shopping
- ❑ Recreation/entertainment/ Religious place
- ❑ Other

D4. How did you get to this location?

(Select **one or more** transport modes)

- ❑ On foot
- ❑ On bike
- ❑ Driving car - with this number of passengers:☐

- ❑ Passenger in a car
- ❑ Motorcycle or moped
- ❑ Taxi
- ❑ Bus
- ❑ MidiBus
- ❑ Minibus
- ❑ Bajaj
- ❑ LRT

D5. What was the transport time getting to this location?

In Minutes: ☐

D6. For respondents between 4 and 7 years of age, please indicate:

- ❑ Travelled with/accompanied by another household member
- ❑ Travelled alone

Loop back to question **D3** until no more trips has been done by this person (until interview-day at 04:59). Remember to record last trip also (typically back to home again).

When no more trips for a person restart from question **D1** for next person in household.

Loop above until trip dairy for all persons in household has been recorded.